Reliability through the Ages

Enslaving Rather than Being Enslaved in Material Applications

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Abstract

With the advance of times, reliability and maintainability have an increasingly great impact on us. As a matter of fact, the concept of reliability originated from its application in military affairs. As early as before World War II the United States started to attach great importance to its research on reliability to meet the military requirements. In addition, reliability plays a pivotal role in NASA, the application of nuclear energy and in the operation of man-made satellites. Human civilization was, sometimes, derived from wars. The conclusion reached by a philosopher—"The civilization we enjoy today originated from quarrels and wars."—may court dispute, but so far as reliability is concerned, his remark is an undeniable truth.

Reliability is a way of evaluation. Judged by reliability no system is permanent in history. This article is devoted to the illustration of the close relationship between reliability and human beings from the perspectives of engineering history and human society, including urban architecture, aviation, auto manufacturing and insurance. Besides, the cure rate of diseases, survival rate after surgery, the warranty period of automobiles, the maintainability of aerospace and nuclear energy and value-preserving rate in insurance industry are all the manifestations of reliability. Of all the systems, human beings are the least reliable, to be followed in succession by traffic accidents and wars. The failures of microelectronic systems are fairly low. Compared with all the above-mentioned systems, the accident rate of aeroplanes and nuclear power plants is even lower. In this article some pertinent solutions to the various reliability-related problems are offered to help human beings to reach the state of "enslaving rather than being enslaved in material applications."

The Essence of Reliability

The role played by reliability and maintainability in traditional industry and modern technical products is such a broad subject that one article cannot cover it all. This article is intended to discuss reliability from a historical perspective and take a panoramic view of the relationship between our daily life and reliability in the past, at present and in the future.

Though the study of reliability started only after World War II, its findings have exerted great influence on us in the past decades. For example, the cure rate of diseases, the mortality rate of cancer, the effects of some medications on human health and the harm of the residual pesticide on farming produce done to our life through food chain are all related to reliability. As expected life is mentioned in healthcare, the reliability we are discussing is probability or statistical probability. Either probability or statistical probability is beyond the comprehension of ordinary folks. For example, a patient is told after carcinectomy that the survival rate is

90%. This is a vague expression. If the doctor tells the patient how long he or she can live, that's a concrete concept easy to comprehend. Expected life means how long one can live.

Expected life, which is closely related to probability, is in fact another indication of reliability. Expected life is relevant to warranty period in the manufacturing industry. In early days the American auto industry offered a one-year warranty to its customers. Later Chrysler changed the one-year warranty to a three-year warranty. TOYOTA extended its warranty period to five years. Then Chrysler provided a seven-year warranty. Recently some auto manufacturers started to offer a life-long warranty for certain main parts of the car. Did the auto manufacturers lose money for issuing such a long warranty? The answer is no. If they had been bankrupt, there would not have been any auto manufacturer now. All in all, the auto manufacturer was still the final beneficiary. By the end of the 20th century the manufacturers made profits by a thorough study of the quality reliability of their products, a careful analysis of the expected life of their products and the cost of the expected life. The improvement of reliability benefits both the manufacturers and the customers who use the products.

In addition, reliability covers an area of the design of risk analysis, the fault tree analysis of nuclear energy and the fault tolerant analysis of software. For example, the insurance industry is a continuation of reliability. The fundamental aim of the insurance industry is to earn the money from the insured party and they will not do unprofitable business. To attend college is much more complicated than before. Formerly a candidate only needed to fill in an application form. Nowadays the multiple-enrolment system makes the process so complicated that applicants and their parents can hardly comprehend it. The complexity of choosing one's ideal programs and specialized subjects poses some knotty problems. This belongs to the category of reliability, too. That's why education is also related to reliability.

Politicians often make irresponsible promises or put up empty slogans. We may as well listen to the figures listed by politicians, but we are not supposed to believe them because of great uncertainty about these figures. Why do people think the remarks made by politicians are unreliable? Why do the politicians elected by the majority utter so many high-sounding words? Why are there so many people who still believe their slogans?

Reliability Bottleneck and Historical and Societal Track

The above-mentioned general survey and essence of reliability can be summed up in Table 1 below. What is reliability? Take a story about Confucius for example. Confucius had 3,000 disciples. Of them only 72 were top students who are as qualified as today's academicians of various academies. Of the 72 disciples, Yan Hui was the most outstanding one. Confucius said, "For three months at a time Hui does not lapse from benevolence in his heart." Such a talented student could only be free from lapsing for three months. One month consists of 30 days and three months consist of 90 days. Calculated by days, his accident rate is about 1%. What about the others? There are changes every day and even every hour. The comment made by Confucius about Yan Hui can be considered as a good example of the best performance of a human being's reliability.

Table 1, Synonyms of Reliability in Different Industries

	Synonyms of Reliability
Agriculture, Medicine	Cure (Survival) Rate
Healthcare	Expected Life
Manufacturing	Warranty Period
Aerospace, Nuclear Energy	Maintainability, Half-life
Insurance	Value-preserving Rate
Education	Enrolment (Graduation) Rate
Politics, Economy	Policy Stability

Reliability involves quite a lot of factors, of which the human being is a very critical bottleneck. As we know, Yan Hui's reliability is the upper bound — the maximum of human performance. There are a lot of subsystems under the main system and even more unreliable factors. Why do we hold the opinion that reliability is worth studying from the historical perspective and is one of the priority subjects for the future development of science and technology? Take Li Bai's famous poem *A Trip to Kiang-ling* for example. His last line "The skiff slid myriad mount ranges away" enjoys great popularity. Li Bai was a native of Sichuan province and described the Three Gorges of the Yangtze River in some of his poems collected in *Three Hundred Poems of the Tang Dynasty*. In *A Trip to Kiang-ling* he described the Qutang Gorge—one of the Three Gorges, which is close by to Fengjie. I'd like to tell you the story about White King.

By the end of Western Han Dynasty, Wang Mang usurped the throne. Wang Mang was a scholar and made great contributions to his country. He usurped the throne for the sole purpose of governing Western Han Dynasty with Confucian doctrines. He advocated a lot of good administrative policies, but failed to carry them out due to his poor execution and considerable resistance. Gongsun Shu, a high-ranking general under his command, crowned himself king on the slope of a hill in Fengjie. He was known as White King. After Wang Mang's downfall White King was the only successful ruler. Even though Gongsun Shu was defeated by Liu Xiu not long after that, the local people built the White King Temple to show their gratitude to him. And the hill was thereafter called the White King Hill. According to the Chinese fengshui theory the White King Temple, sitting against a hill with water on three sides, is located in the most favorable surroundings. As a result, many collections of stone tablets were established in the White King Temple and the statues of Guan Yunchang and Liu

Bei were placed there. The White King Temple became a tourist attraction. The local people in Fengjie thought the White King Temple would last forever. According reliability theory, nothing will last forever. As a matter of fact, after the Three Gorges Dam was built, the White King Temple area was inundated and became an island. Only the temple stands above the water. No one can ensure the eternity of such a fabulous and famous historic site. Isn't this a phenomenon of reliability's influence on a city? This phenomenon shows that reliability does not equal quality.

The most noticeable difference between reliability and quality lies in: reliability is a time function whereas quality is more static. As a time function, there is no constant phenomenon. Take the well-known cliff-side paths of Sichuan for example. The paths are 65 kilometers long. Whenever the Yangtze River was stricken by flood, navigation became impossible. That's why people dug out cliff-side paths during the past 1,500 years. The distinctive cliff-side paths, which were used to facilitate the transportation during the Anti-Japanese War, have a historical significance. They are submerged due to the building of the Three Gorges Dam. Nobody had ever predicted this before. Even the challenging cliff-side paths are not independent of the control of time factors.

While we allow some historic sites submerged, people are unearthing some other historic sites such as the terra cotta warriors and horses of Qin Dynasty. Even the First Emperor of Qin Dynasty would never expect that his mausoleum would be unearthed. If we look at the world from this perspective, the Three Gorges and the cliff-side paths of Sichuan may re-emerge in 2,000 years. The terra cotta warriors and horses of Qin Dynasty may be buried underneath again. There's nothing permanent or everlasting in the world. That's the most fundamental principle of reliability.

Let's discuss Liu Yuxi's famous poem *The Black-dressed Lane*. This poem demonstrates the intangible impact of reliability on the change of a city. During the period of the Three Kingdoms, the Kingdom of Shu was first defeated by Wu. Wu was situated in the present-day south of the Yangtze River. One year after Wu defeated Shu, Wu was defeated by Wei, hence the end of the period of the Three Kingdoms. After Wu's downfall Sima Yan usurped the throne of Wei and crowned himself Wu Emperor of Western Jin Dynasty. He made Luoyang the capital. After he founded Western Jin Dynasty Sima Yan was ambitious to earn popular support. Misguided by many scholar-officials and hindered by internal turmoil created by eight princes, he failed to invigorate his country. Instead, the national power was declining. Not long after the northern tribes moved southward. After a period of turmoil brought about by the five tribes Western Jin Dynasty was eliminated. That's why Western Jin Dynasty is considered a defeated kingdom. Content to exercise control over part of the country, its successors moved the capital to Jiankang (i.e., Nanjing today) and founded Eastern Jin Dynasty. Are these historical facts pertinent to the poem *The Black-dressed Lane*? During that period of time Nanjing was controlled by the two influential families of Wang Dao and Xie An. It was picturesque near the Red Bird Bridge. Beautiful flowers, combined with a constant stream of horses and carriages, make the Black-dressed Lane a prosperous and flourishing

place.

When Liu Yuxi visited the Red Bird Bridge 500 years later, the prosperous Black-dressed Lane was nowhere to be found. That's why he wrote the following poem: "The wild flowers spread near the Red-Bird-Bridge side/The setting sun was passing the Black-dressed Lane by/Swallows once nestled in the high official chamber/Now flying into the plain house of the commoner." (Tr. Manfield Zhu with adaptation) That means the expected life of a city is only 500 years. Everything has a lifespan. A politician in power may boast a life of splendor, but his glorious days will be numbered. Judging the world from this perspective, few big cities can remain prosperous for over 500 years. Liu Yuxi can be regarded as a person of foresight because he was able to predict that the best lifespan for a city was 500 years.

Reliability and Public Construction

Take the Hyatt Regency Hotel in Kansas City for example. This five-star hotel collapsed suddenly 25 years ago. That means something must have gone wrong with the building design. It is important that the reliability of a public construction could be ensured only after a series of simulated tests.

Reliability is of primary importance in the construction of a power plant. A short-out accident occurred in a well-known power plant one night in 2003, which caused a blackout in the border area between Ohio and Michigan. The power failure produced a huge impact to society. We can reach the conclusion that reliability is essential to power transmission and nuclear power plants. If we experience a sudden blackout, all of us will be thrown into panic and feel at a loss in the streets. Can our society cope with such a chaotic situation? Do you think people would rush to the streets in good order? I cited these examples to show that reliability has great impact on our life.

The airplane is a fairly reliable means of transport, but still there are a lot of airplane incidents. An airplane incident often causes heavy casualties. The door of an African airplane suddenly opened itself in mid-air and 21 passengers were sucked out of the cabin. Someone in Nigeria took a photo of the incident. These simple examples demonstrate that reliability has great impact on our life. Reliability is a time function. Its effect will be felt in due course sooner or later.

It's very important to study reliability of a life-cycle. For example, how do we define the lifespan of something? When shall we make a simple and correct estimate of the life-cycle cost based on the lifespan? The space research in the United States is undoubtedly first-class in the world, but still several incidents happened to American spacecrafts, often caused by minor problems, resulting in huge losses. Every time a spacecraft incident occurred, people would sigh helplessly, "It's too late!" Many corporations and enterprises ignored the study of reliability. Only after incidents happened did they take some remedial measures in a hurry. If they had taken preventive measures, they could have reduced their expenditure. All the above-mentioned examples indicate that reliability will inflict great impact on our cities,

bridges, historic sites and on water and soil preservation.

Let's talk about a dam. It started with a small crack in the dam, which grew bigger gradually under the pressure of rushing water. Finally the water flooded the whole city. You may want to know how long it takes for a crack to expand and the leaking water finally to breach the dam. The whole process took only six hours before the city was engulfed. Just as an old Chinese saying goes, "one ant-hole may cause the collapse of a thousand-li dyke". That's why a course in reliability is often offered and the related research is conducted in the departments of hydraulics and civil engineering.

Several big accidents happened in nuclear power plants. One occurred in the American Three Mile Island. Thanks to the well-conceived design of the American nuclear power plant, no serious damage was done. The one that occurred in Chernobyl Nuclear Power Plant of the Soviet Union was the most devastating. It's interesting to learn that the accidents of the nuclear power plants in the Soviet Union and America all took place at night. Let's bear in mind what Confucius said —"human beings are the most unreliable". If we can improve the human factor, if our politicians talk less about figures, if the reliability of human beings improves by 1% or 1.5%, it will be ten million times more efficient to improve the well-being of mankind than investing in high technology.

High Technology and Reliability

Fifty years ago the integrated circuit was composed of four electronic transistors only. People tended to ask its inventor, "Will the integrated circuit products break down?" The inventor answered, "They will not break down. They will work for ever and ever." How will it be possible? The greatest challenge that electronic products will meet today is not how to make 8-inch or 12-inch wafers, but how to deal with reliability. In the present-day electronic factories reliability is considered their top secret. I once took my students to a modern manufacturer, to visit their reliability-related facilities. But our request was turned down because one of my students used to work at Samsung and they did not want him to have access to their top secret. Why are the reliability-related documents rated as the top secret of electronic products? Firstly, the acceptance rate of the anno electronic products is very low. Secondly, they don't want to reveal the fact that they are turning out unreliable products. That's why no magazines have published the acceptance rate of transistors produced in factories. Not once! The reason is that they don't want other people to know that the acceptance rate of their electronic products is actually very low.

As for today's nanotechnology, its initial reliability was similar to that of human beings, i.e., less than 10%. If somebody provides data about reliability or makes some proposals to improve its reliability, nanotechnology will certainly have a bright future. Some people suggest that the lifespan of human beings is long while that of nanotechnology is short. A new product will appear before the lifespan of the previous product is completed. Doesn't this mean that reliability is not so important? On the contrary, as the lifespan of a product is short, demand for higher reliability must be satisfied. Simply because we have to use a new product

even before we fully understand the reliability of a previous product, we must not only control and manage the reliability of a new product, but also design its reliability. In respect of its design, reliability covers a wide range. I mentioned ordinary life and early life. Let's look at aging. Take the graying of hair, for example. The location where every one's hair turns gray is a random distribution. Even twins' hair may turn gray at different areas of their head.

Stress and Strength

A recent research in America cited one of the ten biggest challenges in science as: How long can a human being live? The answer is: human beings' life expectancy will be 120 years by the year of 2050. This is a random phenomenon for our reference only. So far as height and life expectancy are concerned, the younger generation has surpassed the older generation. This phenomenon reminds me of the relationship between stress and strength. As shown in Table 1, stress and strength are mechanical functions. What strength can we adopt to resist outside stress? If stress exceeds strength, we will collapse. For example, nowadays girls like tall handsome boys. That's why the present-day younger generation is taller than before. A young man with a height of 173 cm used to stand at the seventh or eighth position in a line of soldiers in Taiwan 30 years ago. Today 173 cm is only the men's average height in Taiwan. That means men with a height of 173 cm in Taiwan, which belonged to the top 25% 30 years ago, are now in the first 50%. Does it mean that the taller a person is the better? That's not necessarily the case. Tall men also have their disadvantages. For example, they will bring about more environmental pollution and have an unfavorable effect on materials around them.

When taking a flight, a tall man will feel uncomfortable because he can't stretch his legs. With the increase of one's height, he will gain weight. According to a rough calculation, when human beings' average weight increases from 150 lb to 200 lb, an airplane with a seating capacity of 45 can only take 41 passengers to ensure flight safety. If the average weight reaches 250 lb, the plane can only take 36 passengers. Once there is stress, there will be proper strength to resist it. These two factors are relative. If we take time function into consideration, their relationship will become more complicated. The greater the disparity between strength and stress, the higher the reliability will be. The parts which do not overlap will never be zero, because these two functions are both continuous functions of time.

I mentioned before that reliability is a time function and, on the other hand, it is also the result of contention between strength and stress. When stress exceeds strength, accidents tend to occur. When stress is far inferior to strength, accidents will be less probable.

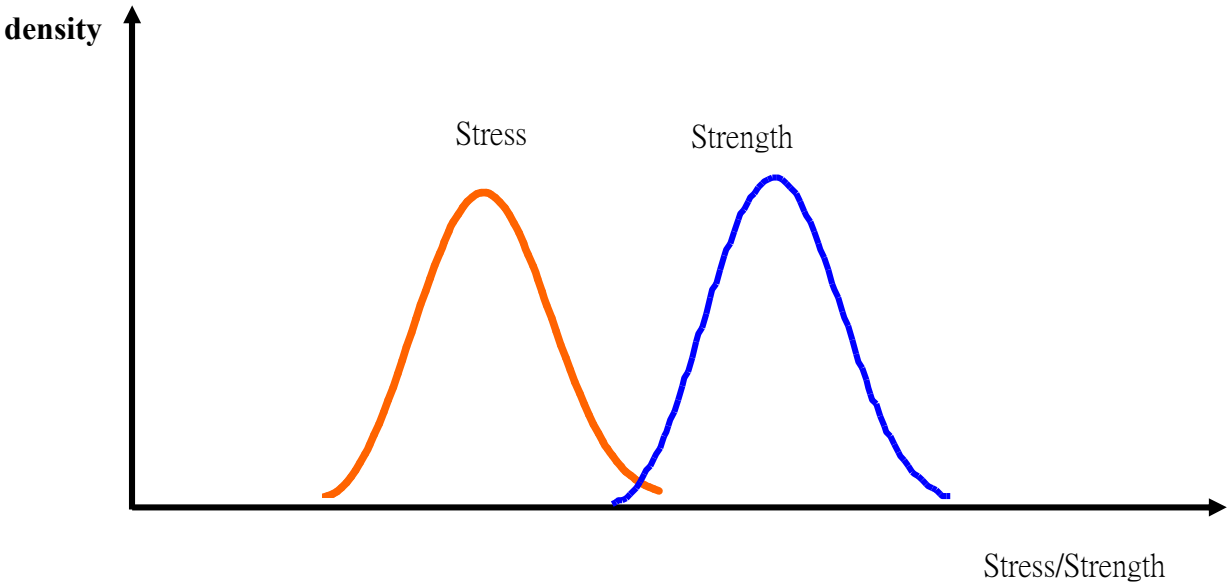

Figure 1: Stress and Strength

Infant Mortality

The "infant mortality" of reliability plays a very interesting and important role in today's society. People tend to change their computers and cell phones every two years. That's an issue related to infant mortality. Infant mortality originally means within 72 hours after its birth. As for an electronic product, it means within one year after its use. A great challenge facing us is how to reduce the probability of infant mortality before the product is delivered to the customer. The reliability-related problem of software mainly occurs during the period of infant mortality. The manufacturers offer a warranty period for their products so as to ensure that they will provide free maintenance and replacement if the products break down during their lifespan. Have you heard about a warranty issued for software? Who can guarantee that their software will never break down? I haven't seen such a warranty. On the contrary, I only saw a notice on the package of some software: "The durability of this software is not guaranteed." As the period of infant mortality of software is especially long, the study of its infant mortality is highly important.

When SARS was rampant two years ago, newspapers said at the beginning that "the mortality rate of SARS is very low". Take the following figures as an example: 100 patients still hospitalized, 21 discharged and 4 dead. Mortality rate can be calculated in various ways. The first way is: 4/(100+21+4) = 3.2%. The initial report about its mortality rate was carried in the newspaper. This was based on the hypothesis that none of 100 hospitalized patients would die. That was actually the lower bound of the mortality rate of SARS. Anybody who has some knowledge of biostatistics knows that it was only a rough calculation. The next day another improved calculation was published in the newspaper, i.e., 4/(21+4) = 16%. This way

of calculation excluded the hospitalized patients as if they were not patients at all. That ought to be the upper bound of the mortality rate of SARS. This was not a correct calculation, either. The correct answer should be between the lower and the upper bounds (See Table 2).

Table 2: Calculation of the Mortality Rate of SARS

Calculation	Mortality Rate（Supposed 100 hospitalized, 21 discharged and 4 dead）
I	$4/(100+21+4)=3.2\%$
II	$4/(21+4)=16\%$
III	$3.2\% < ? < 16\%$

How to calculate the mortality rate of SARS remains a complicated problem. Many doctoral dissertations have been devoted to this subject. Thus we are faced with another problem: “Should we serve reliability or should reliability serve us?” Professors and students in colleges often publish theses. Do we write theses for fun? Do we wish to serve society with the results of our research published in our theses? There is another way of evaluating the mortality rate of SARS, introduced by an article published in the newspaper. This article divided people into three age groups: below 24, between 25 and 60 and above 61. There were 55, 205 and 40 deaths respectively in the three age groups. The data was collected during a certain period after the dissemination of SARS. The newspaper reached the conclusion: “people between the age of 25 and 60 are likely to die”. A few days later this conclusion was corrected, because in Taiwan’s population structure, the ratio of these three age groups is 2.5:6:1.5. The age group between 25 and 60 is the largest. When you calculate mortality rate, you have to take the addition of population ratio into consideration. So far as population mobility is concerned, the young people are the most active. The mobility ratio of three age groups is 3:5:2, and the second age group surpasses the other two age groups. But the alertness of this age group is the lowest. Without the addition of other factors the mortality rate of the second age group is the highest. However, when we take addition into consideration, the mortality rate of the old people is the highest while that of the young people is the lowest. If we don’t take all the related factors into consideration, I believe the mortality rate of SARS among the mental patients is even lower. Because they have fewer visitors and have least access to the outside world, they are not likely to contract SARS. This conclusion is of course absurd. In the field of biostatistics the survivability is reliability.

Let’s take the spacecraft for example. The analysis of the safety of flight vehicles has shown that the flight vehicles, whether aircraft or spacecraft, are the most unsafe when taking off or landing. The space administration is unable to ensure the safe launch of a spacecraft. As a matter of fact the space center is unable to ensure the safety of any mission of space flight. As a result, reliability is not only important, but also incomprehensible and uncertain. We must exercise extreme caution in this respect.

Nuclear Energy Industry

From the economical perspective, nuclear energy and coal are regarded as the most cost-effective energy resources. Their average generating cost is 2.2 US cents/kwh, only half of the average generating cost of oil and natural gas. A nuclear power plant is one of the safest workplaces with less than one accident per two million work-hours. Its accident rate is lower than that of the finance, insurance or real estate industries and far lower than the manufacturing industry (whose average accident is 45 per two million work-hours). As the nuclear energy produces less CO_2 and other harmful materials than other energy resources, its additional value is much higher than other energy resources (See Table 3).

Table 3: The Highest Environmental Value of Different Energy Resources

	NO_X	SO_X	Ng	CO_2	Total Value	Present Value
	(US$/kw/year)				(US$/kw)	
Nuclear Energy	11.6	5.3	12.0	61.2	90.0	750.1
Wind Energy	2.2	0.7	1.6	17.1	21.6	180.1
Solar Energy	1.5	0.3	0.8	13.7	16.2	135.3
Bioenergy	-4.3	3.7	8.5	51.5	59.4	495.1

Source：Electric Power Research Institute, 2003

Finally, as is shown in Table 4, from the perspective of life and health, only 0.4 day will be taken off one's expected life even if he/she resides near a nuclear power plant all his/her life, much lower than the average 435 days taken off one's expected life by other accidents. No matter from which perspective, if you make a careful evaluation of reliability, the nuclear energy is undoubtedly the most economical, space-saving and cost-effective energy resource in our life. We should attach importance to the nuclear energy.

Table 4: Days Taken Off Expected Life by Outside Factors

Outside Factor	Days Taken Off Expected Life
Being male	2800
A packet of cigarettes daily	1600
Living in poverty	700
All kinds of accidents	435
Occupational accidents	74
A cup of sugar-free drink daily	2
Civil aviation accidents	1
Residing near an N-power plant all one's life	0.4

Electricity in US entirely N-powered	0.03

Source：B.L. Cohen, *Before It's Too Late*

In mid 1990, a heated discussion was held in s beautiful town over the plan to increase nuclear reactors so as to promote the construction there. However, people of the town all rose against the plan. It was interesting to learn that they were not against the aftereffects of the nuclear energy industry, but against the man-made pollutions brought about by the popularization of nuclear energy. Why are there so many anti-nuclear activists? Nucleon is a very sensitive noun. When MRI (Magnetic Resonance Imaging) was invented, some people were wise enough not to adopt the term "Nuclear Resonance Instrument". Otherwise this modern medical instrument, which has benefited a lot of people, would inevitably be doomed.

Conclusion

In the above-mentioned discussion, I mentioned that Yan Hui was the most outstanding scholar who made the least mistakes in the world. He is much more reliable than other human beings. Roughly speaking, the probability of causing an accident in driving is 1/10,000. Its reliability is much higher than Yan Hui and all the other human beings. In the War of Iraq, the mortality rate of the American soldiers is 1/10,000. The total mortality rate in all the battles in the 20th century is about 1/1,000,000. The drinking incident happened some 15 years ago when a syringe needle was found in a coke can. The headquarters of the company held a press conference that day and announced that the probability of finding a foreign matter in a can was 1/1,000,000. Even as low as this, it was a serious mistake and caused a great uproar in the country. How could a syringe needle appear in a can? The accident rate of the computer system and software is one out of ten million. The accident rate of nuclear facilities is one out of a trillion. It is known to all that of all the daily operative systems, the most unsafe factor is the human beings. They will profoundly affect the whole society. Some people are against the nuclear energy, but nuclear energy will not likely cause accidents. If a nuclear energy facility is well maintained, its accident rate is the lowest compared with other daily-life-related factors. Human beings make mistakes every day. Why don't we have an in-depth review of this phenomenon? If we improve ourselves and act 1/10 as well as Yan Hui, all the systems will be much safer. In a very big system we must find out where its bottleneck is and conduct radical reforms there.

Of all the systems, the human being is the most unreliable factor. The human being is the biggest bottleneck in enhancing our living quality. With the improvement of the human factor, much better results will be yielded.

I'd like to quote Confucius' remark as my conclusion. Confucius said, "A benevolent person will live a long life and a wise person will live a happy life." Doesn't a long life mean happiness? The reliability of a rocket hitting the target may be only 50%. Even if it hits an enemy warship, it will not necessarily sink the warship. In other words, reliability has two implications. The first implication is whether a life can be prolonged. That's what this article

is about. The other implication is what efficacy a prolonged life will have. In the quotation "a benevolent person will live a long life", a long life means reliability. In the quotation "a wise person will live a happy life", a happy life means efficacy or the happiness we enjoy. I hope our society will emphasize the role of reliability in the evaluation of our life. The twofold purpose of the study of reliability is to prolong the lifespan on the one hand and to improve its efficacy on the other. We must create a healthy and comfortable environment for the welfare of the populace. Don't let fruitless arguments threaten our well-being as well as our lofty aim. Our ancient saint's teaching — "enslaving rather than being enslaved in material applications" – refers to the acme of reliability.

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