Quantifying the Risk in Adventure

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Methods of Assessing Risk

1. Active management of the largest risks
   - Those most prominent and well known
2. High/medium/low classification of risks
   - Two dimensional analysis of L-M-H impact and L-M-H probability
3. Statistical analysis
   - An attempt to move beyond best guess estimates to probability distribution models

Accident Statistics Applied to an Average Adventure Business

If,

- 2,500 client days per year
- 2,500 x 10 years = 25,000 client days
- 6 hours per day activity time
- 6 x 25,000 = 150,000 client hours over 10 years
- This is approximately1/7 of 1 million hours (15%)
- If the business met adventure industry average of 40 events (injuries)/1million hrs, then we could expect 6 events over 10 years
- We could also expect .75 fatalities over 10 years or 1 every 200,000 hours

Comparative Adventure Statistics (Old data)

- Adventure sport death rate =
  5 deaths per 1 million hours of client exposure
- National accidental death rate (all causes) =
  1 death per 1 million hours of exposure
- Vehicle death rate =
  7 deaths per 1 million hours
- Adventure injuries =
  40 per 1 million hours
- Vehicle & football injuries =
  60 per 1 million hours

NOLS Injury & Illness Statistics (2007-2011)

Injuries (average 212 per year)

- 6% of students are injured
- 49% of injured students are evacuated
- 43% of injuries are sprains, strains, tendon injuries
- 37% of injuries are soft tissue injuries
- 6% of injuries are fractures, dislocations

Illnesses (average 179 per year)

- 5% of students become ill
- 41% of ill students are evacuated
- 48% of illnesses are communicable

(Risk Management at the National Outdoor Leadership School, November 2011)

Waterfall Ice (Canadian Rockies) [Joe Josephson, 1994]

- Commitment grade
  - I. Short and easy climb within minutes of the car
  - II. Route of one or two pitches within easy reach of the vehicle or emergency facilities, little or no objective hazard.
  - III. Multi-pitch route at low elevation or one-pitch route with involved approach. The route may take several hours to most of a day to complete. Approach is subject to occasional winter hazards including avalanche.
  - IV. Multi-pitch route at higher elevations or remote regions, more subject to weather patterns and objective hazards. Requires several hours of approach and greater knowledge of mountain travel and hazards.
  - V. A long climb that requires a competent party and all day to complete. Usually on a high mountain face or gully ending above treeline. Subject to sustained climbing and/or avalanche hazards with a long involved approach on foot or ski. A high level of climbing experience and winter travel skills are needed to climb safely. Descent involves multiple rappels from your own anchors.

Waterfall Ice (Canadian Rockies) [Joe Josephson, 1994]

- Commitment grade

  VI. A long waterfall with all the characteristics of a large alpine route. The climbing will be very sustained for its given technical grade. Only the best climbers will complete it in a day. Often requires a ski and/or glacier approach with a difficult and tiring descent. Objective hazards will be high, which may include avalanche, falling seracs, high altitude, whiteout, crevasses and/or remoteness. An extraordinary degree of fitness and experience is required.

  VII. A route that has characteristics of a Grade VI but is considerably longer and harder, both physically and emotionally. The climbing will be technically very difficult for many pitches and may take days to approach and climb. Objective hazards will be very high such as large avalanche bowls and/or active seracs. **A 50-50 chance of getting the chop.**

Aid Climbing Ratings (Don Reid)

A0. When the climber is generally in a free climbing mode and equipment, often fixed, is grabbed or an improvised aid sling used for quick passage.

A1. “Outstanding fall-catching placements,” usually in well-defined cracks.

A2. A good familiarity with equipment options and placement is required while travelling through short sections of marginal security.

A3. Advanced familiarity with equipment options, placement, and marginal rock, coupled with an appreciation for falls of consequence.

Aid Climbing Ratings (Don Reid)

- A4. Modified equipment may be necessary. Exceptional skill and experience required with placement, route finding, and marginal/hazardous rock conditions while operating in situations that normally invite potentially long and/or very serious falls.
- A5. Modified equipment may be necessary. An expert level of skill and experience required with placement, route finding, and marginal/hazardous rock conditions while operating in situations that normally provoke potential death falls.

Rock Climbing Protection Rating

Protection Rating
(Yosemite Decimal System)

G	Good, solid protection ground up
PG	Pretty good, few sections of poor or non-existent placements
PG13	OK protection, falls may be long but will probably not cause serious injury
R	Runout, some protection placements may be very far apart (possibility of broken bones, even when properly protected)
X	No protection, extremely dangerous (possibility of death, even when properly protected)

The Risk Number (RN)

- In most adventure sports there are difficulty ratings but not risk (danger or death potential) ratings.
- For example,
  - Grade 1 to 6 water
  - Grade 5.4 to 5.15 rock climbing routes
- The Risk Number is an attempt to grade the danger associated with specific terrain
- The trick is how to enumerate the many variables

An Example of the Risk Number (RN)

A comparison of two hikes

Categories of Difficulties	**Prepared Trail** (laid out & maintained trail, bridges over streams, trail signage, cliff edge fencing)	**Unprepared Trail** (bushwacking, stream crossings, boulder hopping in talus field, scree slope, open cliff edges)
Trail quality	0	3
Stream crossings	0	3
Talus	1	3
Scree	1	3
Exposure	2	2
RN	**4**	**14**

The Risk Number (RN)

Climbing Length Grade

(Yosemite Decimal System)

I	Up to several hours
II	About a half day
III	A full day, 7-8 hours
IV	A very long day, possible bivouac
V	1 ½ to 2 days
VI	More than 2 days
VII	Big wall ascents in remote situations

The Risk Number (RN)

Combining RN with Length

(Yosemite Decimal System with RN)

I	Up to several hours	
II	About a half day	
III	A full day, 7-8 hours	III•4
IV	A very long day, possible bivouac	IV•14
V	1 ½ to 2 days	V•1
VI	More than 2 days	VI•20
VII	Big wall ascents in remote situations	

The Risk Number (RN)

Combining RN with Rock Climbing Grades

5.7	5.7•1
	5.7•12
5.10	5.10b•4
	5.10b•15

RN Whitewater River Analysis

Elements of Whitewater River Risk Analysis

Factor	# of Elements
Water characteristics	4
Weather	6
Hazards	30
Hydrological considerations	4
River traffic	6
Geological considerations	5
Reconnaissance	3
Portages	2
Off river	10
TOTAL FACTORS	**70**

RN Whitewater River Analysis

Water Characteristics					Weather						
	Water Temperature	Water Turbidity (Water Clarity)	Water Safety of Accidental Consumption	Floating Debris		Trip Duration Sensitivity to Weather	Climatic Severity	Climatic Variability	Wind Strength	Wind Exposure	Dust Storms
	2.5	2.0	1.0	2.0		3.0	3.0	3.0	3.0	3.0	3.0
	1.5	1.0	1.0	3.0		1.0	2.0	2.5	1.0	1.0	0.0
	1.0	2.0	1.0	3.0		0.0	2.0	2.0	1.0	0.5	0.0
	0.5	3.0	3.0	2.0		1.0	1.0	1.5	2.0	2.0	2.0
	2.0	0.0	2.0	0.0		3.0	3.0	2.5	3.0	3.0	1.0
	1.0	0.5	1.0	3.0		1.0	2.0	2.0	1.0	1.0	0.0

RN Whitewater River Analysis - Summary

River	Section	General Rating and Information	Number of Days	Quality Rating for Trip Experience	Time Considerations	River Tech. Class	Risk Number	Gradient (feet/mile)	Volume July 1st (cfs in 000's)	Length in km's
Tatshenshini - Alsek	Dalton Post to Dry Bay		12	*****	D	III+	111.0	28	800 - 6000	200
Upper Skeena	Mosque to Smithers		8	****	D	IV	105.5	37	1000 - 7000	120
Gataga - Keckika	Mayfield Lakes to Terminus Mt.		8	****	C	II+	62.5	10	400 - 4000	100
Chilco - Chilcotin - Fraser	Chilco Lake to Lillooett		9	***	C	III+	104.5	30	30,000 -180,000	220
Firth	Put in to Beaufort Sea		11	****	C	III+	95.5	22	300 - 5800	150
Toodogone - Finlay	Toodogone Lake to Fort Ware		6	****	C	IV	95.5	26	450 - 6500	100

Parks Canada Avalanche Terrain Exposure Scale (Public Communication Model)

Description	Class	Terrain Criteria
Simple	**1**	Exposure to low angle or primarily forested terrain. Some forest openings may involve the runout zones of infrequent avalanches. Many options to reduce or eliminate exposure. No glacier travel.
Challenging	**2**	Exposure to well defined avalanche paths, starting zones or terrain traps; options exist to reduce or eliminate exposure with careful routefinding. Glacier travel is straightforward but crevasse hazards may exist.
Complex	**3**	Exposure to multiple overlapping avalanche paths or large expanses of steep, open terrain; multiple avalanche starting zones and terrain traps below; minimal options to reduce exposure. Complicated glacier travel with extensive crevasse bands or icefalls.

Parks Canada Avalanche Terrain Exposure Scale (Technical Model)

	1 – Simple	2 – Challenging	3 – Complex
Slope angle	Angles < 30°	Low angle, isolated slopes >35°	Variable with large % >35°
Slope shape	Uniform	Some convexities	Convoluted
Forest density	Primarily treed	Mixed trees and open terrain	Large expanses of open terrain
Terrain traps	Minimal, some creeks or cutbanks	Some depressions, gullies or overhead	Many depressions, gullies or overhead
Avalanche frequency (events:years)	1:30 ≥ size 2	1:1 for < size 2 1:3 for ≥ size 2	1:1 for < size 3 1:3 for ≥ size 3
Start zone density	Limited open terrain	Some open terrain. Isolated paths to valley bottom	Large open expanses. Multiple paths to v bottom
Runout zone characteristics	Solitary, well defined areas	Abrupt transitions or depressions	Multiple converging runout zones
Interaction with avalanche paths	Runout zones only	Single paths with separation	Numerous and overlapping paths
Route options	Numerous, multiple choices	Selection of choices	Limited chances to reduce exposure
Exposure time	None, or limited crossing runouts	Isolated exposure to zones & tracks	Frequent exposure to zones & tracks
Glaciation	None	Generally smooth with isolated crevasses	Broken or steep sections of crevasses, icefall & seracs

Parks Canada Avalanche Terrain Exposure Scale (Custodial Group Management)

ATES Rating	Parks Canada Custodial Group Policies
Simple 1	Custodial groups may travel with no specific leadership or custodial permitting requirements in Class 1 (Simple) terrain only. **Parks Canada recommends that custodial groups avoid backcountry travel entirely during Backcountry Avalanche Advisories of POOR.**
Challenging 2	An ACMG or IFMGA mountain or ski guide with a valid permit must lead all custodial groups. Group size must not exceed a total of 10. Travel on avalanche terrain only when the guide rates the slope specific Snow Stability as Good or Very Good.
Complex 3	Custodial Groups will not be permitted into this terrain under any conditions.

Catastrophe Modeling (Shane Latchman)

- Serves to measure the financial impact of catastrophes with a view to estimating expected losses.
- The purpose of “cat modeling” is to anticipate the likelihood and severity of catastrophic events so businesses can appropriately prepare for their financial impact.

- There are 3 main components of cat modeling
  - Event’s magnitude (Hazard)
  - Damage (Vulnerability)
  - Financial loss the event inflicts (Financial)

Three Modules of Cat Modeling

1) Hazard Model

- Looks at the physical characteristics of potential incidents and their frequency
- Includes a “catalogue” of potential future events which forms the basis for drawing conclusions about the perils (e.g., avalanches) that may occur, their intensity, and the likelihood they will occur
- Statistical and physical models are used to simulate a list of possible events. Historical data on frequency, location, and intensity of past events is used to generate a realistic simulation and forecast (what’s forseeable)
- Since the past is not always indicative of the future, the event list may include events that are more (or less) extreme than those that will occur in the future

Three Modules of Cat Modeling

2) Vulnerability Model

- The *vulnerability* module assesses the vulnerability (or "damageability") of an organization when subjected to an accident
- After simulating an event of a given magnitude, the damage it does must then be computed
- The "damage ratio" is the cost to respond to an event and return to "normal"
- It is, of course, quite possible for seemingly identical events to create different levels of damage. For outdoor businesses this may be due to differences in group management, leadership, equipment, response levels, etc. that can have a major impact on losses

Three Modules of Cat Modeling

- 3) Financial Model
  - The damage ratio distribution for a specific event is then multiplied by the incident response, defense and settlement values to obtain the loss distribution.
  - These calculations are done within the *financial module* which also incorporates specific insurance policy conditions that are crucial in accurately determining the insurer's loss.

- A case of two events:
  - The financial module computes the combined loss distribution of all costs through a process known as convolution. This is a means of computing all possible combinations of the loss distributions (in our example, the two events of $L_i + L_j$) and their associated probabilities, given the probability distributions of L_i *and* L_j separately.

Three Modules of Cat Modeling

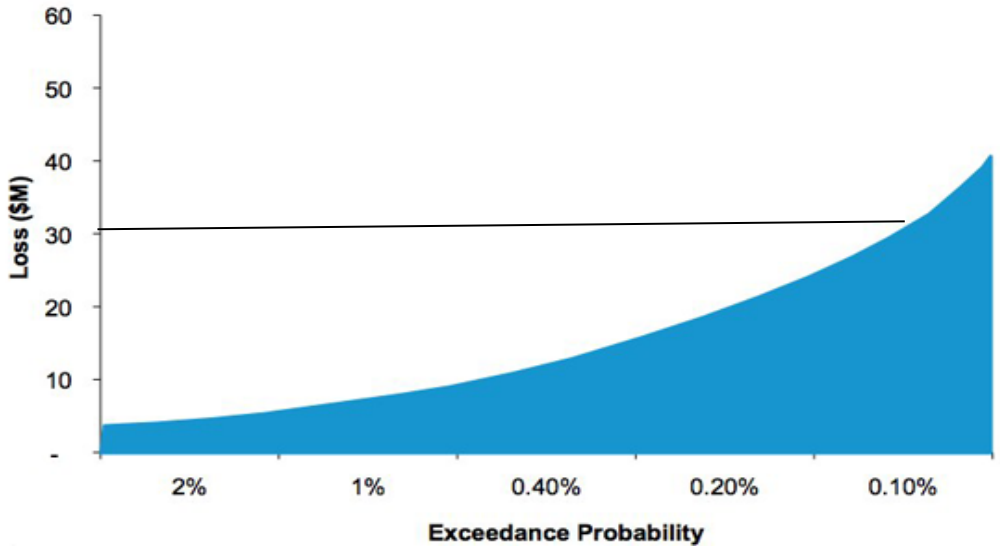
3) Financial Model

- In this case, L_i *and* L_j are the loss distributions for two events, 1 and 2 respectively, for each event.
- This is shown formally below, where *L* represents the total loss for 2 events, P1 (L_i) is the probability distribution for event 1, and P2 (L_j) the probability distribution for event 2.

$$P(L)=\sum L=L_i+L_j \;\; P1(L_i)\times P2(L_j)$$

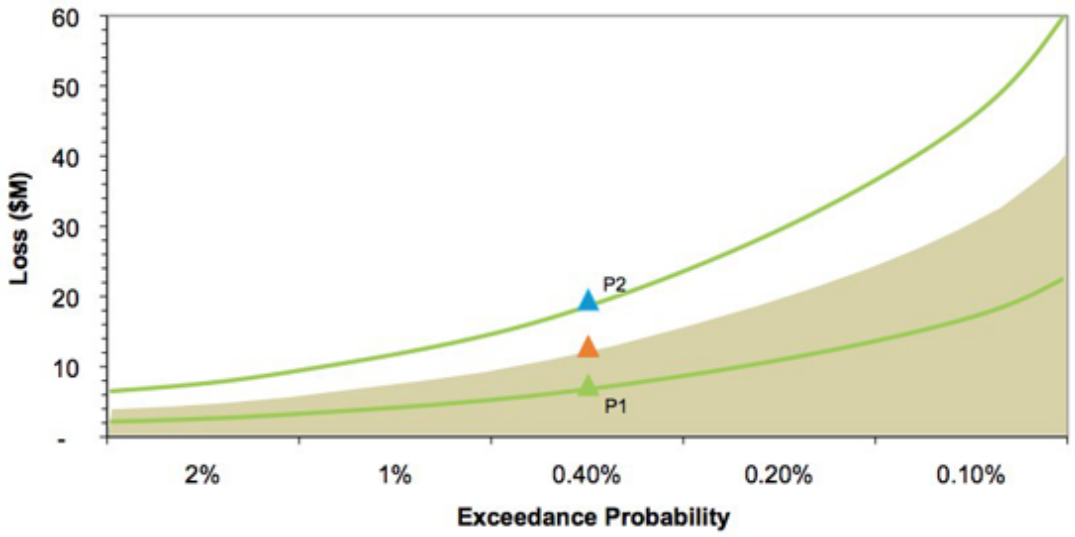
Exceedence Probability

- Describes the probability that a given level of loss will be exceeded in any given year.
- An EP curve is generated by running the list of perils against historic exposure and losses. The total mean loss for each year is calculated and plotted to give the exceedance probability (EP) and corresponding loss at that probability.



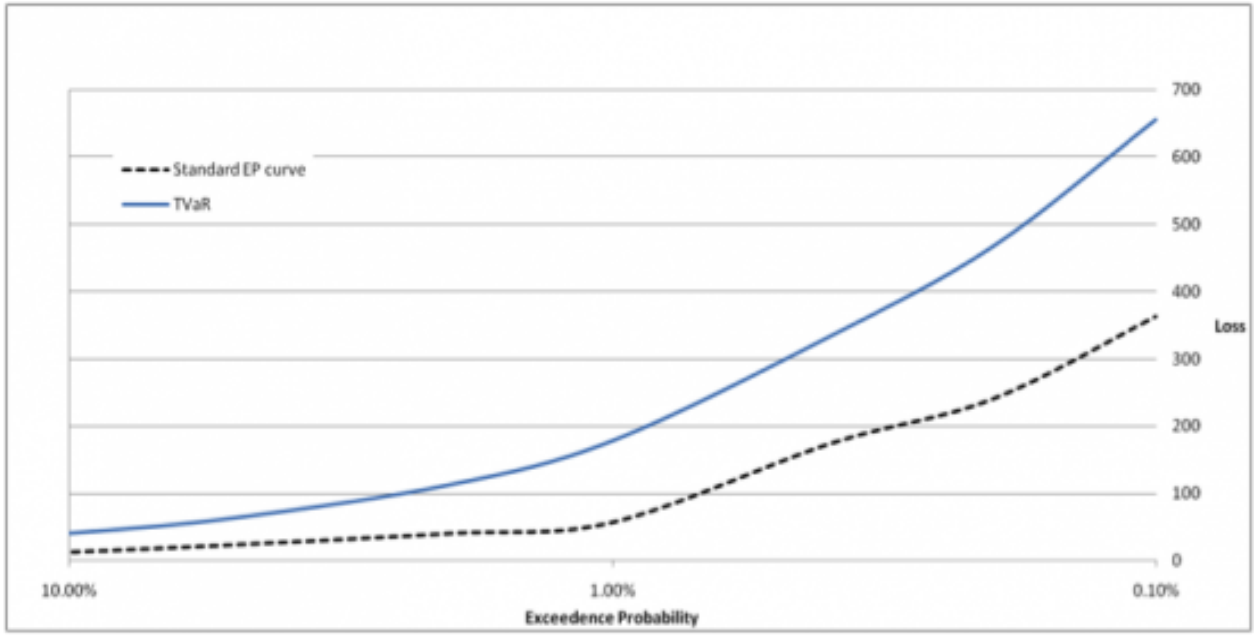
Percentiles

- One way for insurers to assess the potential payouts that could be required in a specific period is through plotting percentiles around the EP curve.
- In this example, the insurer can assess their risk at the 0.4% exceedance probability period by looking at their mean loss at that return period, $10 million in this example.



Tail Value at Risk (TVaR)

- This calculation uses the high average of all losses over a period in order to build in a reserve to withstand a year of exceptional losses
- For example, the TVaR on the graph below calculates the largest payouts in all years and compares it to the EP curve
- Setting premiums based on the TVaR curve will help insurers to withstand a catastrophic year loss (like the 2003 avalanche winter in Canada)



Rating the Risk of Insuring an Adventure Business (Valade & Cloutier)

Insurer Risk Rating Formula:

Frequency + Severity + Defendability = Claim Generation

- Hazard model
- Vulnerability model
- Financial model
- Exceedance probability curves
- Tail value at risk

Quantifying the Risk of Insuring an Adventure Business (Valade & Cloutier)

- The risk of insuring an adventure organization depends on:
  - Operating standards (level of professionalism)
  - Documentation (joining instructions, plans, procedures, waivers, supporting legislation)
  - Loss control program (avoidance, prevention, reduction, segregation, transfer)
  - Guide competencies (first aid, training, experience, judgement)
  - Administrative procedures (staff training, trip planning, safety talks, joining instructions, response procedures)
  - Activity volume analysis (frequency)
  - Activity risk analysis (severity)
  - Operating terrain analysis (simple, challenging, complex)
  - Moral risk (business, owner & guide history)
  - Claim history (minor & major claims, close calls).

Rating the Risk of Insuring an Adventure Business (Valade & Cloutier)

Scoring risk. Turning data into ranking.

Frequency + Severity + Defendability = Claim Generation			
	Scoring 1-10	**Weighting**	**Total**
Operating standards	3	5	15
Documentation content	2	5	10
Loss control program	2	10	20
Guide competencies	2	10	20
Administration procedures	2	5	10
Volume analysis	5	10	50
Activity risk analysis	2	10	20
Operating terrain complexity	2	10	20
Moral risk	2	5	10
Claims history	5	10	50
	27	**80**	**225**