UC2 Risk Ruler

April 6, 2025

V1.4

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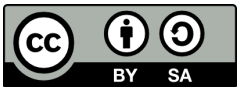

Abstract

The UC2 Risk Ruler is designed to simplify and enhance risk estimation by integrating both quantitative and qualitative assessments from subject matter experts. Building on the Uniform Confidence/Certainty Estimation (UC2) framework, the Risk Ruler offers a scale that adjusts and captures confidence levels in risk predictions, helping subject matter experts express estimates that vary in certainty. By aligning data-driven and expert-derived risk estimates in a unified manner, the tool addresses challenges such as false accuracy, overconfidence, and the difficulty of aggregating disparate data types. Adaptable to a variety of real-world scenarios, such as cybersecurity, national infrastructure, and beyond, it offers decision-makers both insight and transparency in risk management. The UC2 Risk Ruler also seamlessly integrates with existing risk models and workflows, providing a practical and intuitive solution for improved risk management.

Keywords: Risk management, Confidence estimation, Qualitative risk assessment, Quantitative risk assessment, UC2 Risk Ruler, Risk estimation scales, Data-driven analysis, Expert elicitation, Uncertainty management, Risk model integration

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Introduction

The UC2 Risk Ruler simplifies the implementation and deployment of fixed-width, risk management oriented scales discussed in the publication *Uniform Confidence/Certainty Estimation*[1] (UC2). The original scales were developed to provide subject matter experts a set of scales that reflect (and capture) confidence in predictions which often vary from one estimate to the next. Implementation of fixed width scales also offered a way to seamlessly combine quantitative estimates based on data analysis with qualitative estimates from subject matter experts. The UC2 Risk Ruler retains all of the original UC2 Scale benefits including the resolution of problems introduced by non-uniform scales that lead to bias in risk analysis.

Overview

UC2 Risk Ruler for Likelihood or Impact

	Time Frame								Required for Likelihood	
Certain	Ultra Low	Extremely Low	Very Low	Low	Medium Low	Medium High	High	Very High	Extremely High	Ultra High
Range	~ 0 - 10	10 - 20	20 - 30	30 - 40	40 - 50	50 - 60	60 - 70	70 - 80	80 - 90	90 - 100
	Confidence Bands									
Probable	Low ~ 0 - 20		Medium Low 20 - 40		Medium 40 - 60		Medium High 60 - 80		High 80 - 100	
Reasonable	Low ~ 0 - 30			Medium Low 30 - 50		Medium High 50 - 70		High 70 - 100		
Tentative			Medium 20 - 80							
	Low ~ 0 - 40						High 60 - 100			
	Unknown									
Unknown	High - N/A									
	Medium ~ 0 - 100									
	Low - N/A									

Figure 1 - UC2 Risk Ruler - default implementation

At a glance, the default numeric units are percentages. For likelihood that is a point probability and for impact 100% represents a total loss of whatever value (e.g. an asset value) is being evaluated. The UC2 Risk Ruler divides these values into a uniformly distributed ten segment range defined along the top row. As one moves downward, the number of segments reduces to five, three, and one segment with correspondingly wider ranges for each segment. Reducing the number segments and increasing ranges is an intuitively explicit way to express a decrease in confidence, the levels of which are row labels such as Probable, Tentative, and Unknown. The overlapping segments at the “Tentative” level provide an even more nuanced and intuitive way for subject matter experts to express estimations that match real-word scenarios. They are also a nod toward issues of boundary sensitivity inherent to binning.

To those steeped in data analysis, limiting “Certain” estimates to decile ranges may seem absurd, but there is a flip side to calculating and reporting values with single-digit or

[1] https://mpra.ub.uni-muenchen.de/id/eprint/118234

decimal-level accuracy. In practice, risk estimation always contains some level of uncertainty. Presenting astute leaders with measures of likelihood like 42% or 15.478% are often (correctly) perceived as conveying false accuracy that undermines overall credibility. Limiting results to deciles offers a natural way to present estimates, just like weather forecasts. If deciles are just not small enough, smaller segments (e.g. 5 units or 1 unit wide) can be placed above the deciles and labels adjusted accordingly. This illustrates how the UC2 Risk Ruler is designed to be both extensible and practical.

Hard core data analysts and risk aficionados will appreciate that the bottom of the range is expressed as "~ 0", which is a mnemonic reminder that black and gray swan risks have extremely low, but non-zero probabilities. When presenting risks, the tilde almost inevitably invites a question as to its meaning, which provides an opening to discuss this important aspect of any risk analysis.

For any estimate of likelihood, the default UC2 Risk Ruler implementation requires a time frame. One exception is a single discrete event, like a single coin flip. However, most risk management applications have a time component such as a year, quarter, or month in which manifestation of a risk is analyzed. If a time frame is truly not needed, it can be removed. Likewise, other contextual elements may be added to properly define an estimate (e.g. "during a global pandemic"). Estimates of impact and other risk measures can benefit from a time frame as well, but the rules around that are more relaxed in practice.

When estimating impact there are three choices. The default is to set a total-loss value and then measure loss as a percentage of that value. Another option is to replace the percentages with a range of values, which could be expressed as dollars, lives lost, days without service, or whatever units are best suited to the analysis at hand. A third option, which we use in the example below, is to define the impact segments categorically. This last option is suitable when complex outcomes are best grouped into categories or orders of magnitude.

Example Use Case

Uniform Confidence/Certainty Estimation methodology, which led to the development of the UC2 Risk Ruler, was born from the need to estimate risks for which little data existed, but for which there was a pool of subject matter experts available. For example, estimating the risk of a threat actor committing a cyber attack on part of a nation state's critical infrastructure. We will simplify this example to one threat actor (a fictitious Hacktivists group called *Incognito*), one element of critical infrastructure (Manage Elections), and one Impact (Public Trust). David is our fictitious risk practitioner and the three subject matter experts are: Bob, Alice, and Jane.

David has been asked to analyze the risk that the hacktivist group *Incognito* will try to disrupt national elections to sow distrust in the minds of the public that his government is capable of running fair elections. Through discourse with leadership it was determined that the time frame of concern is the three months leading up to the election and one week after the election during which votes are to be tallied and published.

Many *Incognito* statements have been released indicating that they intend to show the public how untrustworthy the government is when it comes to elections. However, it is a relatively new group for which there is not any historic attack data or precedence of tactics they might use.

David provides the default UC2 Risk Ruler to the experts for estimating likelihood in both scenarios as a range from ~0 - 100%. He also wants to use the UC2 Risk Ruler to elicit impact estimates. Leadership has agreed to a 5-point scale for measuring the impact that looks like this:

Low - Isolated anti-government election posts on social media.

Medium Low - Articles in 20% of the *local* newspapers are anti-government election articles

Medium - Articles in 20% of the *national* newspapers are anti-government election articles.

Medium High - More than 10% of local regions have filed lawsuits challenging the election process and/or the election results.

High - More than 25% of local regions have filed lawsuits challenging the election process and/or the election results.

David prepares a modified UC2 Risk Ruler for impact estimations by removing the ten-segment scale, and moving the "Certain" label down to the five-segment label, because five is enough in this case. All references to numeric ranges are removed because they are not relevant to categorical estimations. The resulting risk estimation worksheet (see Appendix A) with all scales, definitions and instructions is given to the subject matter experts to elicit uniform estimates in a crowd-sourced manner. Figure 2 illustrates David's modifications.

UC2 Risk Ruler for Impact

Certain	Low	Medium Low	Medium	Medium High	High
Tentative		Medium			
	Low			High	
	Unknown				
Unknown	High - N/A				
	Medium				
	Low - N/A				

Figure 2 - UC2 Risk Ruler - Modified for 5-point impact estimate.

Analysis

Bob, Alice, and Jane return their risk estimations, which include an estimate *and* a confidence level for that estimate. The capture of both elements is what makes the Risk Ruler a better option than just a single multiple choice question. It resolves the tension that inevitably builds among subject matter experts when they are asked to make predictions. Allowing estimates to span multiple categories gives experts a way to avoid getting stuck in analysis-paralysis and it allows them to break out of the rigid categories when circumstance warrant.

Table 1 summarizes the estimates that Bob, Alice, and Jane made by following the worksheets presented in the Appendix.

Expert	Scenario	Likelihood	Confidence	Impact	Confidence
Bob	Pre-Election	Medium High	Probable	High	Certain
Bob	Post-Election	Medium	Unknown	Medium	Tentative
Alice	Pre-Election	Low	Tentative	Medium	Tentative
Alice	Post-Election	Medium Low	Probable	Medium	Unknown
Jane	Pre-Election	High	Tentative	Low	Certain
Jane	Post-Election	Medium	Unknown	Medium	Unknown

Table 1 - Results of expert estimations

Using the data above, David presents leadership with a picture of the risks *and* the confidence surrounding the estimates. Pie charts are used to convey confidence and certainty. Histograms are used to present the raw data. Together they convey powerfully informative information that avoids doing math on ordinal values, which is a big no-no in this type of analysis.

Scenario One - Pre Election

Likelihood and impact histograms are constructed using the top-row (highest confidence) of the scenario-specific risk ruler as the base. The bars for each are built “tetris style” with multi-segment estimations dropping down to their lowest unfilled level.

The names of the experts are included to make it easier to follow the logic from the table above to the distributions below. However, the decision to tag experts is optional and may not be appropriate in certain cases.

Histograms 1 and 2 illustrate the results of the pre-election data extracted from Table 1 and presented as histograms that visually present the results, including things like skew, which is clearly seen in Histogram 1. Impact, as shown in Histogram 2, has a distribution that is completely flat, indicating that any one damage scenario is as equally as likely as any other.

Likelihood

	Jane			
Alice	Alice		Bob	
Low	Medium Low	Medium	Medium High	High

Histogram 1 - Likelihood estimates from the pre-election scenario.

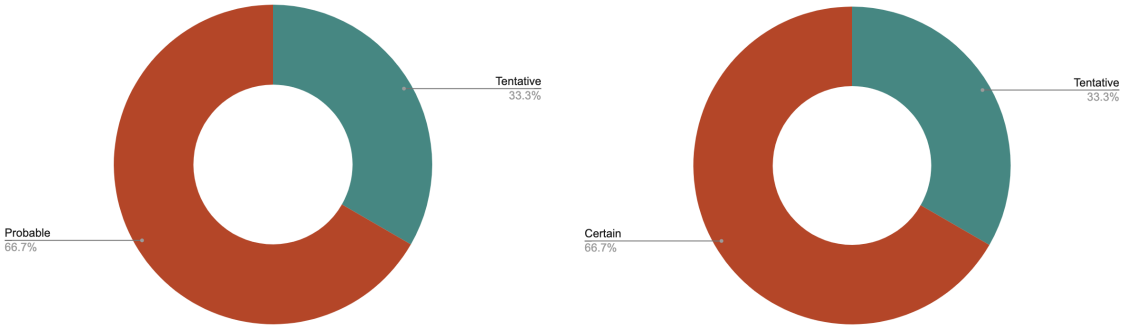
Impact

Jane	Alice	Alice	Alice	Bob
Low	Medium Low	Medium	Medium High	High

Histogram 2 - Impact estimates from the pre-election scenario.

It should be obvious that presenting the data as histograms is not the only way to ingest the information. David could interpret the likelihood data as a range from ~ 0 - 80% and the most likely value as Medium Low, the center-point of which is 30%. Stochastic risk models that expect a PERT distribution can ingest the expert-driven estimates accordingly, and PERT is just one option for David. This illustrates another key feature of the Risk Ruler, which is the ability to accommodate both qualitative and quantitative methodologies from the same dataset.

Likelihood and Impact Confidence



Confidence Charts 1 and 2 - Confidence of likelihood (left) and Impact (right) for the pre-election scenario are depicted as pie charts.

The confidence around likelihood estimates appears to be that of a well educated guess. Two thirds are in the probable range with the rest as tentative. Meanwhile, confidence around impact is higher because the majority of estimates were certain. The estimates in both cases, while imperfect, should be enough for making rational decisions about pre-election risk. For example, leadership might aim one third of the mitigation resources to further reduce likelihood and distribute the other two thirds across impact mitigation — probably weighting the latter toward the worst-case legal outcome.

Scenario Two - Post Election

Analysis of this second scenario, follows the same pattern as before. The data is presented as a histogram for visualization.

Combined Likelihood Results

	Alice			
Jane	Jane	Jane	Jane	Jane
Bob	Bob	Bob	Bob	Bob
Low	Medium Low	Medium	Medium High	High

Histogram 3 - Post election likelihood estimations

The results above include two “Unknown” estimates from Bob and Jane. When an expert selects this level of confidence it indicates that all segments are equally likely, thus their representation above. Only Alice made a more specific estimation. While not as peaked as the likelihood distribution for pre-election risk, this risk still hovers to the low side of equal chance.

The inclusion of an Unknown option for subject matter experts is another important feature of the risk ruler. Rather than force experts to make a wild guess, perhaps defaulting to one extreme or the middle option, allowing them to say they don’t know the answer is not only more accurate, the fact that they do not know is an intrinsically important piece of information. If the majority of experts respond with Unknown, it is a good indication that the scales are off or that the requested level of certainty in estimations is out of alignment with reality.

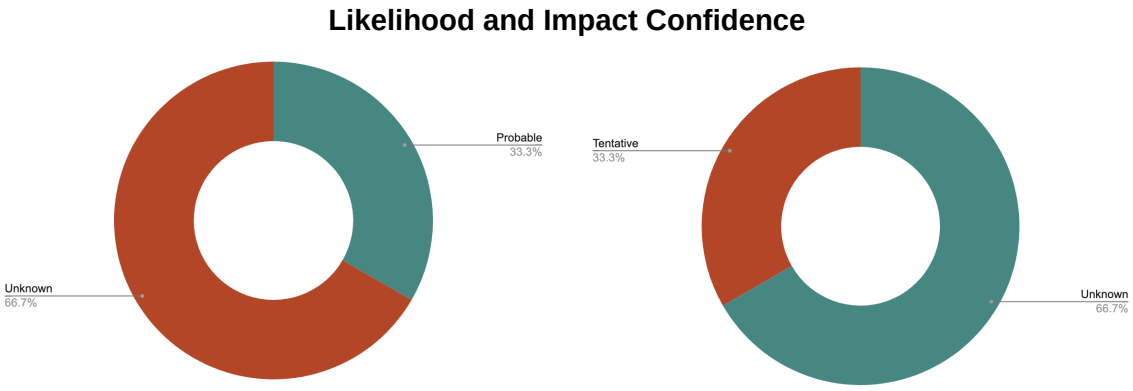
Combined Impact Results

	Bob	Bob	Bob	
Jane	Jane	Jane	Jane	Jane
Alice	Alice	Alice	Alice	Alice
Low	Medium Low	Medium	Medium High	High

Histogram 4 - Post election impact estimations

The impact result for post-election impacts shows a more normal distribution around the medium impact level defined by leadership. It is starting to take on that classic bell-shaped curve. However, the two Unknowns from Alice and Jane force the distribution to be flatter and wider than a perfect bell shape. By design, all of this is readily evident in the shape of the chart, which aids communication and avoids pitfalls like false-precision.

Up to a point, increasing the number of estimations adds more definition to these charts. This fact illustrates how adding additional subject matter experts is beneficial. It is also important to note that histograms will more transparently expose situations where estimations cluster around two values. A distinctive double-camel hump will appear that clearly indicates there are two camps of thought, which is valuable information that would be lost in a simple average.



Confidence Charts 3 and 4 - Confidence of likelihood (left) and Impact (right) for the post-election scenario are depicted as pie charts.

In this case, both likelihood and impact confidence is quite low. Each is dominated by two out of three unknown estimates in the raw data. This kind of result is a good sign that more analysis is justified. Meanwhile, leadership should take from this that there simply is not a consensus and one outcome is as likely as another. Then leadership needs to decide if additional resources should be spent on trying to obtain an answer. If not, the resources should just be split evenly among the mitigation options to provide broad, albeit shallow, protection.

Conclusion

The UC2 Risk Ruler offers an intuitive way to organize and collect risk estimates from subject matter experts. The example likelihood estimations illustrate the UC2 Risk Ruler's compatibility with both quantitative values and harnesses binning as a way to overcome false-accuracy issues when using raw statistics. The astute reader will see that while estimates of likelihood fall neatly into the default 0 - 100% (zero to one) — nothing prevents the range from being defined as something like $100m - $700m or 10 - 50 quality adjusted life years. The flexibility of deployment across a range of quantitative scenarios and measures was deliberate.

The election examples used above also show how the UC2 Risk Ruler adapts well to qualitative estimates. This was another deliberate design factor that extends to the way post-estimation analysis is performed. Instead of dubious math on ordinals and such, the histograms allow qualitative analysis to live peacefully alongside quantitative values.

As noted in the per-election analysis, the results from this kind of elicitation and analysis are also compatible with quantitative models that depend on ranges and most-likely values. The process also allows subject matter experts to self-calibrate themselves on a per-estimate basis as various risk scenarios may (or may not) fit with their expertise. Though out of scope for this introduction, the UC2 methodology and the Risk Ruler also give the risk analyst the ability to stress-test models against more (or less) certainty to determine what level of confidence best supports a particular predictive effort.

The last big feature of the UC2 Risk Ruler is the capture and presentation of confidence values alongside estimates. The methods employed by this methodology provide much more transparency than other models that tend to conflate statistical confidence with estimation confidence. When transparency is combined with qualitative and quantitative estimation, the result is a better and more transparent method for estimating risks from multiple sources that feeds seamlessly into both quantitative and qualitative risk models. For more information on the underlying principles and for a deeper discussion of data types, scale problems and more, see also *Uniform Confidence/Certainty Estimation* available at https://AcornPass.com/

Appendix A

Pre-Election Risk Estimation Worksheet

Instructions: On <u>each</u> of the charts below, circle the segment that best reflects your estimate of likelihood and impact. You may wish to work from the bottom, starting with Unknown, and move up as confidence in your knowledge and experience dictates.

Likelihood Estimation: What is the likelihood that *Incognito* attacks election infrastructure up to *three months before* the election?

UC2 Risk Ruler for Likelihood or Impact

	Time Frame		Three Months						Required for Impact	
Certain	Ultra Low	Extremely Low	Very Low	Low	Medium Low	Medium High	High	Very High	Extremely High	Ultra High
Range	~ 0 - 10	10 - 20	20 - 30	30 - 40	40 - 50	50 - 60	60 - 70	70 - 80	80 - 90	90 - 100
	Confidence Bands									
Probable	Low ~ 0 - 20		Medium Low 20 - 40		Medium 40 - 60		Medium High 60 - 80		High 80 - 100	
Reasonable	Low ~ 0 - 30			Medium Low 30 - 50		Medium High 50 - 70		High 70 - 100		
Tentative			Medium 20 - 80							
	Low ~ 0 - 40						High 60 - 100			
	Unknown									
Unknown	High - N/A									
	Medium ~ 0 - 100									
	Low - N/A									

Likelihood Estimation: What is the estimated impact of such an attack, should it manifest?

UC2 Risk Ruler for Impact

Certain	Low	Medium Low	Medium	Medium High	High
Tentative		Medium			
	Low			High	
	Unknown				
Unknown	High - N/A				
	Medium				
	Low - N/A				

Low- Isolated anti-government election posts on social media.

Medium Low - Opinion columns in 20% of the *local* newspapers are anti-government election

Medium - Opinion columns in 20% of the *national* newspapers are anti-government election

Medium High- Opinion columns in 50% of the local and national and newspapers are anti-government

High - More than 10% of local regions have filed lawsuits challenging the election process and/or the election results.

Post-Election Risk Estimation Worksheet

Instructions: On <u>each</u> of the charts below, circle the segment that best reflects your estimate of likelihood and impact. You may wish to work from the bottom, starting with Unknown certainty, and move up as confidence in your knowledge and experience dictates.

Likelihood Estimation: What is the likelihood that *Incognito* attacks election infrastructure *one week after* the election?

UC2 Risk Ruler for Likelihood or Impact

	Time Frame								Required for Impact	
Certain	Ultra Low	Extremely Low	Very Low	Low	Medium Low	Medium High	High	Very High	Extremely High	Ultra High
Range	~ 0 - 10	10 - 20	20 - 30	30 - 40	40 - 50	50 - 60	60 - 70	70 - 80	80 - 90	90 - 100
	Confidence Bands									
Probable	Low ~ 0 - 20		Medium Low 20 - 40		Medium 40 - 60		Medium High 60 - 80		High 80 - 100	
Reasonable	Low ~ 0 - 30			Medium Low 30 - 50		Medium High 50 - 70		High 70 - 100		
Tentative			Medium 20 - 80							
	Low ~ 0 - 40						High 60 - 100			
	Unknown									
Unknown	High - N/A									
	Medium ~ 0 - 100									
	Low - N/A									

Impact Estimation: What is the estimated impact of such an attack, should it manifest?

UC2 Risk Ruler for Impact

Certain	Low	Medium Low	Medium	Medium High	High
Tentative		Medium			
	Low			High	
	Unknown				
Unknown	High - N/A				
	Medium				
	Low - N/A				

Low- Isolated anti-government election posts on social media.

Medium Low - Opinion columns in 20% of the *local* newspapers are anti-government election

Medium - Opinion columns in 20% of the *national* newspapers are anti-government election

Medium High- Opinion columns in 50% of the local and national and newspapers are anti-government

High - More than 10% of local regions have filed lawsuits challenging the election process and/or the election results.

Appendix B

Most of the criticism of the Risk Ruler requires a graduate level understanding of math to even articulate and a rare level of humility among the learned to see beyond. However, it is important to note that these academic and philosophical arguments are often the largest and most formidable barriers to practicality. The tension between mathematical perfection and good enough leads to an enormous amount of conflict and represents analysis paralysis in its most pure form. Breaking through this barrier may be the greatest feature of the UC2 Risk Ruler.

The short version is: "All models are wrong, but some are useful." - George E. P. Box

The longer version involves a quant walking into a kitchen where he sees a chef using Fahrenheit (°F) or Celsius (°C) for her recipes and ovens plus a gas stove with knobs that read high, medium, and low. He argues that unless she precisely measures heat as the movement of molecules on a proper scale, such as Kelvin, and that she precisely calibrates her equipment and controls, then all her food is inedible. She laughed; he starved to death.