RSE Lite Tool Methodology

1 Overview

The RSE Lite tool was created to estimate the Risk Spend Efficiency (RSE) of a proposed program given the program characteristics such as scope, cost, effectiveness, benefit length, etc. This tool uses existing baseline risk data from the bowtie specified in the Enterprise Risk Model (ERM)[1] and uses a simplified risk reduction calculation so that the effects of adjusting program characteristics can be quickly estimated.

To illustrate a use case for the RSE Lite tool, say a program manager may need to choose between two types of components that will be installed as part of a mitigation program: one that has a higher unit cost but has a higher effectiveness compared to another. The RSE Lite tool would be run for the same program with the two different components. The results would enable the comparison between the two components in risk reduction and cost and ultimately the RSE of the program.

2 Calculation Methodology

The RSE Lite tool requires as an input the yearly Likelihood of Risk Event (LoRE), Consequence of Risk Event (CoRE), and Tranche Exposure. This LoRE and CoRE represent baseline risk, which assumes that the control programs are in place as it has been in the past. This has implications when calculating risk reductions for controls and mitigations. We assume that mitigations are programs that further reduce risk from the baseline risk score in the presence of the program, while controls are programs that would increase risk from the baseline risk score in the absence of the program.

To estimate the risk reduction and RSE of a program, the following user input regarding the program is required. An example characterization of a proactive asset replacement program is provided in Section 3.

1. Program scope describing how much of the tranche exposure is affected by the program in each year.

2. The risk reduction impact of the program, characterized by
    a. Effectiveness as a % reduction of specific driver/sub-driver LoRE and/or % reduction of the consequence of a risk event in specific attribute for the specified program scope.

       For mitigations the effectiveness is expressed as a reduction relative to the baseline.

       For controls the effectiveness is expressed as a reduction relative to the inherent risk, i.e. the risk without the control. RSE Lite Tool then converts this given effectiveness to

[1] See "Chapter 3: Risk Modeling and Risk Spend Efficiency" and the attachment "Enterprise Risk Model User Guide" of PG&E's 2020 RAMP Report

an effectiveness relative to the baseline risk, to enable estimation of the risk reduction for controls using baseline risk.

b. Benefit length, i.e. the number of years that the risk reduction of the program persists, once the program is implemented.

c. Effectiveness degradation rate or method, describing how the effectiveness degrades over the benefit length.

3. Program Cost and how the cost is allocated to specific Tranches within the Risk Event to get Program Cost by Tranche.

To estimate the risk reduction in each year, the tranche-level effectiveness of the program is multiplied to the Tranche Exposure, LoRE and CoRE at the applicable driver or consequence attribute and then aggregated. Specifically, the risk reduction for year y for a preventive program[2] implemented in year y0 is calculated as:

$$Risk\ Reduction_{y0}(y, Tranche) = Exposure(y, Tranche) \times CoRE(y, Tranche) \times \sum_{subdriver} AvgEff_{y0}(y, Tranche, subdriver) \times LoRE(y, Tranche, subdriver)$$

The risk reduction for year y for a protective program[3] implemented in year y0 is calculated as:

$$Risk\ Reduction_{y0}(y, Tranche) = Exposure(y, Tranche) \times LoRE(y, Tranche) \times \sum_{attribute} AvgEff_{y0}(y, Tranche, attribute) \times CoRE(y, Tranche, attribute)$$

Where

$AvgEff(y, Tranche, \cdot)$ is the tranche-level effectiveness accounting for the program scope, benefit life, and degradation as applicable, which is calculated as:

$$AvgEff_{y0}(y, Tranche, \cdot) = \frac{ProgramExposure_{y0}(Tranche)}{Exposure(Tranche, y)} \times Eff(Tranche, \cdot) \times Degration\_factor(y - y0)$$

Where

$$DegradationFactor(k) = \begin{cases} 0, \ \ if\ k \geq BenefitLife \\ (1 - deg)^k, \ \ if\ k < BenefitLife\ and\ DegradationMethod = esc \\ 1 - deg * k, \ \ if\ k < BenefitLIfe\ and\ DegradationMethod = Linear \end{cases}$$

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[2] A preventive program is a program that reduces the likelihood of a risk event

[3] A protective program is a program that reduces the consequence of a risk event.

Where *deg* is Effectiveness Degradation Rate, and *DegradationMethod* is the Effectiveness Degradation Method from the program inputs.

Risk Reduction from a program for each year is then aggregated over applicable tranches:

$$Risk\ Reduction_{y0}(y) = \sum_{Tranche} Risk\ Reduction_{y0}(y, Tranche)$$

Note that the direct multiplication of the program effectiveness to the CoRE value is a simplification of the ERM model methodology. The ERM methodology applies the program effectiveness to the simulated natural unit of the consequence, applies the MAVF scaling function to each of simulated natural units to calculate the simulated CoRE values, and finally averages the simulated CoRE values to compute the post-mitigation CoRE value.

The Risk Spend Efficiency (RSE) is then estimated as the ratio of the net present value of annual risk reduction to the net present value of the costs:

$$RSE_{y0} = \frac{NPV\left(Risk\ Reduction_{y0}(y)\right)}{NPV\left(Cost_{y0}\right)}$$

3 EXAMPLE CHARACTERIZATION OF PROACTIVE ASSET REPLACEMENT PROGRAM

For this type of program, assets that are predicted to fail within the year are replaced before failure in order to improve reliability and prevent failures. The units replaced are out of the ones that are predicted to fail within the year.

Table 1 shows an example. In each year, the assets that are expected to fail within a tranche are identified and enumerated. Let's assume that due to budget constraints, only a subset of the assets identified as expected to fail within the year are replaced. Based on the asset characteristics, once it is replaced, the likelihood of failure is 10%, thus effectiveness of this proactive replacement can be estimated as 1-10% = 90%.

After replacement, the number of asset failures expected to be observed decreases by the quantity effectiveness*number of replacements. Since the replacement units are assumed to be among the ones that are predicted to fail within the year, the program scope is the number of replacements divided by the number of assets predicted to fail and the benefit length of this replacement is 1 year.

The characterization of 1 year of benefit life is unintuitive, since it might seem more natural to assume the life of the asset as the benefit length. An important point that bears repeating is that proactive replacement mitigates failure of assets that are predicted to fail within the year[4] and thus immediately reduces the frequency of risk events in the year of replacement but does not impact the group of assets

[4] This would be a conservative and simplifying assumption, since we wouldn't know whether a particular asset that are being proactively replaced were going to fail with 100% if we didn't replace it.

that are predicted to fail in the later years. As shown in Table 1, the impact of the 60 replacements in 2021 in reducing the asset failure reduces the expected failure count from 100 to 54 in 2021 but does not impact the asset failure rate in 2022 because a different set of 200 transformers are predicted to fail. The same argument applies to the replacements in 2022, 2023 and so on.

In contrast, an asset replacement program that addresses factors other than the asset failure as the primary purpose will get the life of the asset as the benefit length. An example of such a program is the Non-exempt Surge Arrestor replacement program, where non-exempt surge arrestors are replaced with new exempt surge arrestors. The primary purpose of this mitigation is to reduce fire risk and bring grounding into compliance, with a secondary effect of reducing the likelihood of equipment failure since old equipment is being replaced with new equipment.

Table 1: Example proactive asset replacement program - Control

	2021	**2022**	**2023**	**…**
Assets predicted to fail within the year in the absence of this control program (i.e. inherent risk)	100	200	250	…
Proactive replacements	60	100	120	…
Control Effectiveness	90%	90%	90%	
Asset failures expected post this control program (i.e., the baseline risk)	100 - 60*90% = 46	200 - 100*90% = 110	250 - 120*90% = 142	…
Control Program Scope (as % of inherent risk)	60/100 = 60%	100/200 = 50%	120 / 250 = 48%	…
Benefit length of control	1 year	1 year	1 year	…

4 CAVEATS AND LIMITATIONS

The RSE Lite tool was designed to independently calculate risk reductions and RSE of each program given the baseline risk score. This is different from the ERM methodology that was used in 2020 RAMP where the portfolio risk reduction was calculated first and then allocated to each of program in the portfolio. Instead, the RSE lite tool estimates the RSE value of each mitigation (or control) based on the risk reduction (or risk increase) of the program when the program is added to (or removed from) the baseline portfolio of control programs. Thus, the risk reduction calculation in the RSE lite tool does not consider diminished risk reduction when a program **interacts** with other programs (i.e. different program mitigates risk on the same exposure for the same sub-driver).

Similarly, the risk reduction calculation in the RSE lite tool does not consider diminished risk reduction when a program **overlaps** itself in time (i.e. same program mitigates risk on the same exposure) while there is residual benefit from the same mitigation from the previous years.

Another caveat is as mentioned above for protective programs, the risk reduction calculation is based on applying effectiveness to the CoRE reduction, not Natural Unit reduction.

All of these issues are noted to provide more insights on the assumptions made in this tool as a comparison to an alternative but more complex calculation done in the ERM.