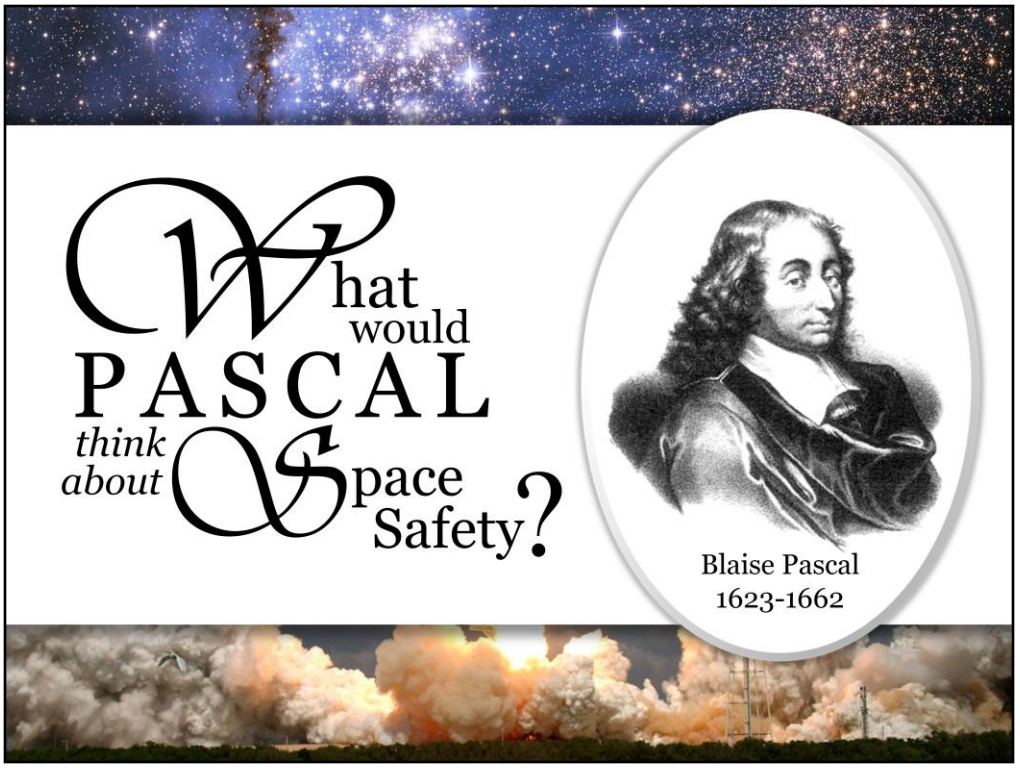
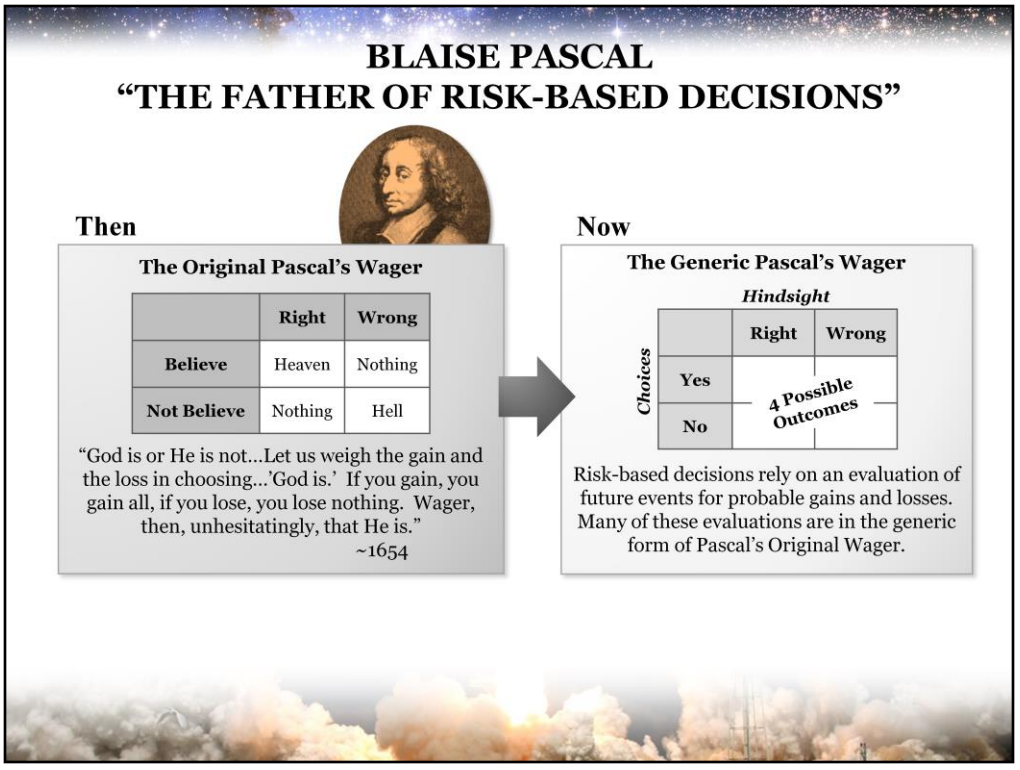


When Tommaso asked me to speak, I considered a variety of topics. The one that appealed to me most was to reflect for a few minutes on what the father of modern risk assessment, Blaise Pascal, might think about this society, and what advice he might have.

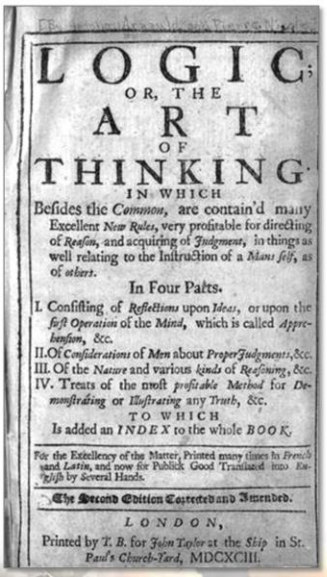
As background, I should tell you that I began my career as a Range Safety Officer over 40 years ago evaluating risk of harm, and during the last 15 years I have served on a variety of panels and groups for the purpose of developing and writing risk-based standards. In that capacity I have been paid to conduct research and teach classes on the history of modern risk assessment. This research led me to appreciate the profound role that Pascal has had on the discipline that I practice. So let me begin by explaining some of what Pascal thought.

Pascal was a true Renaissance man being well versed in science, physics, religion, philosophy, and especially mathematics. He had a knack for simplifying complex problems into mathematical formulae. There is little doubt that were he alive today, he would have well-formed opinions about Space Safety.



In one of his earlier publications, he postulated what has become known as Pascal's Wager. It is often taught in philosophy classes. This concept, while it may be flawed in a religious context, has widespread use in a risk management context. We often use it without realizing it by evaluating possible outcomes. As Pascal said, "weigh the gains and losses." It was Pascal who distilled this risk-based decision process into a more understandable and concise two by two matrix, leading to clarity in the answer. We have an apriori choice to make and we know that after we make it we will either be right or wrong. We often use this approach to make daily choices about letting our children cross streets or eating spicy foods or sending our significant other flowers. It is not used when we already know the likely outcome; have you ever been in a situation where you know that anything you say will be wrong but you go ahead and speak anyway? That is not a Pascal's Wager because there is no uncertainty in the outcome.

BLAISE PASCAL
"THE FATHER OF RISK-BASED DECISIONS"



LOGIC;
OR, THE
ART
OF
THINKING
IN WHICH
Besides the *Common*, are contain'd many Excellent *New Rules*, very profitable for directing of *Reason*, and acquiring of *Judgment*, in things as well relating to the Instruction of a *Mans self*, as of *others*.

In Four Parts.

I. Consisting of *Reflections* upon *Ideas*, or upon the *first Operation* of the *Mind*, which is called *Apprehension*, &c.
II. Of *Considerations* of *Men* about *Proper Judgments*, &c.
III. Of the *Nature* and various *kinds* of *Reasoning*, &c.
IV. Treats of the most *profitable Method* for *Demonstrating* or *Illustrating* any *Truth*, &c.

TO WHICH
Is added an *INDEX* to the whole *BOOK*.

For the Excellency of the Matter, Printed many times in *French* and *Latin*, and now for Publick Good Translated into *English* by Several Hands.

The Second Edition Corrected and Amended.

LONDON,
Printed by *T. B.* for *John Taylor* at the *Ship* in St. *Paul's Church-Yard*, MDCXCIII.

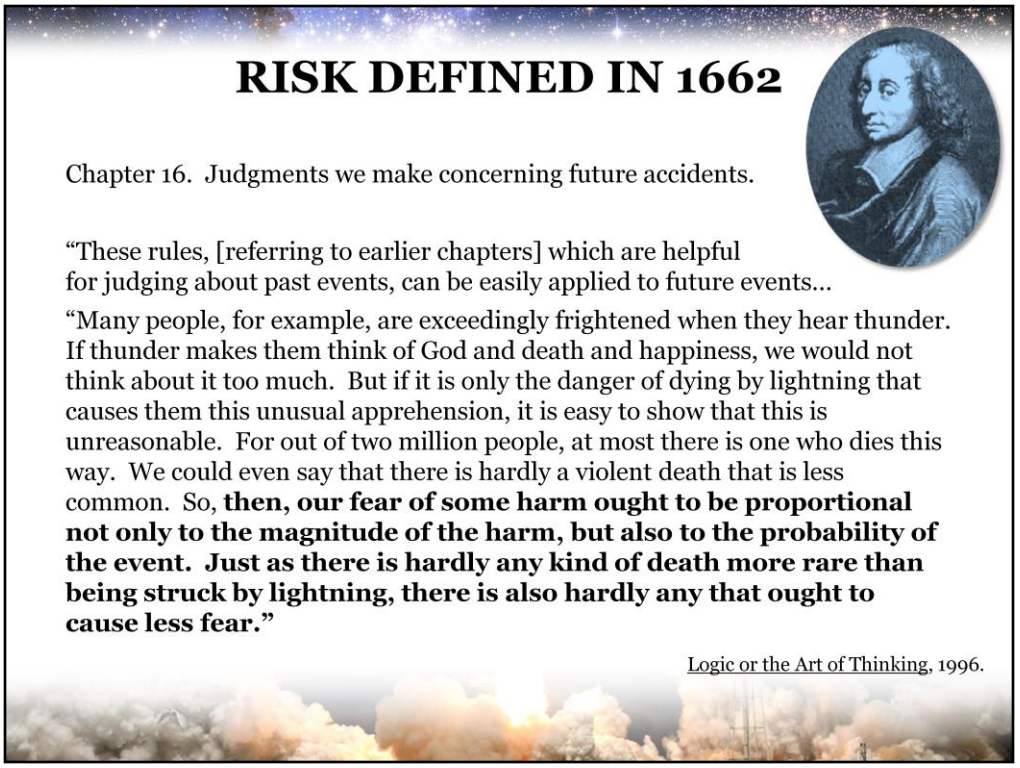
Logic or the Art of Thinking

"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

The most compelling publication was this book of a composite set Pascal's teachings originally written in Latin. Logical thinking is described as an art. Years ago, when I first found this reference and read these words, it stopped me cold to realize that so long ago mathematicians of the top order were postulating solutions that we use today.

Look at these 24 words and consider this, it is the earliest known mathematical definition of risk: Probability of event equates to likelihood; and magnitude of harm means consequences that are measured. What about the math, these two factors aren't added together they are multiplied in exactly the same manner that the laws of physics multiply contributions that are orthogonal in nature. Momentum = Mass x Velocity; Torque = Length of Moment Arm x Force; Risk = Likelihood x Consequence…. In teaching risk management classes, students often ask why the two independent factors are multiplied. They aren't squared, they aren't added, they are a product. I never have a good answer, and usually rely on something akin to, "well Pascal was one of the world's greatest mathematical minds and he said it was so." What Pascal thought or would have thought is therefore important.



Let's delve a bit deeper into this specific idea of risk to get more context. He wrote a short chapter on evaluating future risks. Take a moment to read his words. It is amazing to me that he somehow had access to knowledge of the frequency of death by lightening, at one in two million. In today's notation, that is 5x10-7. This accuracy is quite astonishing since the risk today, 450 years later, of lightening fatality in the US is 3x10-7.

You also see that he was not an advocate emotion-based fear, he writes: "this unusual apprehension is unreasonable." We as humans tend to have unusual apprehension for scary things like lightening, sharks, snakes, tornadoes, and fiery things falling out of the sky; these all cause unusual apprehension. Having studied the risk of things falling out of the sky for years, it is interesting to me that the worst of these in many years is falling coconuts, which at one time killed 22 people per year. We simply cannot generate "unusual apprehension" because of a coconut.

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 are 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:

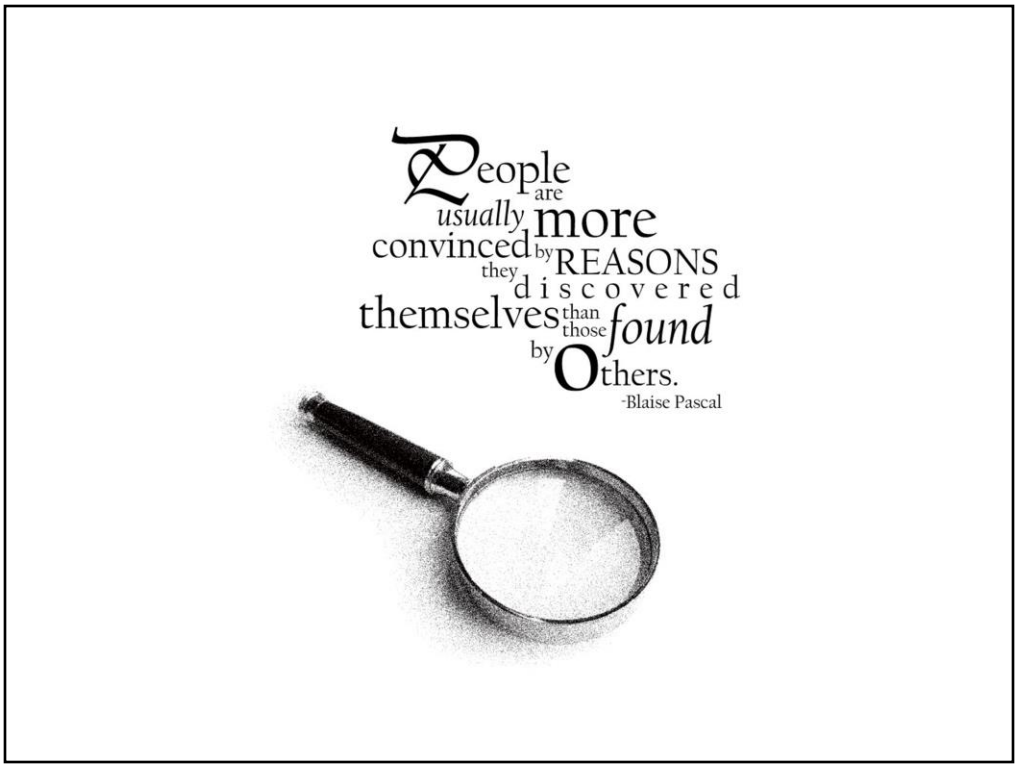
7. Treat things in their natural order beginning with the most general...
8. Divide each genus into species, each whole into part, and each difficulty into all its cases.

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

Logic or the Art of Thinking, 1996.

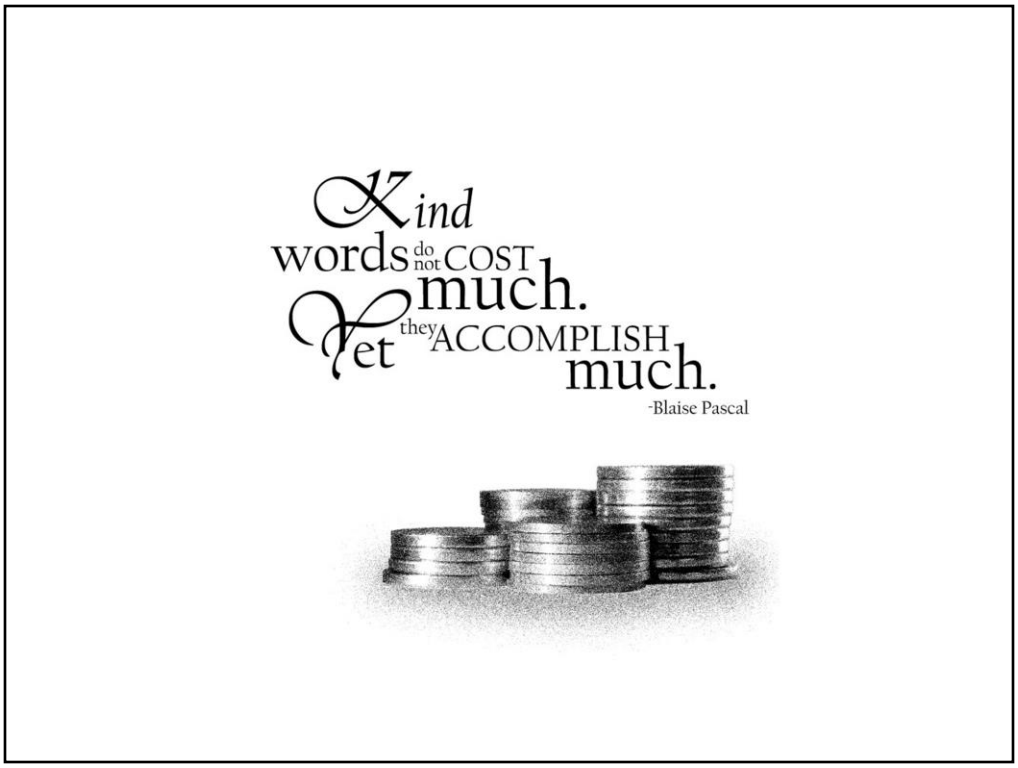
Pascal was also a major contributor to the scientific method in general, he advocated defining your terms clearly. He advocated tests of hypotheses. He advocated the use of dendritics to break a situation down into its component parts. These rules form the foundation for risk analysis, as well as many forms of scientific study.

Pascal was a man of many letters, and his letters became the foundation for much of what we know about him. Like Churchill, like Lincoln, he preferred short and concise language, and recognized that it took work to be concise.

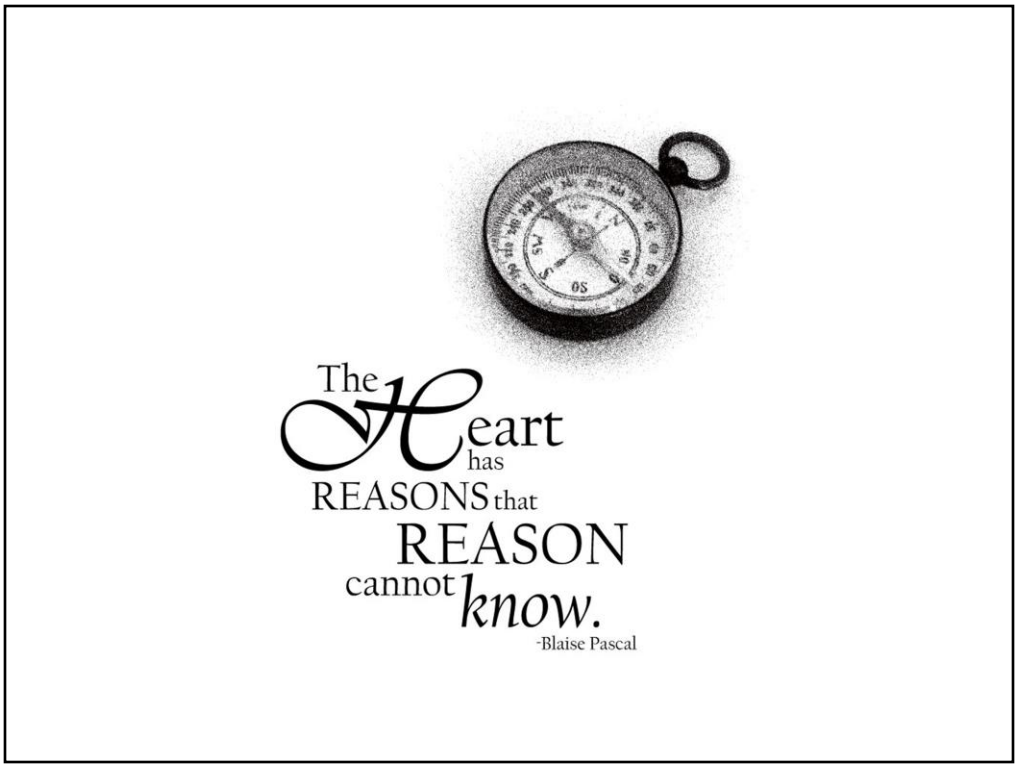


He understood human nature and became an advocate for helping people make their own discoveries, even if others had made the discovery previously.

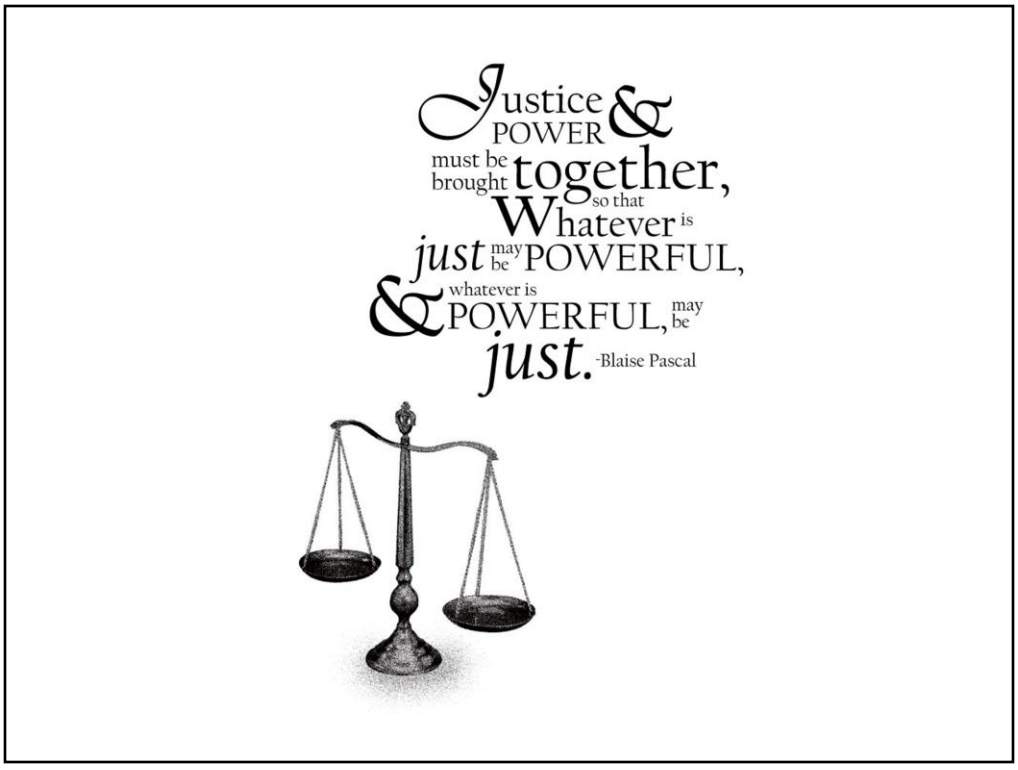
He was passionate about his beliefs, and encouraged others to so be.



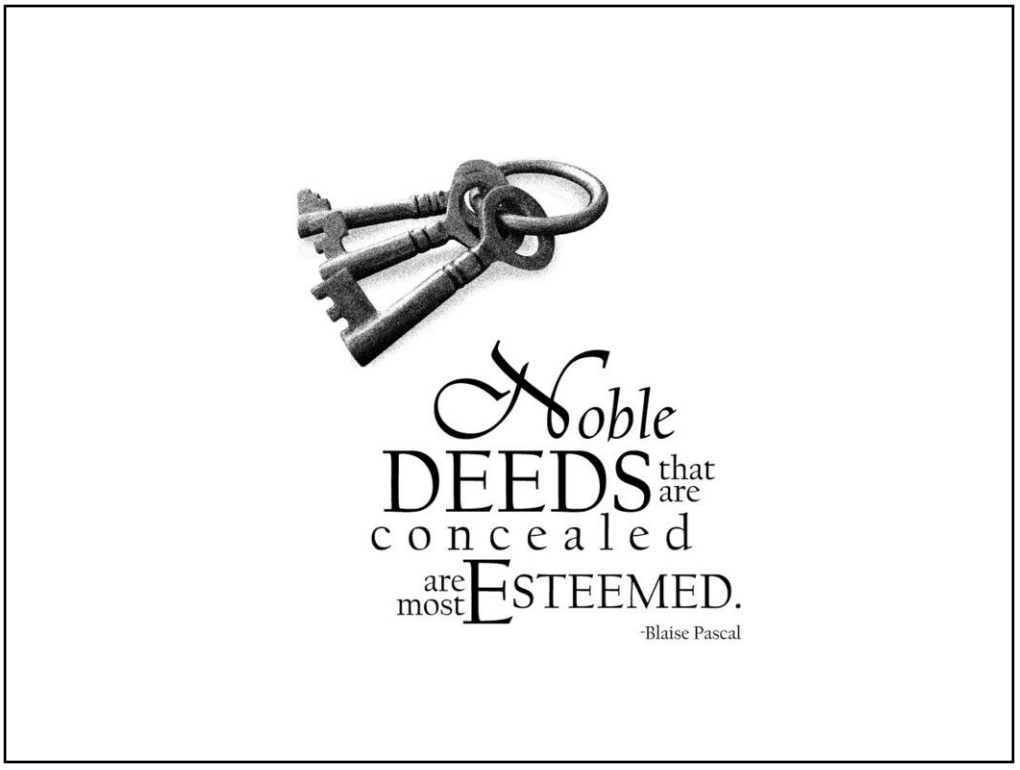
Kindness was a part of his belief system.



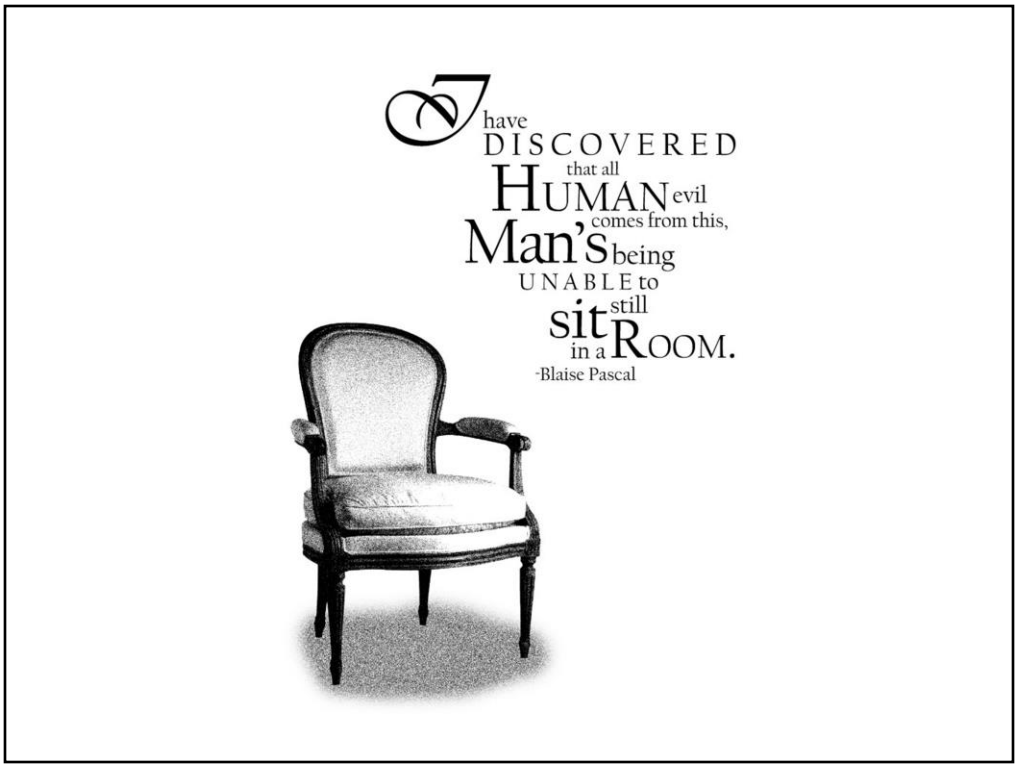
As was acknowledging issues of the heart.



He strongly advocated fairness, especially in those promulgating influence and power.

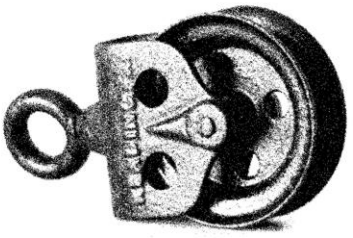


He believed in humility and good works. In general, Pascal became a role model for what we today call “seeking the moral high ground.”



Throughout his writing, there is a strong sense wit and of poking fun at himself…

So what would Pascal think?

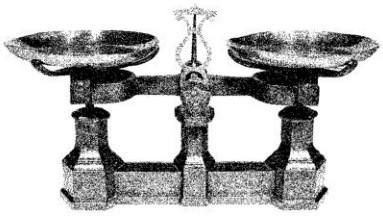


1. Do not *create* FEAR nor *elevate* unwarranted CONCERN.

I think Pascal would be quite proud that we are applying his concepts and precepts. Pascal is among the most rational thinkers in history. I feel certain he would council the leadership of this society to be wary of allowing the emotional aspects of space safety to dominate our thinking. He recognized that bad things can happen anywhere for multitudes of reasons.

So what would Pascal think?

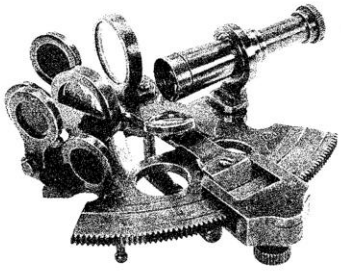
2. *Neither* OVERSTATE *or* understate your Best rational estimates *of* RISK.



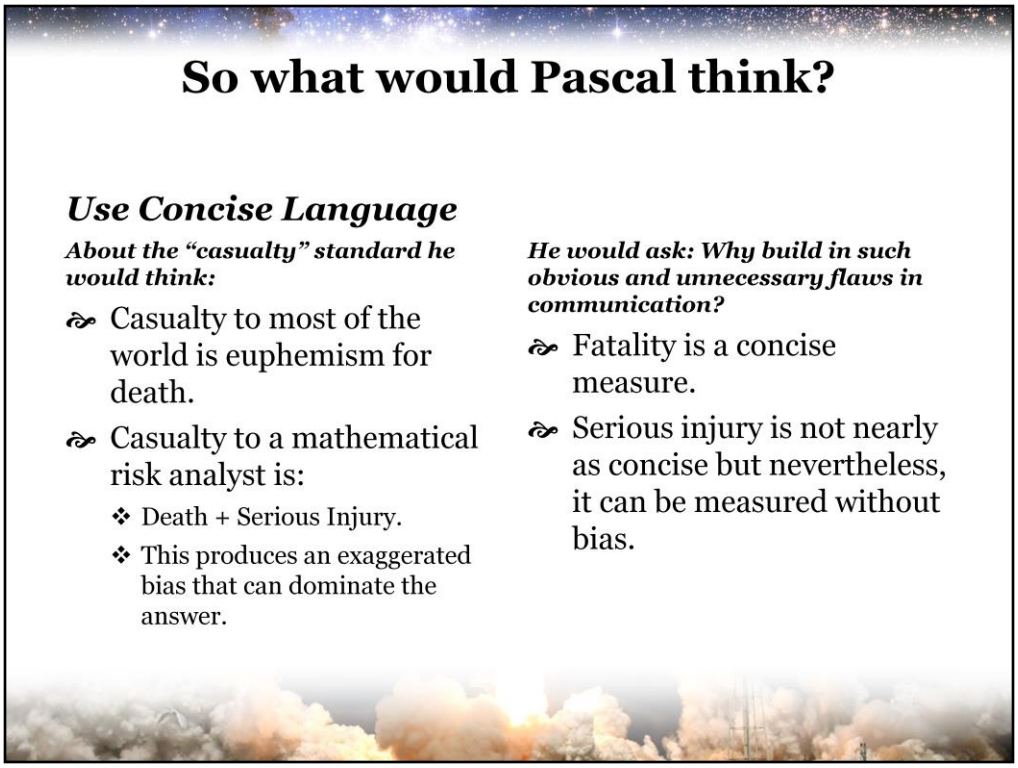
That same rationality would cause him to argue for avoiding bias in either direction. Focus on what we know, not what we fear.

So what would Pascal think?

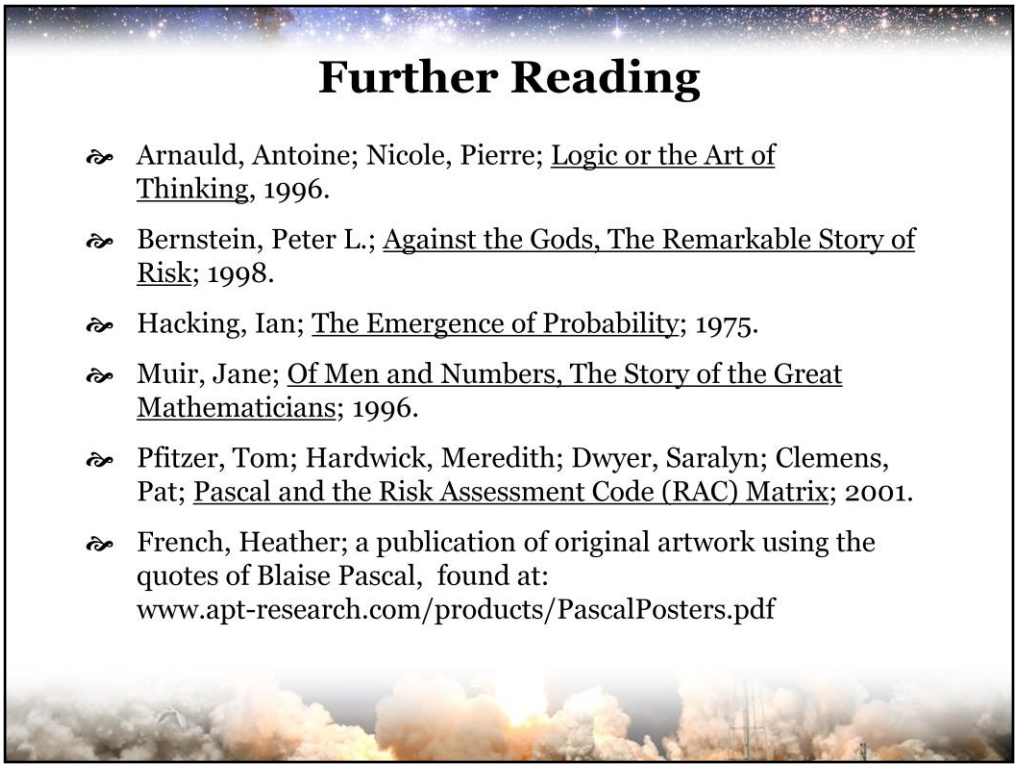
3. *When* ESTABLISHING *Metrics of* RISK:
be concise,
be *unbiased,*
be TRUTHFUL.



My final thought is about establishing standards or metrics, I am certain Pascal would have a strong opinion here. This society, which is moving toward becoming involved in more regulatory activities, can use his thoughts.



And I want to close with one example of where we have not followed Pascalian logic. There are others, but this one has jumped out at me for the last dozen years. The risk of activities in space is often characterized using a common metric associated with "casualties." This metric is used in a variety of risk-based standards, and frankly, I think Pascal would poke humor at it. He might say to its advocates, "you need to sit still in a room a bit longer." Why? First it is not concise; in fact, it is widely accepted as a euphemism meaning fatality to most of the world. To the risk analyst however, it is calculated by summing the expected fatalities with the expected major injuries. The resultant answers can be different by more than half an order of magnitude. It is overstating the understanding of risk, and well, it is not our truthful best assessment of risk. We, the space safety community, should adopt standards that are widely accepted in other safety communities associated with injuries and fatalities. Pascal would want us to do so.



So in closing I think it is always a good exercise to ask yourself, "what would Pascal think?" His thoughts are widely published and here are a few references you may care to read. I'd like to especially note the original artwork of Heather French which is available on the APT homepage. And of importance I would like to dedicate this talk to our colleague, Pat Clemens, who contributed substantially to this research and who passed away on May 11th. The top four references are publications of a historical nature.

Thanks to Tommaso, thanks to the IAASS, to Montreal, to our French colleagues and especially to Pascal who's ideas we use daily.