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How to Communicate Results of Risk Analysis

A young engineer fresh out of university, was hired by a large oil company. One of his first tasks was to perform an economic evaluation of an oil reserve. With his classes in probability theory and statistics still fresh in his mind, he performed the full range of decision analysis calculations that included a full sensitivity analysis, a Monte Carlo simulation, several decision trees, and other methods. So after weeks of intense work, the young engineer reported his results to his manager. Wanting to impress on his first major assignment, he created a magnificent computer presentation with dozens of slides full of frequency histograms, cumulative probability charts, and other very scientific looking pictures. After the presentation, the manager was silent for a minute and then asked: "This is very nice. But what should we do? Should we drill or not drill?" (A similar situation happened in the First World War, a military commander, had just received the "new" tanks, which he had never seen before. After three day of training, he had only one question, "How do we harness a horse to this thing?").

At this point engineer answered: "Based on my probabilistic assessment and given the uncertainties in cost, production, and prices, there is a 67% chance that NPV will be less then $2 M". If a politician used a similar sentence during a budget debate, it probably might convince the audience of his high intelligence. From the manager's perspective the main question, to drill or not to drill, had not been answered. The engineer had just wasted his time. The feedback the young engineer received after the presentation was to focus on old proven deterministic techniques and not to bother with any useless initiatives that produced probabilistic fluff.

This situation, where the decision-maker and the decision analyst are different individuals, happens frequently. Here are two common scenarios:

1. You are a project manager and hire a consultant or ask a member of your project team to perform an analysis. You need to make a decision based on the analyst's report.
2. Opposite situation. You are analyst or consultant and want to communicate results of the analysis to the project manager.

Decision analysis reporting has a number of specific issues that differentiate it to regular business communications. Here are the two most important issues:

1. People usually have difficulties making judgments when uncertainties, risks, and probabilities are involved.
2. In many cases, decision analysis methods and tools are very complex. Many project managers are unfamiliar with decision analysis theory and practice and they have difficulties interpreting the results of quantitative analysis.

In addition, project managers and analysts may have different motivational and cognitive biases that they bring to these discussions. In the next section, we will provide a few tips on how to best communicate the results of project decision analysis, which should help to reduce the opportunity for a biased decision.

Motivational Biases in Reporting Results of Analysis

A senior engineer of a construction company suggested a new design for a large underground structure that was part of the project he was involved with. According to his estimates, the new design would require less materials, be quicker to construct, and would reduce vibrations of the nearby buildings during construction. A technical committee was supposed to review the two designs: the original and one proposed by the senior engineer. The committee requested a comprehensive analysis of both alternatives. The engineer wanted his design to be approved, so he furiously lobbied his case:

1. *He talked separately with most of the members of the committee before the meeting to explain the benefits of his solution.*

2. *He had his subordinates perform the technical analysis of two solutions, particularly, the calculation of amount of materials and construction duration. He recommended reducing probability of events that could cause a delay in the new design and increase the probability of the delays in original design.*

3. *He managed to invite people who were particularly concerned about vibration of nearby buildings to the approval meeting. Experts in vibration gave vivid (remember our discussion about availability heuristic) descriptions of what could occur if the issue was ignored. This ensured that this issue was viewed as critical by the committee.*

> It is very hard to mitigate effect of motivational factors when you interpreting an analytical report. The solution is to establish the decision analysis process in the organization, which would reduce influence of motivations factors on the decisions.

This can be a very successful plan for anybody looking to get their project, plan or other agenda approved, but it is not a good decision analysis process. You can probably guess which design was approved by the committee, but was it the right choice? The answer is: nobody knows. The committee was presented a report that had been affectively *"gamed" by the engineer to achieve his purposes. It is quite possible that the engineer's design was better, but as a result of engineer's lobbying activities, the committee members became biased against the original design, and could not properly review the risks and uncertainties in the projects.*

Both analysts and decision-makers may have **motivational biases**. In other words, they may have a personal stake in the results of this analysis. Remember, analyst are supposed to be neutral, otherwise they become just another lobbyist.

So in our example, the construction company had a decision analysis process, but it failed in this instance It didn't fail because it selected the wrong alternative, it failed because the selection was biased due to the efforts of the engineer. More disturbing is that all the committee members knew that engineer had a personal stake in new design and that the analysis was performed by his subordinates.

These things happen very often. In many cases, the decision-maker may favor the alternative even before analytical report is presented. And even worse, the decision-maker can be an administrative boss, who has power to override or hide the analyst's findings.

So, are there any methods to reduce or mitigate the effects of these motivations and biases? Unfortunately, by the time you get to the reporting stage, it is much more difficult, but here are some suggestions.

- If you are a decision-maker, you must try to clearly understand all of the potential motivational biases involved in the preparation of this report. In business, it is frequently impractical to request another report or remove someone who may be unduly influencing the decision-making process. However, you can request clarifications, additional analysis, and other information. If possible, invite outside moderators and experts to review or audit the report. Remember, defining probabilities is fraught with opportunities for error, so perform reality checks for all probabilities defined in the report;
- If you are an analyst, even you have not been improperly influenced by somebody, for various reasons, you may have your own biases regarding this project. Try to make sure that your personal preferences are not reflected in the report and ensure that you include a section describing the methods used for assessing the project's uncertainties and probabilities you identified.

This commonsense advice is easy to offer, but difficult to put into action. A lot depends on the **corporate culture** and especially your ability to voice opinions and openly challenge superiors. However, if the organization has an established a decision analysis process, motivational biases should play a much smaller role in the decision-making.

Put it into perspective

The weather forecast for tomorrow calls for a 30% chance of rain. Does this mean clear skies ahead and you can leave the umbrella at home or should you carry it just in case? A similar situation exists in project management. You receive a report that forecasts an 86% chance that your project's cost will be below $100,000. What does this mean? Should you budget for $100,000, or more, or less? Is this good news or bad news? If the report has simply said that the cost of the project is $115,000, this is absolutely clear (whether this is accurate is another question). But if the results are expressed as probabilities, ranges, or distributions, they are much more difficult to interpret.

Let us go back to the umbrella, how are going to determine your course of action? You try to remember what happened last time the forecast called for a 30% chance of rain, did it pour or was it just a small shower? If it was just a shower, the umbrella won't be needed. However, if you are risk-averse, you may take umbrella and wear a rain jacket just in case. Obviously, for different people, chance or probability has different implications depending upon their subjective experiences.

To overcome our subjective reaction to probabilistic forecasts, we recommend providing clear comparisons between the alternatives, potentially using historical data to strengthen your presentation. If you have two alternatives, one that generates $115,000 in revenue and a second that generates $150,000 in revenue, but is significantly more risky, what is the best method to show this?

Here are a few methods for **visualizing the results of decision analysis**. One of the methods to report probabilistic information so that it is meaningful is to present statistical distributions associated with different projects on the same chart, as shown on Figure 1. You can clearly see that Alternative A revenue is lower (mean is only $115,000), but risk is also lower compared with Alternative B. The distribution for Alternative B is much wider than for Alternative A. Looking at this report, decision-maker can easily compare the risk profiles of both projects.

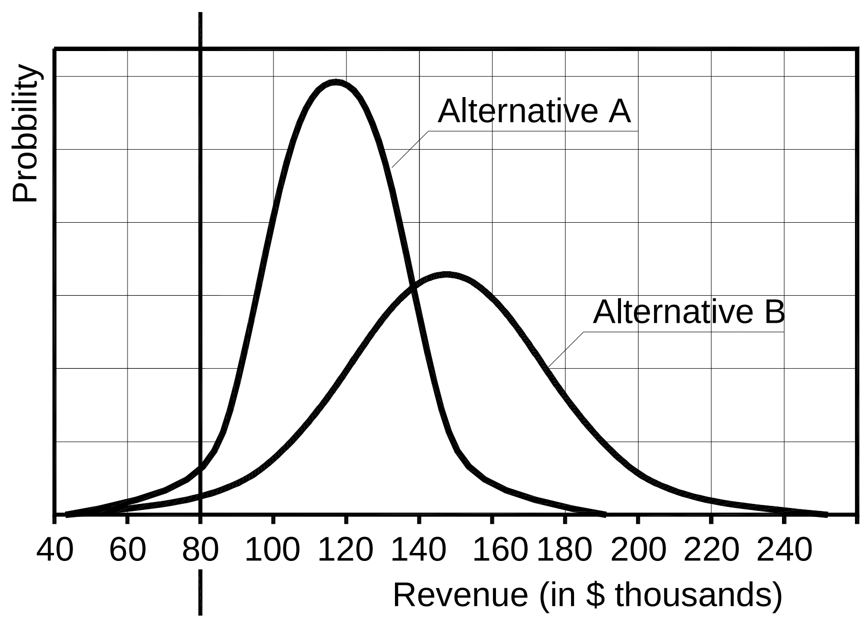

Figure 1. Comparison of two project alternatives

The same chart is useful if you want to visualize the chance that revenue (cost, duration, or other parameters) will be less or greater than a certain value. For example, draw vertical line at $80,000 revenue. Now you can compare areas of the charts left of the line. You will clearly see that the chance that Alternative A would have revenue lower than $80,000 is much higher than chance for Alternative B.

Another useful tool is shown on Figure 2:

- The vertical axis of this chart represents revenue, but it can also represent cost, duration, or other project parameters.
- The horizontal axis represents the risk associated with revenue as a result of quantitative analysis. If we have the statistical distribution, we get some statistical parameters, such as standard deviation, percentiles (P10, P90, P99), and others. These parameters can be used as a measure of the risk.
- Each circle represents a project alternative.
- The diameter of each circle represents an additional parameter for the alternative. For example, if the chart shows cost vs. risk associated with cost, the diameter may could represent the duration of the alternative.

To illustrate how you can evaluate a project alternative using this chart, split the area into three zones:

1. **High Revenue and Low Risk** (Alternative A): it is always nice to see one of the alternatives in this zone, unfortunately, quite often this is an indicator that some risk factors have not been accounted for in the alternative
2. **Balanced Revenue and Risk** (Alternatives B and C): high risk is associated with high risk; low revenue is associated with low risk.
3. **Low Revenue – High Risk** (Alternative D): alternatives with this combination of risk and return should be first candidates for rejection.

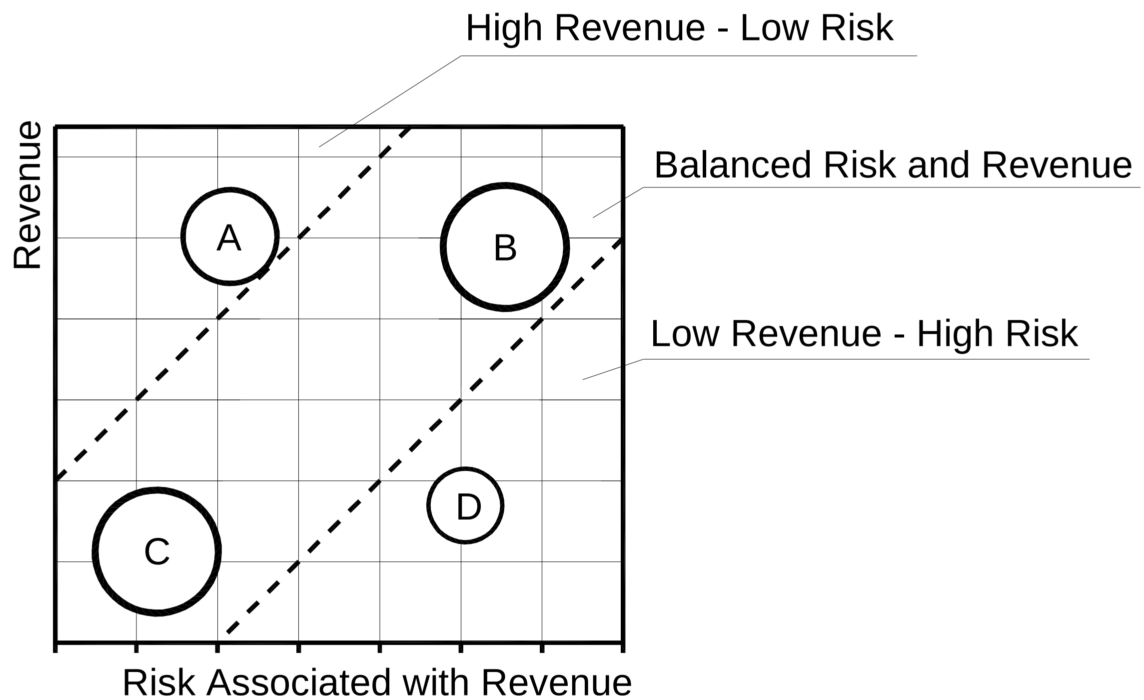

Figure 2: Risk versus Return Chart

This chart is also extremely useful as a **reality check**: if an alternative seems too risky to be placed in the low risk zone, this can indicate that there is something amiss with the data used in the quantitative analysis.

Another way to present alternatives is to combine them on a **Gantt chart**. In addition, Gantt charts can be used to represent the project schedule with and without risks and uncertainties (see Figure 3). The project schedule without risks and uncertainties, even it is not realistic, is a good reference point for the analysis.

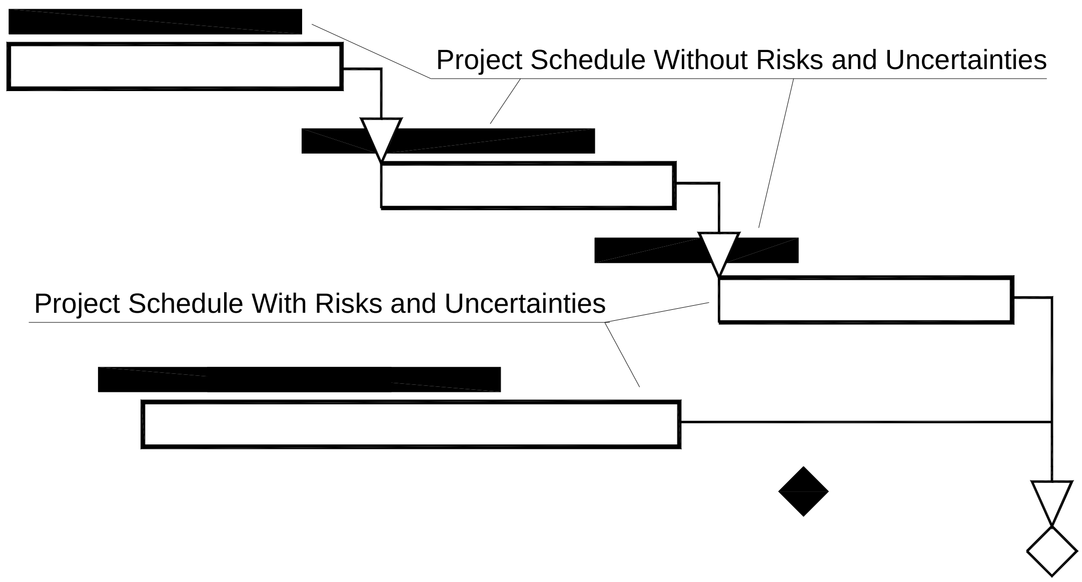

Figure 3. Gantt Chart that combines schedules with and without risks

In this example, you can see that risk and uncertainties significantly extend the project duration.

Presentations must be meaningful

Have you even been in a meeting where the presenter uses a PowerPoint slide containing a table with hundreds of numbers? The presenter, usually shows a tiny number (usually cost) somewhere in the middle table, which is used to prove the point he attempting to make. After pausing only a moment of so, he moves quickly along to his next slide, believing that this dramatic use of numbers will impress upon his audience the thoroughness of his analysis. This quick transition may have left you a little befuddled as you are not quite sure what that number actually indicated. But because everyone else is smiling and slowly nodding their heads, you remain silent as you do not want to be the only one in the meeting who is too dim not to grasp the significance of the numbers. So, you just nod your head like the others, Well, guess what, no one else can understand the numbers either, so we all just nod our heads so we don’t look foolish. If you add quantitative analysis into the mix, the presentation can become even more obscure. The presenter might as well be speaking Greek with Latin subtitles. Everyone recognizes it as an impressive intellectual achievement, but no one has a clue what is being said. To avoid this scenario, here are few tips on how to present results of decision analysis:

1. **<u>Try to minimize the use of statistical terminology</u>**. If you say that the ninety-fifth percentile of the statistical distribution of duration is higher for the second alternative, you can be sure that you are speaking Greek to most of your audience; all that is missing is the subtitles. For the benefit of your audience, a better way of presenting your analysis is to show how one alternative is 50% more risky than the other one.

2. **Try to minimize the use of numbers** in your presentation, especially those related to probabilities, correlation coefficients, percentiles, and other similar parameters. People understand numbers that have a reference point. Everybody understands dollars or days, but we cannot be sure that everyone in the audience understands standard deviation. You can test this assumption by simply asking your peers, “What units is standard deviation measured in?” The answers will be enlightening. Still, key numbers are very important, so here is an example of a table you can use to present the results of your analysis (you can also use a frequency histograms as shown on Figure 1):

A comparison of revenue for two projects

	Project A	Project B
Deterministic (no risks and uncertainties)	$100,000	$120,000
With risks (low estimate)	$70,000	$100,000
With risks (mean)	$115,000	$150,000
With risks (high estimate)	$150,000	$200,000

Table 1: Example of the report table

3. **Try to use only a few meaningful charts**. Quantitative analysis software tools produce a whole bunch of different charts. Some of them are more intuitive, some less. For example, cumulative probability plots, as we already mentioned, are not very easy to interpret. Even tornado and spider diagram may cause some confusion. We recommend that you use only a couple of charts of the types shown on Figures 1, 2, and 3. Finally, be creative! Use whatever you think will be the most appropriate for your report.

Expression of uncertainty

Probability is the relative frequency of an event based on empirical evidence. If we have this evidence and we have performed quantitative analysis, we can come up with some certain numbers (50% chance that project will cost $100,000). However, in project management, we often do not have enough reliable data to assess probabilities. In these cases, people very often use **verbal expressions of uncertainty**, such as “possible”, “probable”, “may”, “unlikely”, etc. (Brun and Teigen, 1988). One of the problems is that people interpret these words differently. Richard Heuer is his book “Psychology of Intelligence Analysis” (1999) gives the following example:

“*Consider, for example, a report that there is a little chance of the terrorist attack against the American Embassy in Cairo at this time. If the Ambassador’s preconception is that there is no more than one in a hundred chance, he may elect to not to do very much. If the Ambassador’s preconception is that there may be as much s one-in-four chance of an attack, he* *may decide to do quite a bit. Term "little chance" is consistent with either interpretation, and there is no way to know what the report writer meant".*

To illustrate the point, Heuer included the result of an experiment with 23 NATO military officers working with intelligence reports. They were presented with the sentence like "There is a little chance that …". They were asked to put a percentage associated with each verbal expression of uncertainty. The experiment showed a shown wide disparity in interpretation of these words. We did our own informal experiment of some engineers to see how their perception if their uncertainty differed from that of the NATO officers. We asked 23 engineers involved in oil and gas related projects to answer similar questions. Overall, the results were very close (see Figure 4). Regardless of the area in which we work, our perception of uncertainty, as expressed in words, is very similar. The ranges of answers are very high. To check it out, you can do this experiment in your organization.

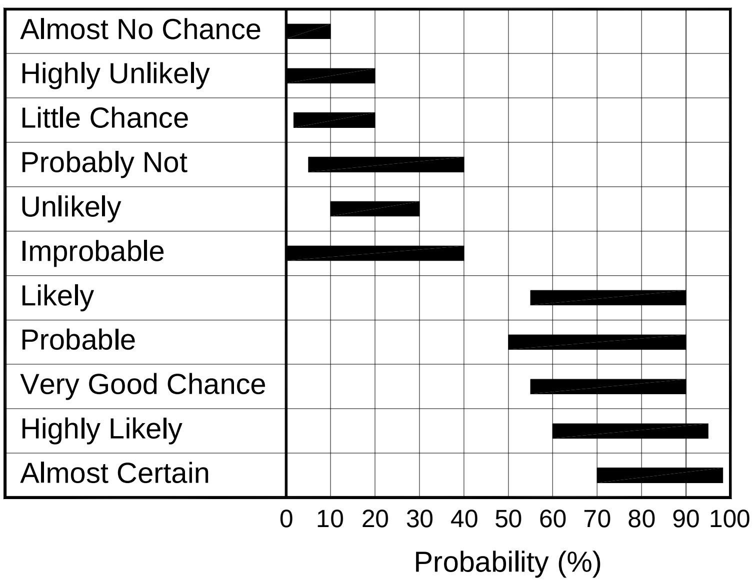

Figure 4. Perception of verbal definition of uncertainty

In some industries there are strict guidelines regarding what specific terms mean. For example, in the oil and gas industry, there is are very well defined classifications for proven and possible reserves. However, in most cases, these guidelines are not available. If you are an analyst and need to express probabilities, try to use numbers rather than words. If you are a decision-maker who reads the reports, ask the analyst what does "little chance" or "almost no chance" mean.

The power of fear

On September 2006, architect Nodar Kancheli gave an interview to Moscow radio. Shortly before the interview, he had been given amnesty from the charges of criminal negligence he faced. The changes were related to mistakes in the design of large Moscow water park. In 2004, the roof of the water park has collapsed and caused the deaths of a 28 people. During the interview, Kancheli mentioned that there was a remote chance that roof of Moscow's largest *arena could collapse during an upcoming Madonna concert because of the sound from the powerful speakers. While we are sure that Kancheli was not seriously trying to panic the public, the media took his words out of context and reported it a number of times. Due to the engineer's notoriety from the previous collapse, this lent him some credibility (at least in the eyes of the public) as an "expert" in collapsing structures and helped this become a major news story in Moscow. Despite this "expert's" ominous warning, Madonna's concert merely raised the roof rather than collapsing it.*

Sometimes we may report that there is a very small chance that a major or catastrophic event will occur. There are some difficulties when we do this. First, we cannot actually comprehend probabilities on such a small scale. For example, if the chance of fire is 0.01% or 0.001%, what does that mean? Do you feel any more trepidation due to the higher probability of the former compared to the latter? Probably not, as both probabilities are so small that they will not have any significant differences upon your actions; although, the first one has a 10 greater chance than the second one. On the other hand, you would surely appreciate the difference between 6 % and 60% chance.

Now, let's assume that you have a report on your desk that indicates that there is a remote chance of some calamitous event. The report does not provide any concrete action plans; therefore, it is your responsibility to furnish an action plan. The best way to determine this is to perform a reality check based on its outcome. The simplest way assess such an event is to create a rough estimate of the expected value of event. For example, an uninsured building that is under constructions costs $200,000. The report tells you that over last year, of the 2000 buildings that were constructed in the city, only one had a major fire. So the chance of your building suffering a major fire event is 1/2000 and the expected loss would be $100.

In some cases, information about rare events is collected and used for guidelines or regulations. For example, most bridges can sustain extremely high flood waters, but data indicates that once every one thousand years there will be a flood that will be high enough to collapse the bridge. We could build a bridge in such way that it would sustain even the highest forecasted floods, but it would increase the costs so dramatically that it would not make any economic sense.

Unfortunately, often there is not enough historical data for this type of assessment because there is no record of similar events having occurred. Take our example from above, how many times has an arena's roof collapsed during a rock concert because of sound waves? Scenarios like this make it very difficult to determine the probability of risk, but this is not the main problem that you face.

Your main problem is that your judgment about the probability of these types of calamitous events can be tremendously influenced by emotions, particularly fear. In many cases, authors of an analytical report that includes a chance of a rare disastrous event are not trying to create a panic; they just want to ensure that the decision makers are aware of all potential dangers to the project, regardless of the remote chance that they can occur. However, because people are prone to over react to the threat of a disastrous event, quite often this psychological effect is taken advantage of by individuals who may want to promote a particular agenda. These individuals may be members of your project team, but often they are the media, politicians, local community activists, and other interested individuals and organizations. Their concerns cannot be discounted out of hand as they often have valid points. For example ecological considerations are often ignored, unless one of these interested parties vividly demonstrates the destructive effect a project can have on the environment.

So how should you deal assess the probability and outcome of such rate events? If your own reality checks do not confirm the analytical assessment of the event, ask for more information. Has someone in your organization dealt with this type of event before? Are there other organizations that you can look to for information? Do you have any information about analogous events? What is their probability? In cases of rare events with dramatic outcomes, intuition is generally not the preferred instrument for decision-making.

Summary

- Reporting the results of decision analysis is complicated by the fact that decision-makers have difficulties assessing information related to probabilities, risks, and uncertainties.

- While interpreting a report, decision-makers should take into an account that the authors of the report have some motivational biases. The best way to deal with these biases is to establish a decision analysis process in your organization.

- Visualizing the results of your decision analysis using a few intuitive charts will help decision-makers understand the report.

- To simplify interpretations of the report, analysts should avoid verbal definitions of uncertainties (“possible”, “probable”, “may”, and others), minimize use of statistical terminology, and present only the most important numerical results.

- Information about rare events with catastrophic consequences should be carefully presented to avoid biased assessment. Reality checks may be required and additional information can be requested.

References

Brun, W., K.H. Teigen, 1988. *Verbal Probabilities: Ambiguous, Context-dependent, or both*? Organ. Behavior Human Decision Processes 41(3) 390-404

Heuer, R. J., Jr., 1999. Psychology of Intelligence Analysis, U.S. Government Printing Office