



Presented as one of several keynote addresses at 2013 IAASS in Montreal.

What
would
PASCAL
think
about ~~Space~~ *System*
Safety?



Blaise Pascal
1623-1662



BLAISE PASCAL

“THE FATHER OF RISK-BASED DECISIONS”



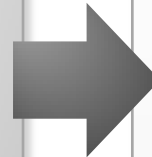
Then

The Original Pascal's Wager

	Right	Wrong
Believe	Heaven	Nothing
Not Believe	Nothing	Hell

“God is or He is not...Let us weigh the gain and the loss in choosing...’God is.’ If you gain, you gain all, if you lose, you lose nothing. Wager, then, unhesitatingly, that He is.”

~1654



Now

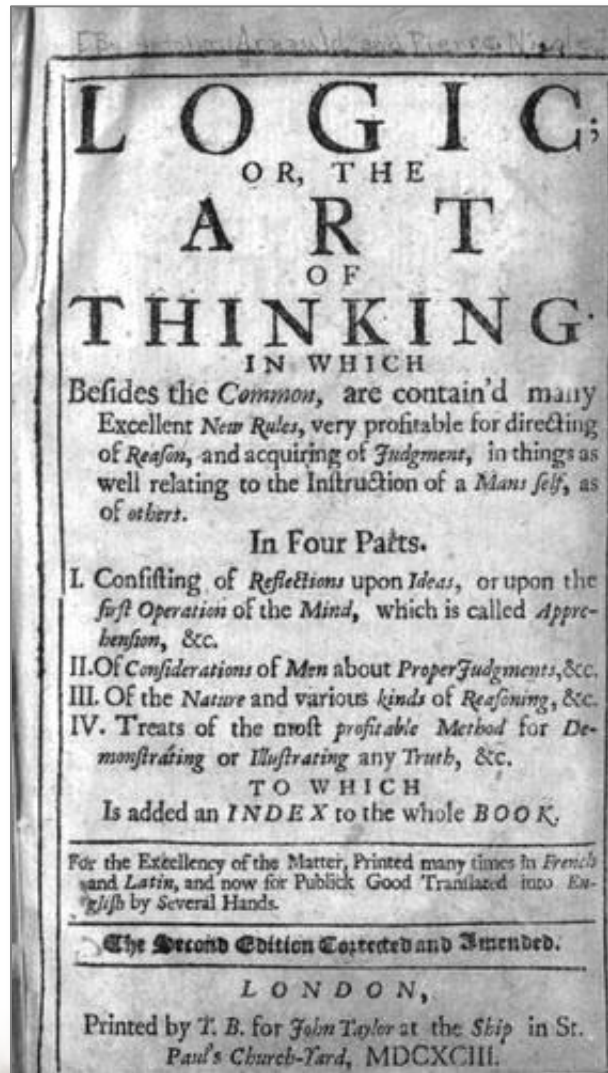
The Generic Pascal's Wager

<i>Hindsight</i>		
	Right	Wrong
<i>Choices</i>	Yes	4 Possible Outcomes
	No	

Risk-based decisions rely on an evaluation of future events for probable gains and losses. Many of these evaluations are in the generic form of Pascal's Original Wager.

BLAISE PASCAL

“THE FATHER OF RISK-BASED DECISIONS”



Logic or the Art of Thinking

“So then, our fear of harm ought be proportional not only to the magnitude of the harm but also the probability of the event.”

- 1662



Basic Risk Equation:

Risk = Likelihood × Consequences

RISK DEFINED IN 1662



Chapter 16. Judgments we make concerning future accidents.

“These rules, [referring to earlier chapters] which are helpful for judging about past events, can be easily applied to future events...

“Many people, for example, are exceedingly frightened when they hear thunder. If thunder makes them think of God and death and happiness, we would not think about it too much. But if it is only the danger of dying by lightning that causes them this unusual apprehension, it is easy to show that this is unreasonable. For out of two million people, at most there is one who dies this way. We could even say that there is hardly a violent death that is less common. So, **then, our fear of some harm ought to be proportional not only to the magnitude of the harm, but also to the probability of the event. Just as there is hardly any kind of death more rare than being struck by lightning, there is also hardly any that ought to cause less fear.**”

Logic or the Art of Thinking, 1996.

PASCAL'S 8 RULES

Chapter 11. The scientific method reduced to eight main rules.

Definitions:

1. Leave no term even slightly obscure or equivocal without defining it.
2. In definitions, use only terms that are perfectly known and have already been explained.

Axioms:

3. In axioms, require everything to be perfectly evident.
4. Accept as evident what needs only little attention to be recognized as true.

Demonstrations:

5. Prove all propositions that are even slightly obscure...
6. Never exploit the equivocation in terms by failing to substitute mentally the definitions that restrict and explain them.

Methods:

7. Treat things in their natural order beginning with the most general...
8. Divide each genus into species, each whole into part, and each difficulty into all its cases.

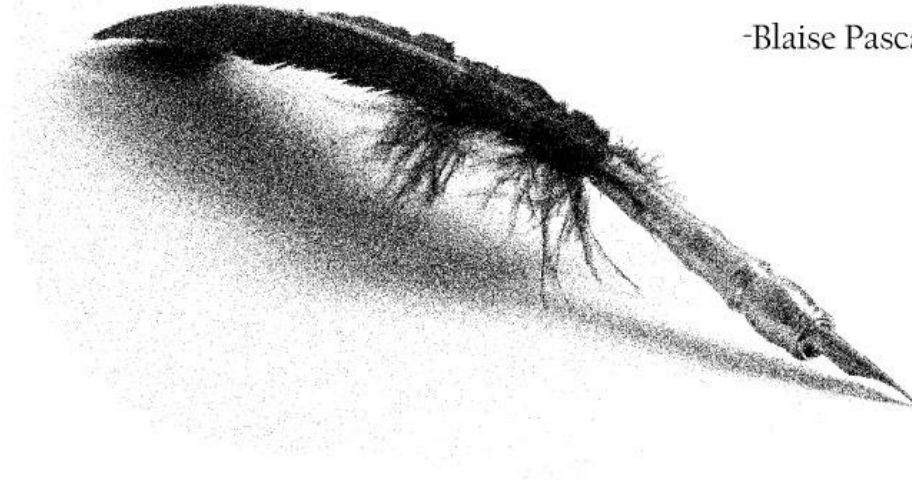


Pascal, one of history's greatest mathematicians, encouraged a concise, disciplined, and structured approach.

Logic or the Art of Thinking, 1996.

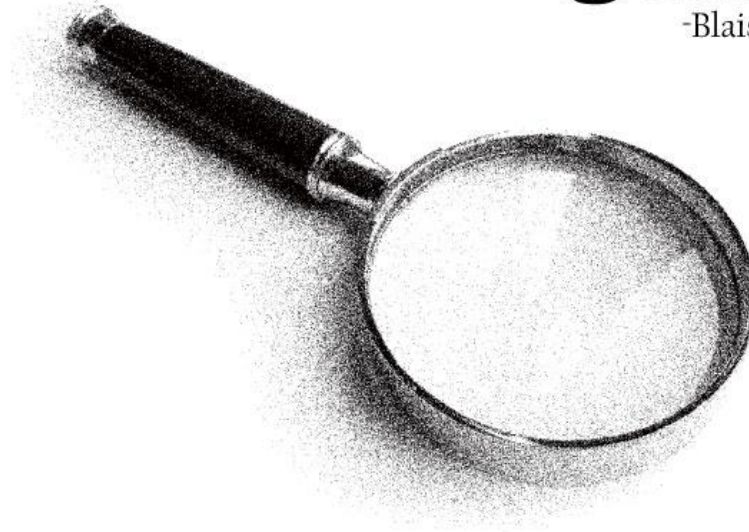
I have
made this
Letter
longer than usual,
BECAUSE
only I have
not had
the
TIME to make
IT
shorter.

-Blaise Pascal



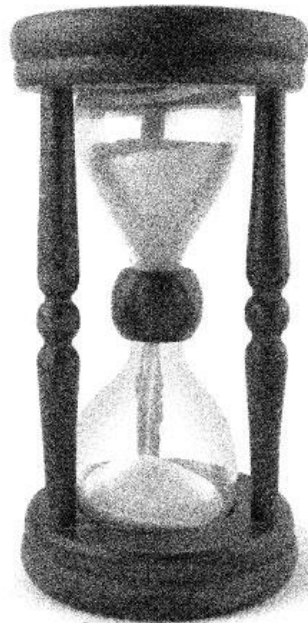
People
are
usually more
convinced by REASONS
they discovered
themselves than those found
by Others.

-Blaise Pascal



Nothing is so
INTOLERABLE to
man as being
fully at rest,
without *a passion,* without BUSINESS,
without *entertainment,*
without CARE.

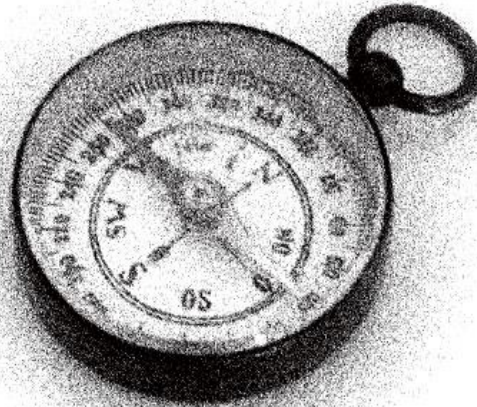
-Blaise Pascal



Kind
words ^{do}_{not} COST
much.
Yet ^{they} ACCOMPLISH
much.

-Blaise Pascal

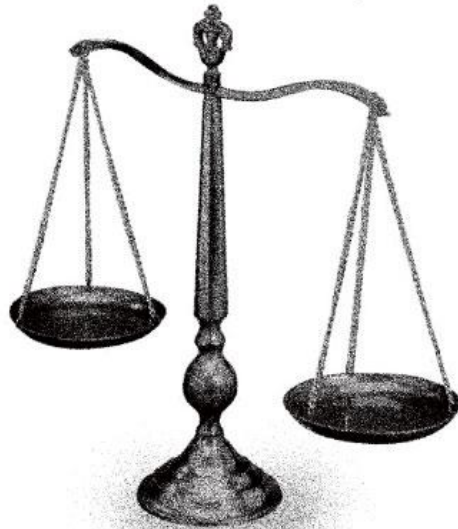


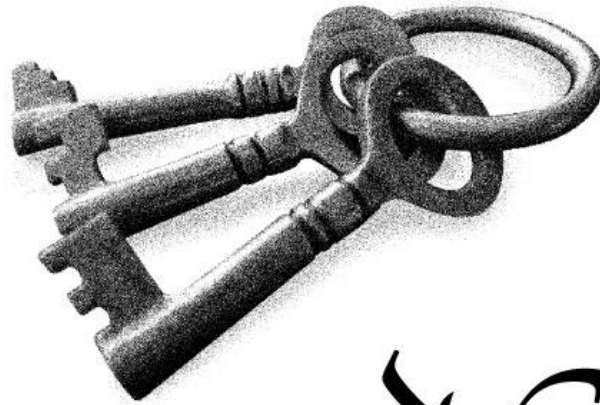


The
*H*ear
has
REASONS that
REASON
cannot *know.*

-Blaise Pascal

Justice &
POWER
must be
brought together,
so that
Whatever is
just may be POWERFUL,
& whatever is
POWERFUL, may be
just. -Blaise Pascal





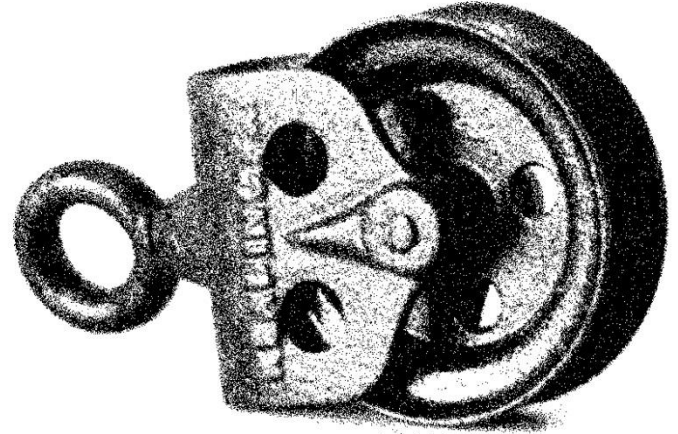
Noble
DEEDS ^{that}
_{are}
concealed
^{are}
_{most} **E**STEEMED.

-Blaise Pascal

I have
DISCOVERED
that all
HUMAN evil
comes from this,
Man's being
UNABLE to
sit still
in a ROOM.
-Blaise Pascal



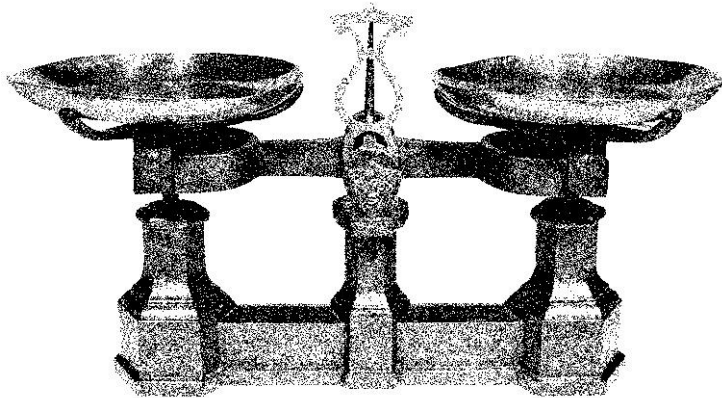
So what would Pascal think?



1. Do not
create **F**EAR nor
elevate unwarranted
CONCERN.

So what would Pascal think?

2. ~~Neither~~ ^{OVERSTATE or}
_{understate}
your ^{Best} rational
estimates of **RISK**.

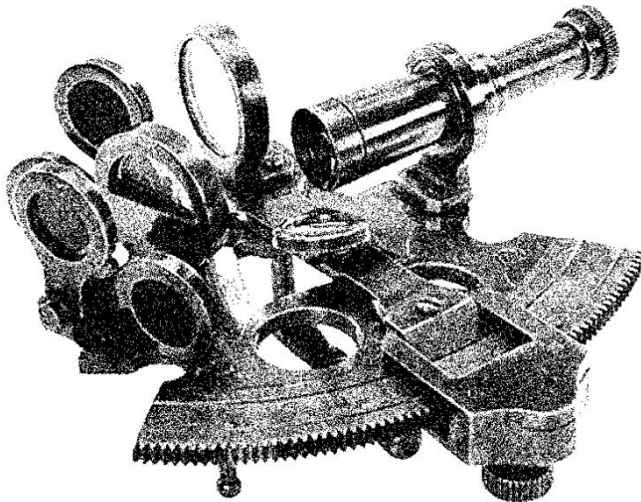


So what would Pascal think?

3. *When*
ESTABLISHING

*M*etrics *of*
RISK:

be concise,
be *unbiased*,
be TRUTHFUL.



So what would Pascal think?

Use Concise Language

About the “casualty” standard he would think:

- ∞ Casualty to most of the world is euphemism for death.
- ∞ Casualty to a mathematical risk analyst is:
 - ❖ Death + Serious Injury.
 - ❖ This produces an exaggerated bias that can dominate the answer.

He would ask: Why build in such obvious and unnecessary flaws in communication?

- ∞ Fatality is a concise measure.
- ∞ Serious injury is not nearly as concise but nevertheless, it can be measured without bias.

Further Reading

- Arnauld, Antoine; Nicole, Pierre; Logic or the Art of Thinking, 1996.
- Bernstein, Peter L.; Against the Gods, The Remarkable Story of Risk; 1998.
- Hacking, Ian; The Emergence of Probability; 1975.
- Muir, Jane; Of Men and Numbers, The Story of the Great Mathematicians; 1996.
- Pfitzer, Tom; Hardwick, Meredith; Dwyer, Saralyn; Clemens, Pat; Pascal and the Risk Assessment Code (RAC) Matrix; 2001.
- French, Heather; a publication of original artwork using the quotes of Blaise Pascal, found at:
www.apr-research.com/products/PascalPosters.pdf



APT Research, Inc.



Blaise Pascal and the Risk Assessment Code (RAC) Matrix

**International System Safety Conference
Huntsville, Alabama
September 13, 2001**

**APT Research, Inc.
Tom Pfitzer, Meredith Hardwick, Saralyn Dwyer**



A-P-T Research, Inc.

THE 882D RAC MATRIX AS VIEWED BY PASCAL'S PROPORTIONAL CONCEPT

Mishap Probability Levels	Mishap Severity Categories			
	(1) Catastrophic	(2) Critical	(3) Marginal	(4) Negligible
(A) Frequent	1A	2A	3A	4A
(B) Probable	1B	2B	3B	4B
(C) Occasional	1C	2C	3C	4C
(D) Remote	1D	2D	3D	4D
(E) Improbable	1E	2E	3E	4E

—10⁰

—10⁻¹

—10⁻²

—10⁻³

—10⁻⁴

—10⁻⁵

—10⁻⁶

—10⁻⁷

—10⁻⁸

—10⁻⁹

\$2B

\$200M

\$20M

\$2M

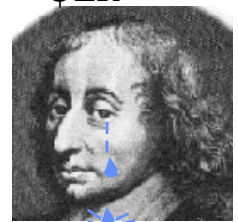
\$200k

\$20k

\$2k

Under the proportionality concept:

- Risk in 2C varies by a factor of 50 (1.6 orders of magnitude)
- Risk in 1D varies by a factor of 1,000,000 (6 orders of magnitude)
- Risk in 3D varies by a factor of 20,000 (3.3 orders of magnitude)





APT Research, Inc.

PROPORTIONAL RAC MATRIX EXAMPLE 1

Quantitative risk assessment would be better served by an expanded proportional RAC matrix.

Many Deaths (>10) or Many Very Severe Injuries (>100)	Multiple Deaths(1-10) or Many Severe Injuries (11-50)	Death or Injuries (2-10)	Severe Injury	Minor Injury	Less than Minor Injury	
UNTHINKABLE						Frequent Likely to occur frequently
						Probable Will occur several times
						Occasional Likely to occur sometime
						Remote Unlikely but possible
						Improbable May not be experienced
						Extremely Unlikely
						Extremely Remote
						Extremely Improbable

<u>Annual All People</u>	<u>1 Operation All People</u>	<u>Annual 1 Person</u>
10	1	10 ⁻¹
1	10 ⁻¹	10 ⁻²
10 ⁻¹	10 ⁻²	10 ⁻³
10 ⁻²	10 ⁻³	10 ⁻⁴
10 ⁻³	10 ⁻⁴	10 ⁻⁵
10 ⁻⁴	10 ⁻⁵	10 ⁻⁶
10 ⁻⁵	10 ⁻⁶	10 ⁻⁷
10 ⁻⁶	10 ⁻⁷	10 ⁻⁸

Footnote: This RAC was proposed for use by the Range Commander's Council in 1996.



APT Research, Inc.

PROPORTIONAL RAC MATRIX EXAMPLE 2

Probability of Occurrence Per _____ Uses (Estimate of Total Annual Exposure)

	1 2	3 3/10	4 1/10	5 3E-2	6 1E-2	7 3E-3	8 1E-3	9 3E-4	10 1E-4	11 3E-5	12 1E-5	13 3E-6	14 1E-6	15 3E-7	Expected Deaths	Expected Serious Injuries	Expected Minor Injuries	Expected \$ Loss
a	Unthinkable														>1000			
b															>300			
c															>100			
d															>30			
e															>10			
f															>3			
g															>1	>10		
h																>3		
i																>1	>10	
j																	>3	
k																	>1	100K
l																		30K
m																		10K
n																		3K

Footnote: This RAC was proposed for use by the IM Community in 2000 at a NIMIC Conference.



AN APPROACH TO DEFINING PROPORTIONAL RACS

1. Define consequence scale

a. Define units

- Deaths
- Injury
- Cost
- Etc.

b. Define range

c. Define number of subdivisions

2. Define probability (or frequency)

a. Define units

- Events per year (single item)
- Events per year (all items)
- Events per lifetime (single item)
- Events per lifetime (all items)

b. Define range

c. Define number of subdivisions

3. Define upper and lower bounds for risk

a. De minimis

b. Unthinkable

4. (Optional) Color code to illustrate risk concept



Presented as one of several keynote addresses at 2013 IAASS in Montreal.

What
would
PASCAL
think
about ~~Space~~ *System*
Safety?



Blaise Pascal
1623-1662

