# Analysis of Alternative Configurations

The analysis began by creating summary data from the individual alternative configurations run in MANA. This data was organized into two main summary tables, one capturing blue force troop loss and one for blue force vehicle loss. The reason for the separation was to ensure that we could analyze the effects on loss ratio while preserving the proper attribution to the platform on which configurations were made. What the tables show are the configurations along the left-hand side in the first column. These are the alternative configurations that were explored. Along the top row are the names of the platforms and in the first case also Infantry. The data show the aggregate losses by platform by configuration. Highlighted cells indicate the platforms affected by each alternative configuration (e.g., the EM Gun was implemented on the MBT).

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Average Troop Loss By Platform, By Configuration** | | | | | |
|  | **IFV** | **MBT** | **Infantry** | **Helo** | **Loss Ratio** |
| Baseline | 6.857142857 | 7.085714286 | 14.37142857 | 2.228571429 | 0.477232143 |
| STARLite base | 4.714285714 | 3.771428571 | 12.74285714 | 3.6 | 0.387946429 |
| STARLite>Weight | 4.714285714 | 5.714285714 | 12.74285714 | 3.771428571 | 0.420982143 |
| EM Gun | 5.914285714 | 1.485714286 | 16.88571429 | 2.285714286 | 0.415178571 |
| Bradley 105 | 4.885714286 | 5.6 | 7.942857143 | 2.057142857 | 0.320089286 |
| Infrared | 4.628571429 | 6.171428571 | 12.91428571 | 2.285714286 | 0.40625 |
| Composite Armor | 0.085714286 | 5.485714286 | 1.142857143 | 1.942857143 | 0.135267857 |

The first table rolls up troop loss and omits UAV data, as that platform loss never directly results in casualties. The second table rolls up vehicle kills and omits Infantry due to a lack of associated vehicle. No configurations were made to the Helo although it is included in both summary tables in order to capture second-order effects.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Average Vehicle Loss By Platform, By Configuration** | | | | | |
|  | **IFV** | **MBT** | **UAV** | **Helo** | **Loss Ratio** |
| Baseline | 2.285714286 | 1.771428571 | 0.2 | 1.114285714 | 0.477232143 |
| STARLite base | 1.571428571 | 0.942857143 | 0.171428571 | 1.8 | 0.387946429 |
| STARLite>Weight | 1.571428571 | 1.428571429 | 0.085714286 | 1.885714286 | 0.420982143 |
| EM Gun | 1.971428571 | 0.371428571 | 0.257142857 | 1.142857143 | 0.415178571 |
| Bradley 105 | 1.628571429 | 1.4 | 0.228571429 | 1.028571429 | 0.320089286 |
| Infrared | 1.542857143 | 1.542857143 | 0.142857143 | 1.142857143 | 0.40625 |
| Composite Armor | 0.028571429 | 1.371428571 | 0.571428571 | 0.971428571 | 0.135267857 |

The analysis continued by studying the summary data and comparing each of the alternative configurations to the baseline, individually, in order to arrive at an initial view on gross effectiveness. While this provided us with a broad view of the effectiveness of the changes, we wanted to understand more about how the configuration changes influenced the outcome.

Since the alternative configurations were made to the platforms and not individual vehicles, the next task was to roll up the summary data by platform. Viewing the data this way helped visualize the contributions of the platforms to the overall effect on loss ratio for a given configuration. Individual factors were also explored by comparing summary data by platform, across the configurations, giving us cross sectional views into how various changes on a platform affect the outcome. Results are shown in the following figures.

This chart shows a cross-sectional view of the average first-order troop loss directly resulting from MBT kills and is summarized by each alternative configuration and the baseline. This is the second data column in the table “Average Troop Loss by Platform, by Configuration.” The graphical depiction drew attention to the contribution of the EM Gun on force protection.

Similarly, this chart shows a cross-sectional view of the average first-order troop loss directly resulting from IFV kills, summarized by each alternative configuration change and the baseline. This is the first data column in the table “Average Troop Loss by Platform, by Configuration.” The composite armor configuration was the clear winner in this view of the data.

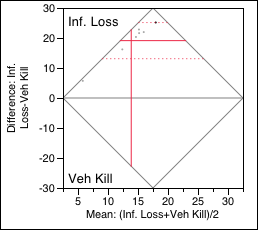
Next, analysis was performed to determine the correlation between troop loss and vehicle kill for each platform. As expected, we found these to be tightly coupled. The interesting finding, though, was that some configurations had a greater effect on loss to infantry squads, which seemed to point to a greater overall effect on force protection.

This chart shows a cross-sectional view of the average second-order troop loss and is summarized by each alternative configuration and the baseline. This is the third data column in the table “Average Troop Loss by Platform, by Configuration.”

The infantry data only account for Infantry Squads and do not take into account infantry loss due directly to vehicle kill, which is what makes this second-order effect interesting. For example, notice that while the EM Gun configuration had the greatest beneficial effect on first-order force protection on the MBT platform, it was the worst performer in terms of second-order effects resulting in the highest infantry loss of all configurations, and even exceeding the baseline.

Separation of the analysis of infantry loss and vehicle kills also allowed an investigation of patterns from one set of data to the other. Specifically, the correlation between infantry loss across all squads and vehicle kills reinforced the connection between platform improvements and force protection, showing that they go proportionally.

**Difference: Inf. Loss-Veh. Kill**



The data above show a high correlation (~84%) between vehicle kills and infantry loss and is especially noticeable in the clustering of data points in the chart, “Difference: Inf. Loss-Veh. Kill.” The chart displays the mean difference of the data for infantry loss and vehicle kills, an indicator of statistical dispersion. Given 4.3102 vehicle kills and 23.4327 infantry lost, the calculated mean difference is 19.1224 with a standard error of 2.46176.

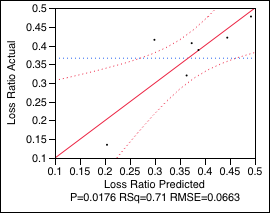
Since loss ratio, calculated as infantry killed divided by total infantry, was perfectly correlated with Infantry Loss, the matched pairs analysis for vehicle kills to loss ratio looked exactly like the chart above. The data show that with only the exception of the EM Gun, the number of vehicle kills predicts infantry loss. This result is also available in the following table.

Visual inspection of the trend lines in the above chart (“Infantry Loss to Vehicle Kill”) shows the correlation which holds for every configuration except EM Gun, as noted earlier. The *y-*axis shows loss and the *x-*axis labels the alternative configuration. In this case, the results were ranked in order of infantry loss to enable the trend lines.

A more thorough analysis yields the following findings, which corroborate and quantify the graph data. The following looks at loss ratio as a function of vehicle kills. As stated previously, loss ratio and infantry kills are perfectly correlated and, therefore, fungible.

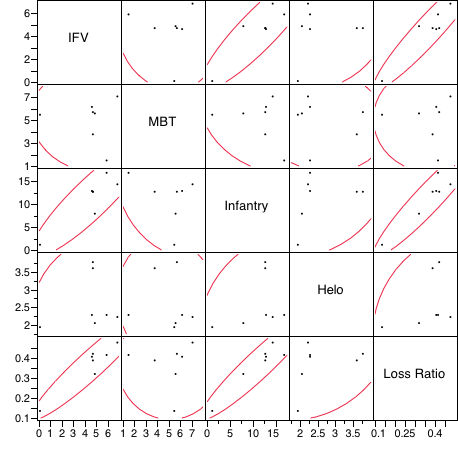
**Actual by Predicted Plot**

**Vehicle Kills vs. Loss Ratio**



The graph shows the actual reported loss ratio along the *y-*axis and displays that against the predicted loss ratio based on vehicle kills. All of the data points but one fall within the predicted range and the analysis of variants yielded a statistically significant ­*p-*value of 0.0176, showing again that vehicle kills are a good predictor for infantry loss taking into account both first- and second-order effects.

**Scatterplot Matrix**



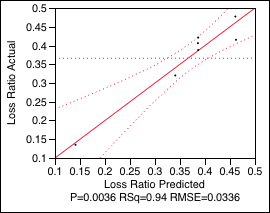
Drilling down farther into the individual squad effects, we notice that the two types of squads that have the greatest effect on loss ratio are Infantry and IFV. The graph “Scatterplot Matrix” shows the correlation between each of the pairs of platforms, plus Infantry and Loss Ratio. These are represented by each of the data columns in the table “Average Troop Loss by Platform, by Configuration.”

While the scatter plot data produced a convincing visual overview of the correlations, a more in-depth analysis yielded a better understanding of both Infantry and IFV, which were the most accurate predictors of loss ratio. This analysis was based on total infantry loss, both mounted and dismounted.

The data show that we could expect that improvements to the IFV platform would tend toward the greatest improvements in loss ratio. This is not surprising in that the IFV generally contains the highest concentrations of mounted infantry. However, let us remember that there were nontrivial second-order effects on dismounted infantry, as well, due to improvements in the IFV.

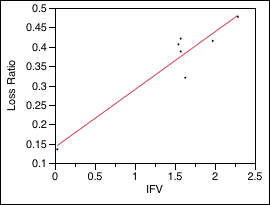
**Actual by Predicted Plot**

**Infantry & IFV vs. Loss Ratio**



Substituting both Infantry and IFV for total vehicle kills reduces our *p-*value to 0.0036, corroborating the findings on the correlation matrix that Infantry and IFV are better predictors of loss ratio that total vehicle kills.

**Regression Plot**



Also supporting these findings is the fit model for IFV, independently, to loss ratio bringing the *p-*value all the way down to 0.0013. The analysis reflects platform kills and those infantry losses resulting directly from the platform kill but no second-order effects like dismounted infantry loss or effects on force protection to other platforms. This highlights the value of the IFV platform to loss ratio and reasserts the importance that improvements to the IFV have to force protection. This was also reflected in the apparent improvements due to composite armor on that platform, for example.