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An Integrated Weather Effects Decision Aid Parameter Weighting Scheme

by Richard J. Szymber, Terry Jameson, David Knapp

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NOTICES

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14. ABSTRACT

An Integrated Weather Effects Decision Aid (IWEDA) rules impact Parameter Weighting Scheme (PWS) has been developed for possible future incorporation in the new My Weather Impacts Decision Aid (MyWIDA). The PWS capability would allow the MyWIDA operator to focus on the most critical weather parameters affecting mission success based on the forecast weather situation, tactical scenario, and mission profile; by choosing the most mission-critical parameters and assigning relative weights according to their importance on operations. The PWS outputs a composite "impact score" at each grid cell for every weather forecast model level. This Cell Impact Score (CIS) quantifies how significantly the weather will impact a mission based on a simple scheme of assigning each parameter a light, moderate, or heavy weight. The development of this prototype PWS capability may eventually more accurately present IWEDA mission impacts due to adverse weather conditions and better-represent the "stoplight code" (green/amber/red) continuum.

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1. Introduction

The Integrated Weather Effects Decision Aid (IWEDA), originally developed by the U.S. Army Research Laboratory (ARL) in 1992, has been fielded on the Integrated Meteorological System (IMETS) since 1997 to provide tactical weather support to the U.S. Army. Background information describing the IWEDA software and its capabilities can be found in Sauter et al., (1999). Verification and validation studies and results of the IWEDA model output are summarized in Raby, et al. (2003). Underlying information on the IWEDA rules development, description, assumptions and criteria is contained in Szymber (2008). The Army IWEDA rules database and IWEDA model software developed by ARL were officially certified and accredited for the Army by the Department of the Army (2006).

By using and experiencing IWEDA over the years, observations have emerged identifying needs for potential improvements: a need to derive overall mission impact due to adverse weather conditions, rather than simply presenting "worst-case" conditions; and a need to better-represent the discrete color-coded impact values (IVs). A prototype Parameter Weighting Scheme (PWS) has been developed to address the need for IWEDA to provide more quantifiable information on the magnitude of weather impacts as portrayed in the traditional IVs. The IWEDA rules "stoplight" code for the IVs has always employed three discrete colors (see figure 1): (1) "green" for favorable impacts (weather impact degradation < 30%), (2) "amber" for marginal impacts (weather impact degradation=30−70%), and (3) "red" for unfavorable impacts (weather impact degradation > 70%). The basis and criteria for this standard "stoplight" code is taken from the Department of the Army (1992).

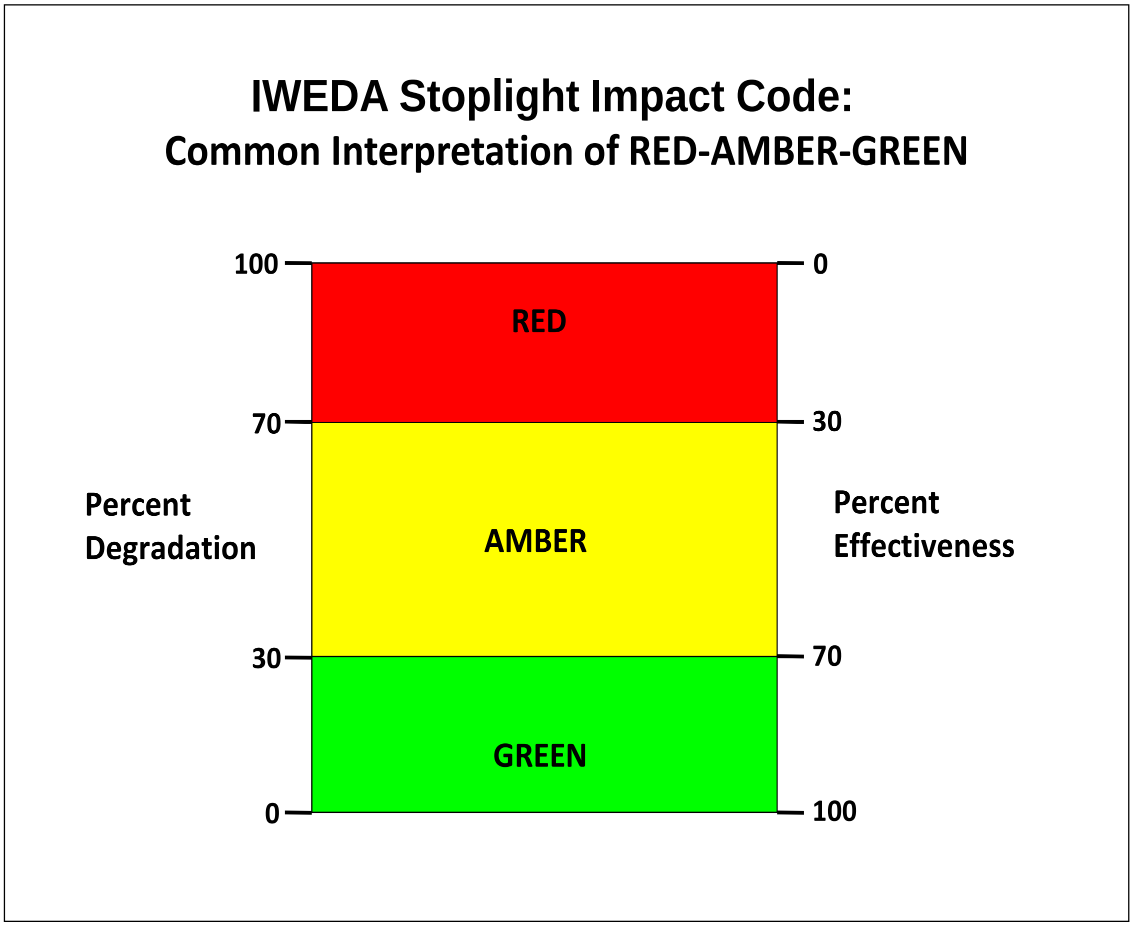

Figure 1. Original IWEDA impact color code.

The novel PWS has been designed (currently as a Java code) to calculate an overall/total mission impact score (by grid cell), based upon the original IVs output by IWEDA, and upon user-input weights assigned to the applicable weather parameters. The PWS outputs a continuum of 10 discrete colors (three minimal impact colors, four moderate impact colors, and three significant impact colors). As depicted in figure 2, this provides additional, quantified information on how negligible or severe the impacts are. The PWS approach provides substantially more information/detail compared to the original IWEDA impact code, as shown in figure 3. It allows the user to prioritize the impacts by assigning greater or lesser significance to certain weather parameters based on tactical mission considerations, and the forecast weather conditions and large-scale patterns. The PWS provides a capability for user-defined, tailored weather impact weights identifying the most important (heavily weighted), marginally important (moderately weighted) or least important (lightly weighted) impact rules parameters, which results in an overall total impact score and associated impact color code. The objective of the PWS is to give the IWEDA user and decision maker (e.g., Air Force Staff Weather Officer and Army Intelligence Officer, Commander, or Warfighter) an improved overall picture and assessment of weather impacts on his/her plans, while highlighting the potential worst-case conditions, based on prioritizing the importance of specific weather parameters on the mission.

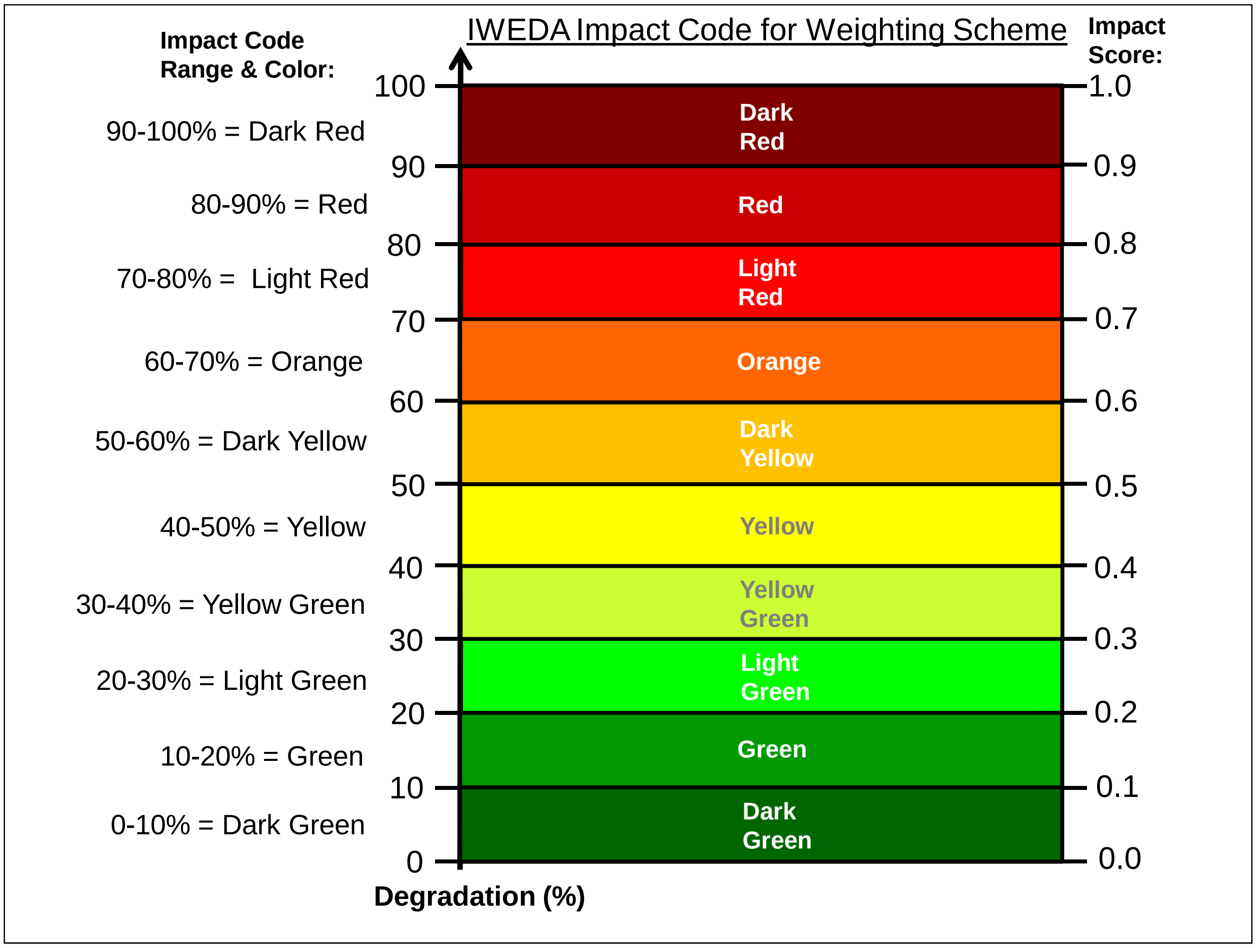

Figure 2. Parameter-weighting scheme impact color code.

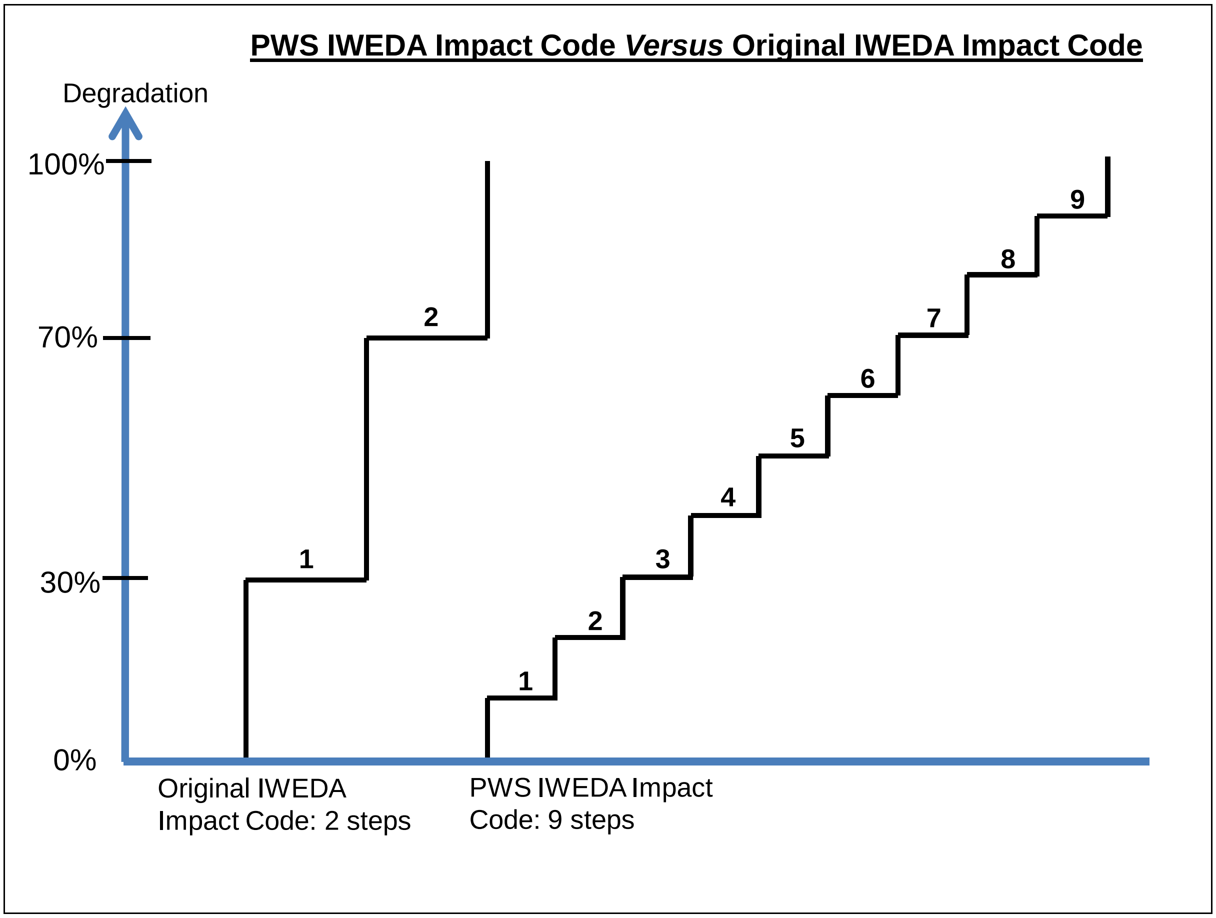

Figure 3. Comparisons of original and PWS IWEDA impact code step functions.

2. Army Missions and Weather Impact Parameters

Szymber (2008) contains the official (1990–2005) U. S. Army weather and environmental data support requirements, and critical threshold values and impacts as stated and validated by Army user agencies and Training and Doctrine Command (TRADOC) proponent centers and schools. The information in Szymber (2008) was used to develop a special set of Army "Mission Command" IWEDA rules. This Army "Mission Command" IWEDA rules set is based on "essential" weather/environmental elements and critical thresholds impacting major Army battlefield systems, operations and tactics, as certified by Army users and the TRADOC proponents. By definition, "essential" data (weather/environmental parameters and thresholds) affect user systems and operations so significantly that a response by the user is required when critical values of these elements occur. The Army "Mission Command" IWEDA rules set contains over 450 mission/operations rules for the 16 Army branch mission areas listed in table

1, and are based on approximately 25 essential weather and environmental parameters, which are listed in table 2.

Table 1. Army "Mission Command" IWEDA rules set mission areas.

Army Mission Areas (Thresholds and Impacts IWEDA Rule Set[a])	
Air Defense Artillery Operations	Medical/Health Services Operations
Armor Operations	Ordnance Operations
Aviation Operations	Quartermaster/Logistics Operations
Chemical Operations	Signal Operations
Engineer Operations	Soldier Support/Personnel Operations
Field Artillery Operations	Special Forces Operations
Infantry Operations	Transportation Operations
Intelligence Operations	
Military Police Operations	

[a] Based on weather/environmental elements certified by the Army user as causing significant impact on their systems, operations, and mission.

Table 2. Army "Mission Command" IWEDA rules set essential weather/ environmental data parameters.

Critical Environmental Impact Threshold Forecast Parameters for Army Mission Areas
Clouds (cloud ceiling, cloud/sky cover)
Humidity (surface)
Icing (aloft)
Illumination (ambient)
Obstructions to vision (fog, blowing dust/sand/snow)
Precipitation (rain, snow, freezing rain, hail)
Severe weather (severe thunderstorms [damaging wind and hail] torrential rain and flooding, tornadoes, hurricanes)
State-of-the-ground (snow depth, freeze/thaw depth, mud, ice)
Temperature (surface)
Thunderstorms/lightning (proximity/distance from site, probability)
Turbulence (aloft)
Visibility (surface)
Wind speed (surface and aloft, wind direction)

The PWS is well-suited to be used in conjunction with the special "Mission Command" IWEDA rules set for Army mission areas. This is because the mission-level rules set represents the most important, most used rules as determined by Army users, and as validated by the Army TRADOC Centers and Schools. The PWS can still be used with the conventional IWEDA rules set for Army systems, subsystems and components; however, mission-level impact rules have a higher priority or level of importance over system/subsystem level impact rules. IWEDA rules for missions/operations provide a top-down approach to the view of adverse weather impacts, whereas rules for systems/subsystems/components provide a bottom-up approach. Mission operations rules are based on thresholds of the weakest link (i.e., most restrictive threshold value) compared to system/subsystem/component asset hierarchy IWEDA rules, which always bubble-up the worst-case IVs. Additionally, mission/operations rules are more generalized in nature; whereas systems, subsystems and component IWEDA rules provide a greater level of detail and complexity.

ARL is developing the second generation of IWEDA, called the My Weather Impacts Decision Aid (MyWIDA). The meteorological forecast model basis for using the PWS on MyWIDA is summarized in figure 4 for two primary Army levels of command–Division and Brigade echelons. The modeling information in table 3 was derived from the Army tactical weather support requirements for meteorological forecasts outlined in Szymber (2003).

MyWIDA is part of the next generation of the original IWEDA and is a new development in the program (i.e., IWEDA Gen II Web Services). MyWIDA provides users with a personalized and customized IWEDA capability, tailored to their unit and missions. It allows operational commanders to determine critical weather and environmental thresholds, balancing the safety and efficiency factors of tactical operations with the criticality of the mission. It also allows battlefield components to identify additional weather/environmental parameters (and thresholds) which may affect operation and should be considered in planning and operations. Key features of MyWIDA include (1) a dynamic rules set with adjustable thresholds and the ability to locally modify and save the dynamic rules set, (2) a new streamlined mission-level operations rules set to compliment and use in conjunction with the larger asset-hierarchal system/subsystem/component rules set (providing both a top-down and bottom-up approach to view of impacts through rules cascading levels of importance), and (3) the ability for users to simply input a localized and tailored rules set independent of the sets mentioned in (1) and (2).

Table 3. Basic meteorological forecast model requirements for Army divisions/brigades.

MyWIDA PWS Basis

• Division level=parameters from GFS (via JMBL)
  • AOI (domain)=350 × 350 km
  • Horizontal resolution=35 × 35 km
  • Vertical resolution=10 pressure levels (sfc to 700 mb)
• Brigade level=parameters from WRF GRIB (via JMBL)
  • AOI (domain)=100 × 100 km
  • Horizontal resolution=10 × 10 km
  • Vertical resolution=30 Sigma levels (sfc to 10,000 feet MSL)

3. PWS and Concept

Army mission planners must be aware of the weather factors that will affect their operations, ensuring the greatest chance of mission success. Use of the PWS involves determining, which forecast weather parameters might have the greatest impact on assigned missions and, therefore, should be given extra consideration and special weighting in operational planning. The PWS can be used when mission operators and planners have a priori knowledge of impending storm systems and associated significant weather events/factors that will impact their area of interest and conduct of operations. Factors influencing the importance of weather parameters when considering which to weight and by how much involve (1) the weather parameter's criticality to the mission operations (i.e., the criticality to the tactical situation and scenario and criticality to the mission profile [especially with respect to time and location]); and (2) the parameter's importance from the standpoint of the weather situation/scenario, based on the synoptic forecast and long-range outlook, climatology and seasonality, geography, and terrain interactions and influences.

For any given mission there may be factors— either meteorological or operational or both—that cause certain events to be more important or significant to mission success than others. Accordingly, it may sometimes be useful or necessary to accommodate the ability to specify relative weights of "importance" for individual events through a parameter/rules weighting methodology. The PWS is designed to operate in two modes: one where the user chooses which parameters to weight and inputs the weights according to the three categories: heavily weighted, moderately weighted, and lightly weighted. The other mode defaults to equal parameter weights where the user does not have to provide any weighting input. Whether specific weight categories are assigned to each parameter or the system defaults to applying equal weights to all weather parameters associated with a selected mission, the PWS provides a composite impact score ranging from 0.0 to 1.0. This Cell Impact Score (CIS) is graphically represented at a grid point by a map plot with a graduated transition from dark green to shades of amber to dark red that corresponds to an 0−100% mission degradation. The CIS reflects the actual number of red, amber, and green IVs registered (and their assigned weights) based on the forecasted weather values, rather than indicating the one “worst-case” value bubbled up as is done in the original IWEDA calculated output.

A basic premise of the PWS is that out of all the associated IWEDA rules weather parameters for a selected mission. The user determines which weather parameters he/she wants to weight. For each of the parameters that will be weighted, the operator assigns an appropriate weight category, choosing from three options: lightly weighted, moderately weighted, or heavily weighted. Multiplying factors are assigned by the PWS accordingly that are referenced to the equal-weight amount. The moderate-weighting multiplying factor is set at 1.0 (meaning a moderately-weighted parameter has the same weight as if all parameters were weighted equally); the light-weighting multiplying factor is half the moderate weight value (i.e., 0.5) and the heavy-weighting multiplying factor, which is automatically calculated by the PWS algorithm. Its exact value is a function of how many parameters are being weighted and how many fall into each of the three weighting categories. Based on the number of parameters chosen for weighting, the program automatically calculates the equal parameter weight, then the light, moderate, and heavy parameter weights. Any remaining weather parameters not chosen for weighting are zero weighted.

Section 3.1 outlines the basic PWS assumptions applied in the algorithm. Section 3.2 describes the formulas used to automatically calculate the parameter weights. A graphical representation of the parameter weight development is provided in figure 4, which aids in visualizing the proportions of the total weights for an example involving six parameters. Section 3.3 outlines the overall multiple PWS for six weighted parameters as used in the example shown in figure 4.

3.1 Cell Impact Score Computation

The following steps are taken to compute the CIS:

1. Parameters are chosen from the mission-level IWEDA rules set that are selected for inclusion in this particular mission (those that will be “non-zero-weighted”). Parameters from the rules set that are not selected are zero weighted and have no impact upon the final CIS.

2. The individual parameter weights are determined (see section 3.2).

3. IVs arrays are read in for each IWEDA grid cell and forecast model level (i.e., a three-dimensional array of 0s, 1s, and 2s), for each parameter being weighted. For example, if six parameters are being included in the analysis, six 3-D IV arrays would be input.

4. For each cell and each parameter, the IV for that cell is multiplied by the parameter weight. These products are called the Weighted Impact Values (WIV).

5. The WIVs for all parameters are then summed, obtaining the Sum of the Weighted Impact Values (SWIV). The SWIV is found for each individual IWEDA cell.
6. Finally, the SWIV for each cell is divided by 2.0. This quotient is the CIS. Dividing by 2.0 "normalizes" the CIS, since 2.0 is the maximum value possible for the SWIV. This would occur only if the IV for every parameter (for that cell) was 2.0. In that case, the actual CIS would then be 1.0 (its maximum value).

3.2 Parameter Weight Development

The sum of the weights for those parameters selected for inclusion in the analysis (the non-zero-weighted parameters) must equal 1.0. If all parameters were to be weighted equally, that equal weight ("eq_param_wgt") is found by dividing 1.0 by the number of parameters. As coded in the PWS Java program, in equation form this is

eq_param_wgt = 1.0 / num_non_zero_wgtd_params; (1)

This equal parameter weight is a variable value, being a function of the number of parameters included in the analysis.

As described in section 3.1, the parameter weights have been separated into three categories (that are referenced to the equal parameter weight): light, moderate, and heavy. The three weights are found by applying a multiplying factor to the equal parameter weight as shown in table 4.

Table 4. Equal parameter weight multiplying factors with and associated IVs.

IVs	Multiplying Factors for Weights
0=Favorable (Green)	Light-weight multiplying factor=0.5
1=Marginal (Amber)	Moderate weight multiplying factor=1.0
2=Unfavorable (Red)	Heavy weighting factor=Derived

As a starting point in the PWS conceptual development, the moderate parameter weight ("mod_wgt") was chosen to be the same as the equal weight (i.e., the multiplying factor is 1.0).

mod_wgt = eq_param_wgt * 1.0; (2)

To facilitate the initial PWS investigations, the light parameter weight ("lgt_wgt") was somewhat arbitrarily set to be one-half of the equal weight.

$$lgt\_wgt = eq\_param\_wgt * 0.5; \quad (3)$$

With the various parameters falling into one of the three weighting categories, the sum of their weights still has to equal 1.0. More specifically; the number of lightly-weighted parameters multiplied by the light-weighting factor…plus…the number of moderately-weighted parameters multiplied by the moderate-weighting factor…plus…the number of heavily-weighted parameters multiplied by the heavy-weighting factor, must equal 1.0.

In equation form this is

$$tot\_wgt = 1.0 = (num\_lgt * lgt\_wgt) + (num\_mod * mod\_wgt) + (num\_hvy * hvy\_wgt); \quad (4)$$

In the development of the three weighting factors, the remaining unknown is the heavy weighting factor ("hvy_wgt"). The preceding equation can be rearranged to solve for "hvy_wgt". Two substitutions have been made prior to solving the equation for "hvy_wgt", those being

$$lgt\_wgt = eq\_param\_wgt * 0.5; \quad (5)$$

$$mod\_wgt = eq\_param\_wgt * 1.0;$$

The equation then becomes

$$hvy\_wgt = \frac{1.0 - (eq\_param\_wgt * (0.5 * num\_lgt + 1.0 * num\_mod))}{num\_hvy}; \quad (6)$$

Figure 4 is a pie-chart graphical depiction of how the parameter weights are determined using the above equations. In this particular example, six parameters are chosen to "play" in the analysis; three of which are to be lightly weighted, one of which is to be moderately weighted, and the remaining two being heavily weighted.

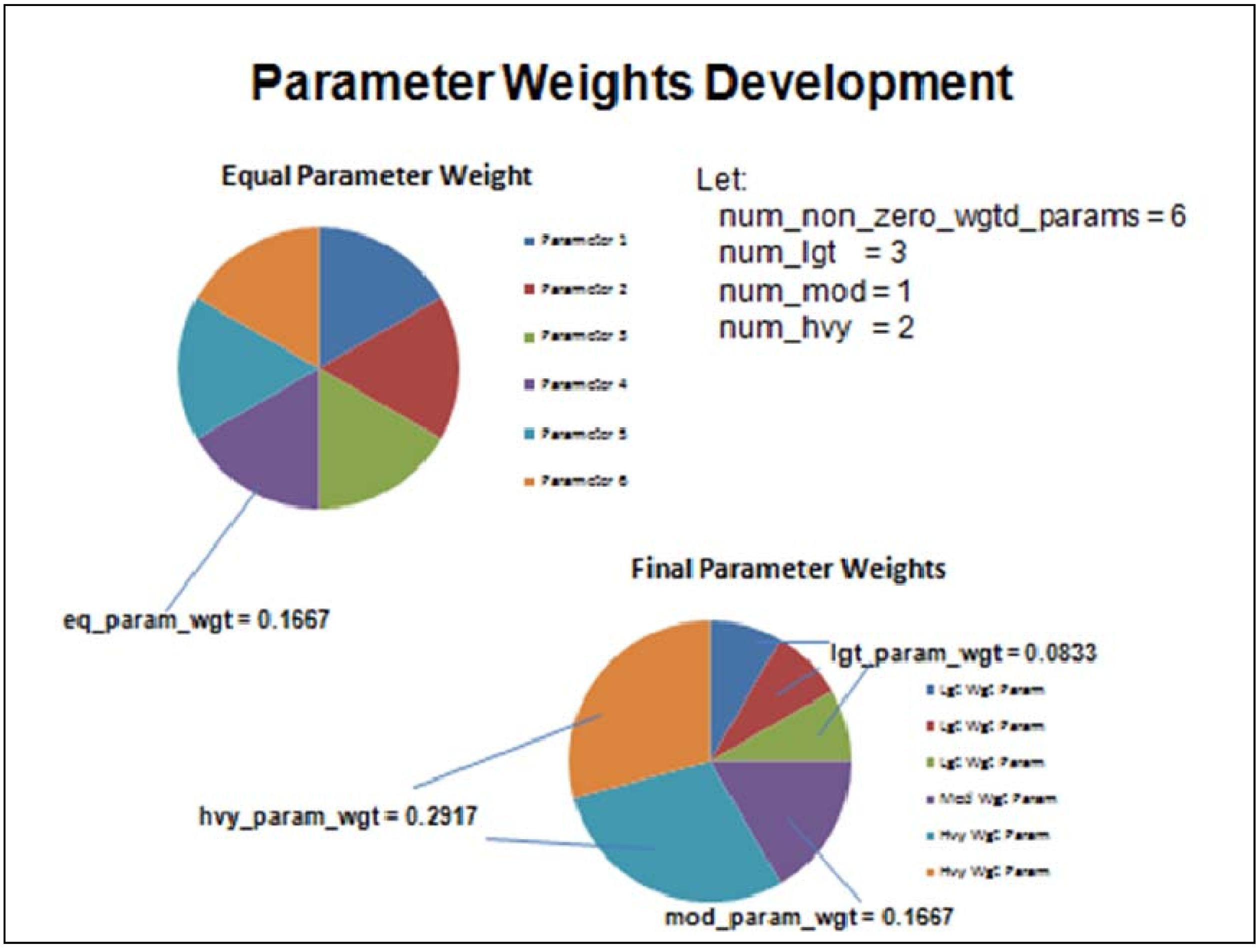

Figure 4. Proportionality of total weights; comparison of the final parameter weights to the equal parameter weights for six parameters.

1. Find the WIVs (for each parameter [n = 1−6] for each cell [x,y,z] in the 3-D IWEDA domain):

   WIV(1) = param_wgt(1) * IV(1)

   WIV(2) = param_wgt(2) * IV(2)

   WIV(3) = param_wgt(3) * IV(3)

   WIV(4) = param_wgt(4) * IV(4)

   WIV(5) = param_wgt(5) * IV(5)

   WIV(6) = param_wgt(6) * IV(6)

2. Find the sum of the WIVs (for this cell):

$$\text{SWIV}(x,y,z) = \sum \text{WIV}(n) \tag{7}$$

where SWIV=the summation of the WIVs.

3. Find the CIS (for this cell):

$$\text{CIS}(x,y,z) = \text{SWIV}(x,y,z) \;/\; 2.0 \tag{8}$$

where 2.0=is the maximum possible "SWIV" for any given cell.

Section 4 includes an actual CIS analysis using the prototype PWS Java code.

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4. PWS Algorithm and Notional Output

In this section, we continue the example started in section 3 by using the PWS with six selected parameters. For purpose of simplicity, the basic PWS algorithm described in section 4.1, and associated example calculation given in section 4.2, uses a representative Battalion-level ground operations mission that has adverse impacts accounted for by a set of IWEDA rules based on 12 weather parameters (of which six parameters are chosen to be weighted). The mission Area of Operations/Interest (AOI) is a 60 × 60-km area with horizontal grid cells 10 × 10 km in size (six rows and six columns of cells) for one vertical level (at the surface).

4.1 PWS Algorithm Setup

The basic PWS algorithm setup for a specific scenario is described below:

1. Input: number of rows (e.g.,= 6), number of columns (e.g.,=6), number of levels (e.g.,=30) in the IWEDA domain and total number of parameters in the particular mission-level IWEDA rules set (e.g.,=12).

2. Select: number of zero-weighted parameters (e.g.,=6 [out of 12 total parameters]), lightly-weighted (e.g.,=3), moderately-weighted (e.g.,=1), and heavily-weighted (e.g.,=2) parameters.

3. Find equal parameter weight:=1/number non-zero parameters (e.g.,=/6=0.1667).

4. Apply the selected multiplying factors for the light and moderate weights: light multiplying factor (L) = 0.5, moderate multiplying factor (M) = 1.0.

5. Calculate the three weights: light weight=L * equal_wt = 0.5 × 0.1667 = 0.083; moderate weight=M * equal_wt = 1.0 × 0.1667 = 0.1667, then solve for the heavy weight (=0.2917) using the rearranged "total weight" equation.
6. Assign weights to specific parameters: e.g., thunderstorms , temperature and wind speed=light weight=0.0833; visibility=moderate weight=0.1667, precipitation and snow depth=heavy weight=0.2917.
7. Read in the impact values (IVs) for each level, parameter, row, and column.
8. Calculate impact scores by level, row, column, (grid cell), by parameter:
    a. Find weighted impact value by cell and parameter=parameter weight × impact value.
    b. Find sum of the weighted impact values by cell.
    c. Find CIS=sum weighted impact values/2.0.
9. Assign appropriate colors for CIS values and plot.

4.2 Example Calculation—Six weighted parameters, one level (surface), 6 × 6 rows/columns

Based upon the algorithm setup described in section 4.1, the following numerical calculations were made.

1. The equal parameter weight is: 0.1667

    The moderate parameter weight is: 0.1667

    The light parameter weight is: 0.0833

    The heavy parameter weight is: 0.2917

2. The Parameter 1 weight is: 0.0833

    The Parameter 2 weight is: 0.0833

    The Parameter 3 weight is: 0.0833

    The Parameter 4 weight is: 0.1667

    The Parameter 5 weight is: 0.2917

    The Parameter 6 weight is: 0.2917

3. These are the IVs for AOI level: 1, Parameter: 1 (Thunderstorms)

1	1	2	0	2	0
2	1	0	2	2	1
0	1	1	2	1	0
2	1	1	0	2	1
0	2	2	1	0	1
1	1	0	2	2	1

These are the IVs for AOI level: 1, Parameter: 2 (Temperature)

1	1	0	2	1	1
0	2	2	1	0	1
2	1	1	0	2	0
1	1	2	0	2	0
0	1	2	2	2	0
2	1	0	2	2	1

These are the IVs for AOI level: 1, Parameter: 3 (Wind Speed)

1	1	2	0	2	0
2	1	1	0	2	0
0	2	2	1	2	1
0	1	2	2	1	0
2	1	0	2	0	1
2	1	0	2	2	1

These are the IVs for AOI level: 1, Parameter: 4 (Visibility)

1	1	0	2	0	1
0	2	2	1	2	1
2	1	1	0	2	0
1	1	2	0	2	0
0	1	2	2	2	0
2	1	0	1	0	1

These are the IVs for AOI level: 1, Parameter: 5 (Precipitation)

0	1	2	2	2	0
0	1	2	2	2	0
0	1	2	2	2	0
0	1	2	2	2	0
0	1	2	2	2	0
0	1	2	2	2	0

These are the IVs for AOI level: 1, Parameter: 6 (Snow Depth)

1	1	0	2	1	1
0	2	2	1	2	1
2	1	1	0	2	0
1	1	2	0	2	0
0	1	2	2	2	0
2	1	0	2	2	1

4. Example Calculation: 6 weighted parameters, 1 level (surface), Row 1, Col 1

   $1 \times 0.0833 = 0.0833$ (Weighted IV for Parameter 1)

   $1 \times 0.0833 = 0.0833$ (Weighted IV for Parameter 2)

   $1 \times 0.0833 = 0.0833$ (Weighted IV for Parameter 3)

   $1 \times 0.1667 = 0.1667$ (Weighted IV for Parameter 4)

   $0 \times 0.2917 = 0.0000$ (Weighted IV for Parameter 5)

   $1 \times 0.2917 = 0.2917$ (Weighted IV for Parameter 6)

   TOTAL =0.7083 (Sum of the Weighted IVs)

   Maximum possible Sum of the Weighted IVs:=2.0

   Normalized Sum of the weighted IVs=0.7083 / 2.0 = 0.3542

   CIS for Row 1, Col 1: 0.3542

5. These are the CIS values for the Level 1 grid:

0.3542	0.5000	0.4583	0.8333	0.6458	0.2708
0.1667	0.7708	0.8750	0.6458	0.9167	0.3125
0.5417	0.5417	0.6875	0.4167	0.9583	0.0417
0.3542	0.5000	0.9583	0.3750	0.9583	0.0417
0.0833	0.5417	0.9167	0.9583	0.8333	0.0833
0.6667	0.5000	0.2917	0.9167	0.8333	0.3542

6. These are the associated CIS colors for the Level 1 grid (see figure 2):

YG	DY	DY	LR	OO	LG
LG	LR	RR	DY	DR	LG
DY	DY	LR	YY	DR	DG
YG	DY	DR	YY	DR	DG
GG	DY	RR	DR	LR	GG
LR	DY	LG	DR	RR	YG

The output overlay of the CIS colors in number 6 above would look similar to the notional output depicted in figure 5, although the figure has 10 rows × 10 columns as opposed to the simplified 6 × 6 example above.

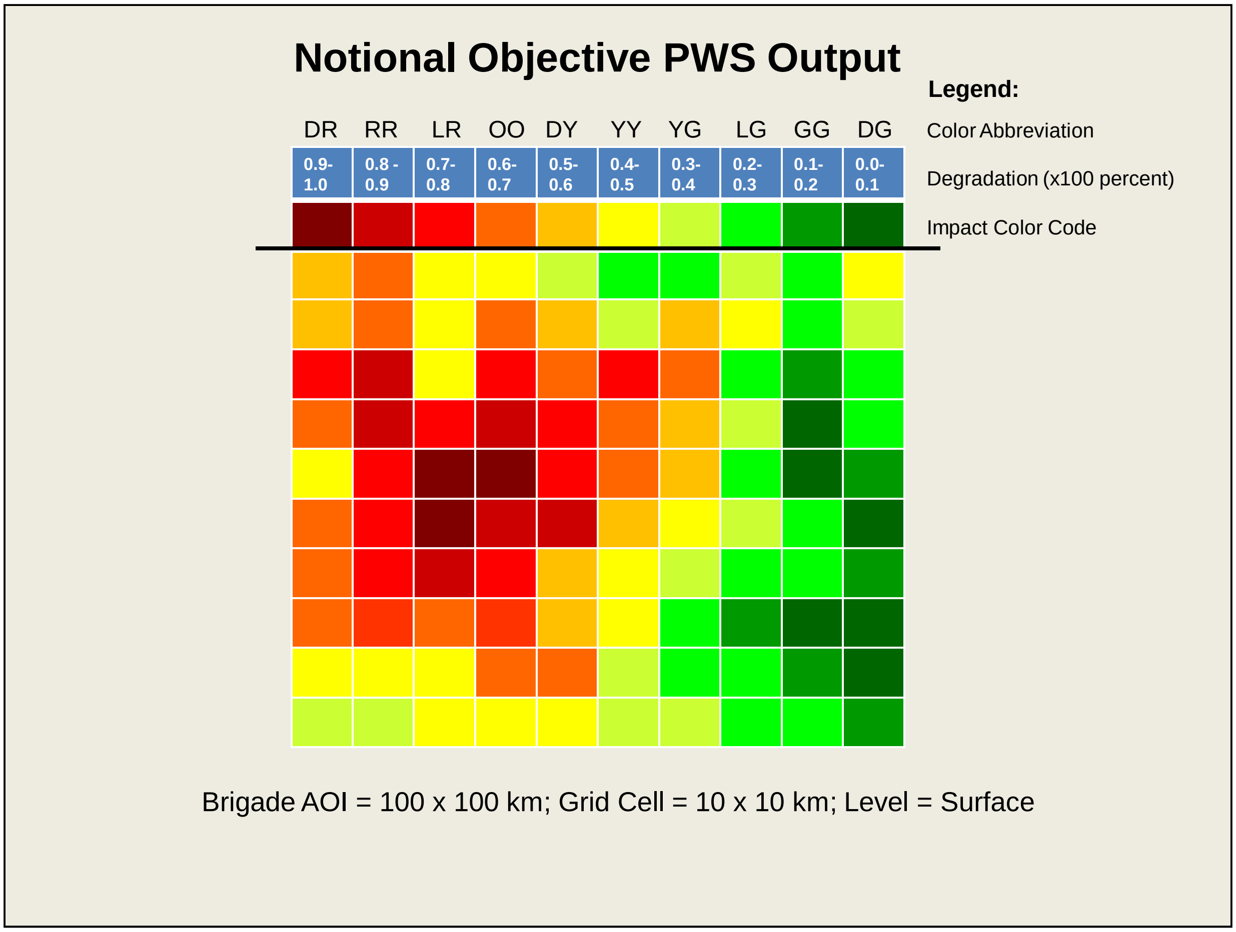

Figure 5. Notional IWEDA rules PWS impacts overlay for an example brigade ground maneuver mission.

The 6 × 6 example above was selected for the sake of simplicity in describing the fundamental concepts of the PWS. The Java algorithm was rerun with input simulating a Brigade-size AOI (a 10 × 10 IWEDA grid) for one level (simulating a ground maneuver mission area). Figure 6 is a notional comparison of the PWS CIS values to the corresponding original IWEDA impacts overlay output. The comparison shows a greater level of detail in the spatial distribution of weather impacts over the AOI, which is achieved through the use of the PWS. For the PWS output overlay in figure 6, strong red areas of extremely unfavorable impacts with operational degradation >90% are displayed, as well as strong green areas of very favorable impact conditions with operational degradation <10%, and areas of all other impact and degradation values in between. These areas are not identifiable in the corresponding original IWEDA output display shown but are simply a notional depiction.

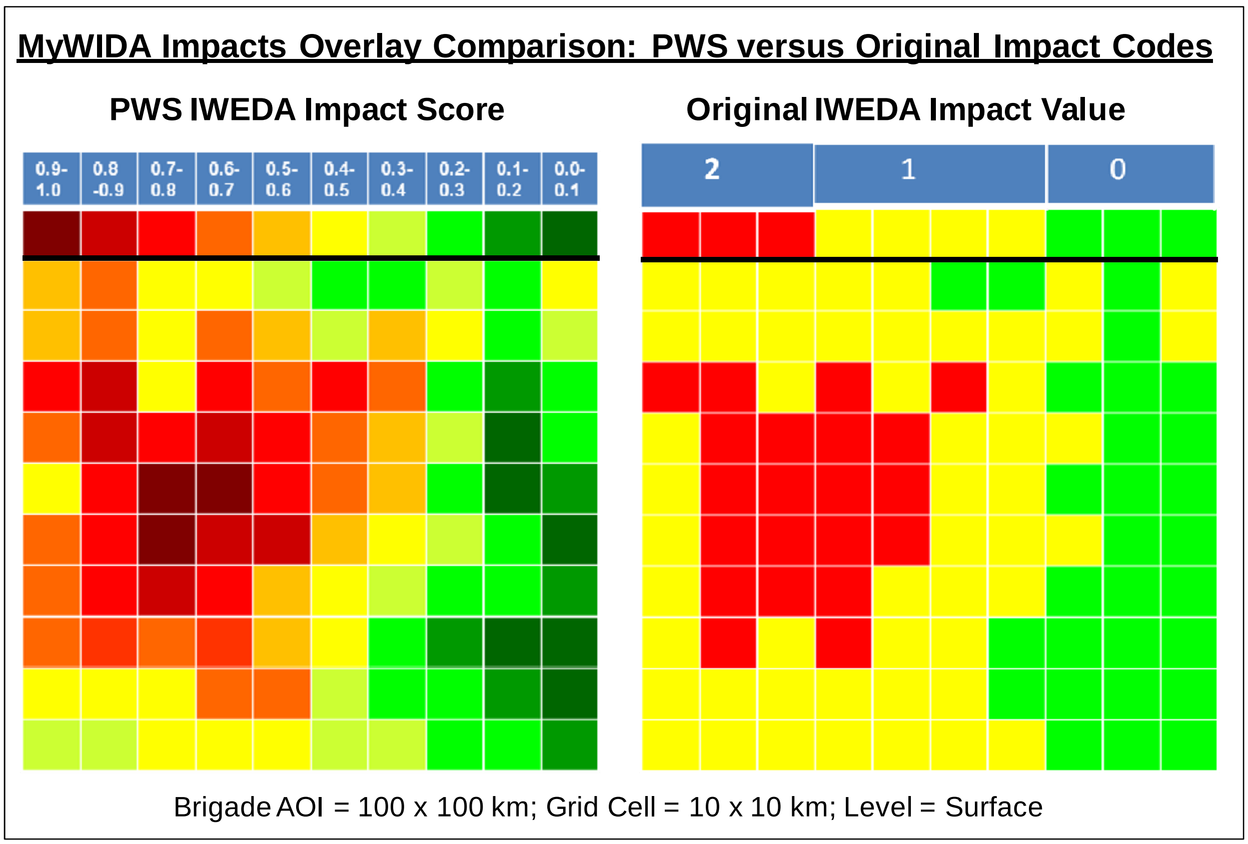

Figure 6. Comparison of notional PWS impacts to original IWEDA impacts output overlays.

Figures 7−10 portray an actual example comparison of the results achieved by using the CIS as opposed to the original IWEDA IVs. For this example, all six parameters will be equally weighted. In figure 7 the original IWEDA IVs overlay are displayed for a hypothetical Parameter 1 and Parameter 2. Figure 8 shows similar information for a hypothetical Parameter 3 and Parameter 4. Note that a severe mission degradation is depicted in the top-left half of the grid for Parameters 1−3 (all red IVs in that section). Similarly, figure 9 displays the IVs for Parameters 5 and 6. Note that Parameters 5 and 6 cause little to no weather impact in the top-left portion of the grid (all green IVs in that section).

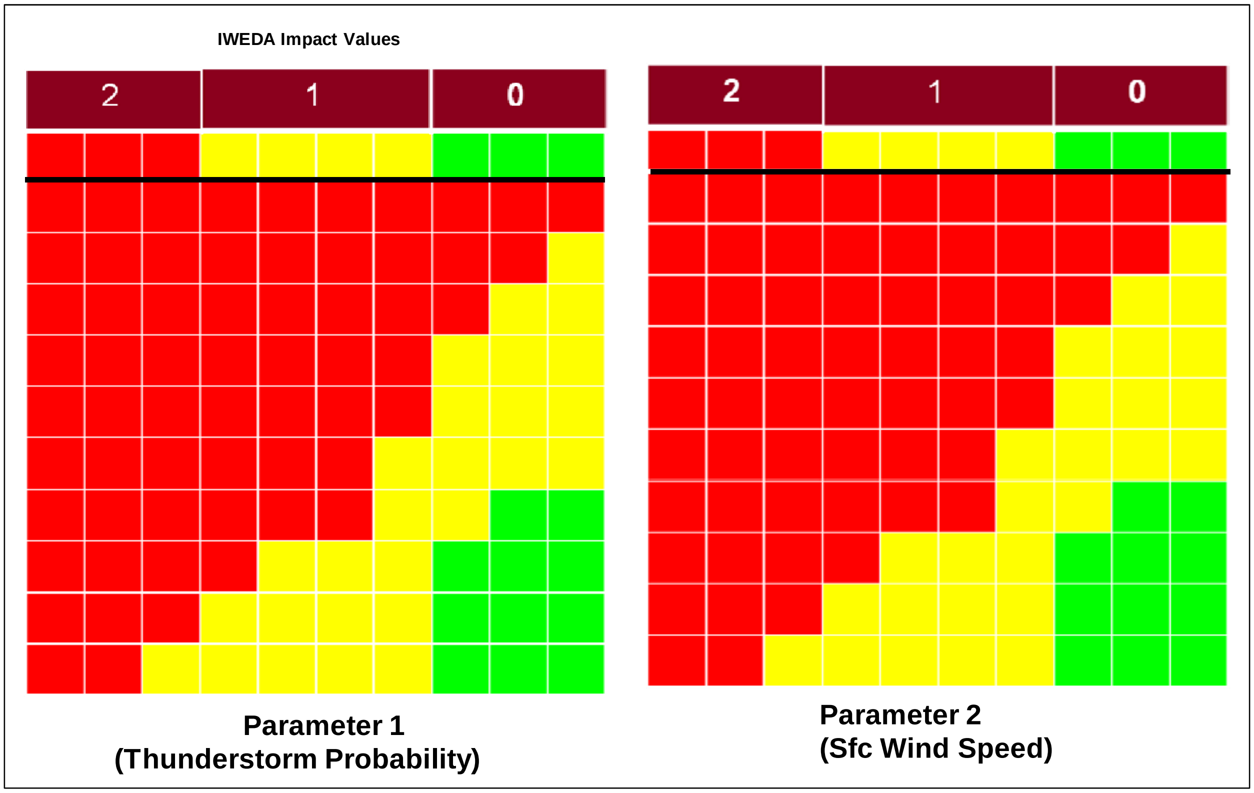

Figure 7. IWEDA IVs for Parameters 1 and 2.

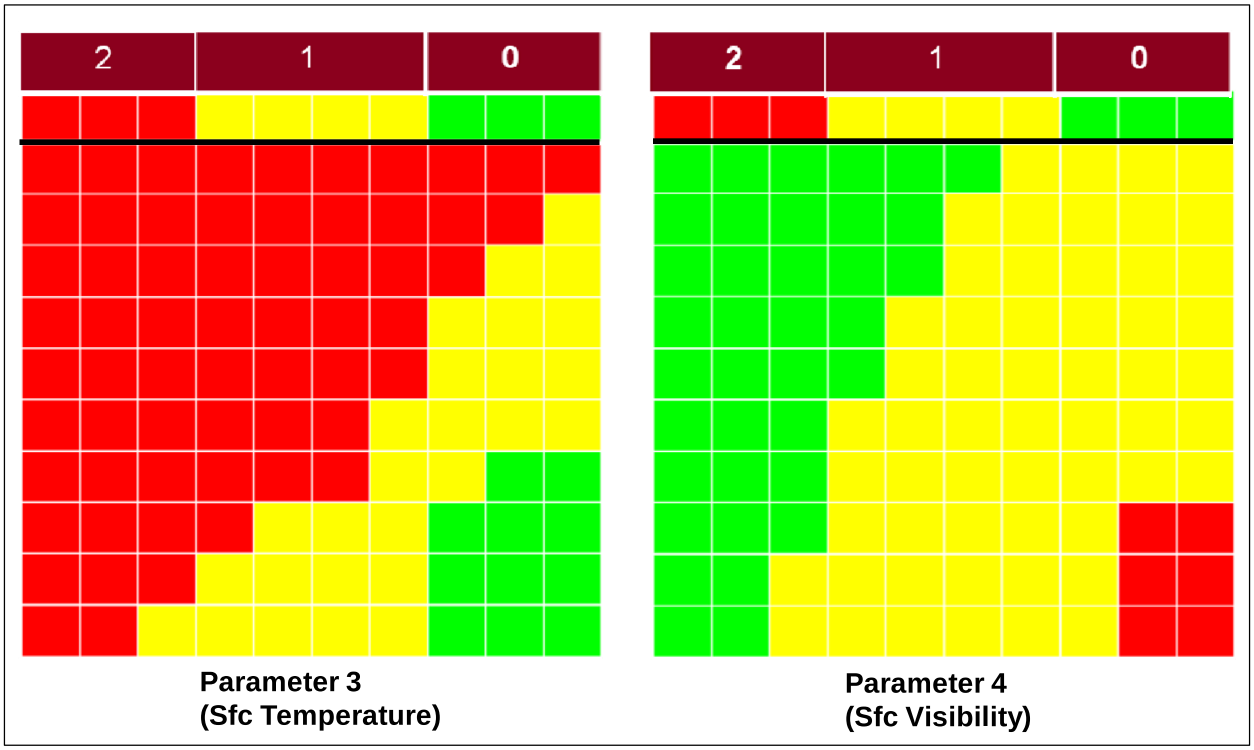

Figure 8. IWEDA IVs for Parameters 3 and 4.

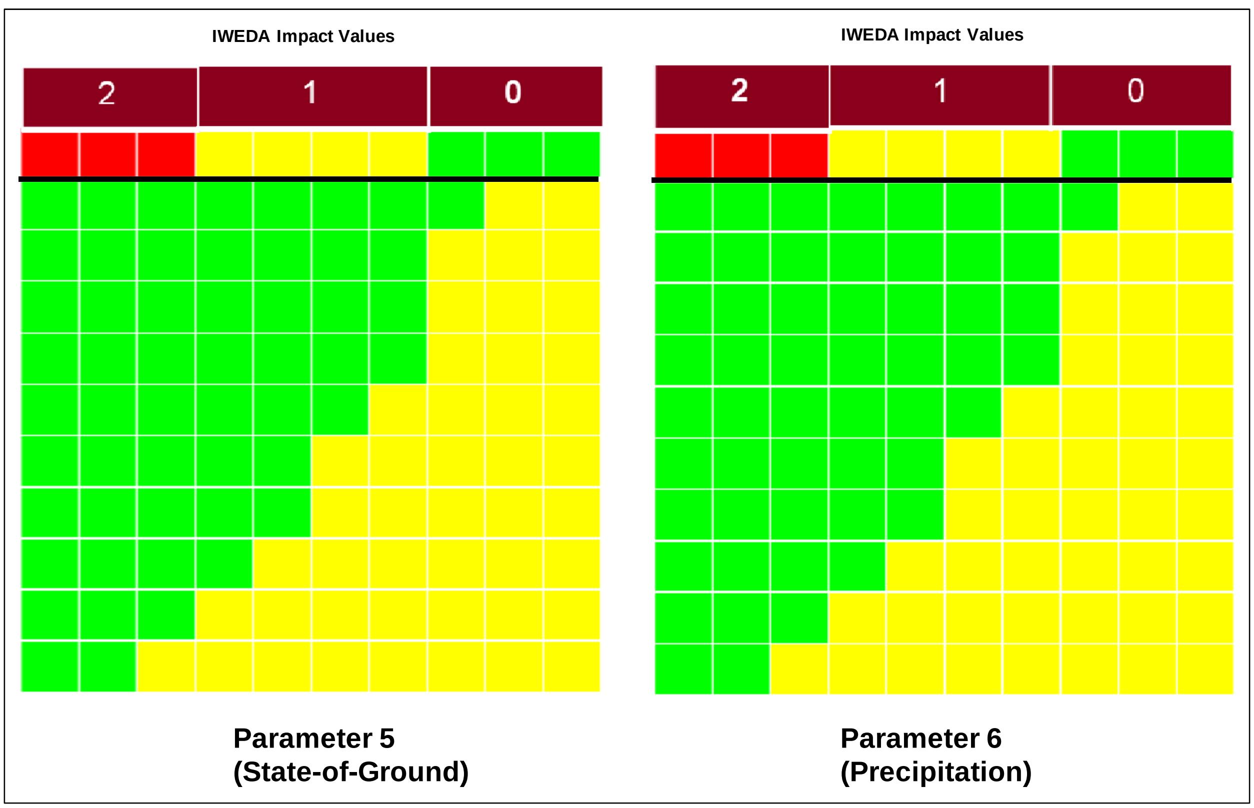

Figure 9. IWEDA IVs for Parameters 5 and 6.

Figure 10 displays the comparison results, which show the output the original IWEDA impacts code would yield versus the output the PWS would generate for this example scenario. The original IWEDA IV plot on the left is a “worst case” composite of the IVs for the six parameters. (i.e., in each cell the color shown indicates the parameter[s]having the highest IV). For this example, every cell had at least one parameter with an IV of “1” (yellow) or “2” (red).

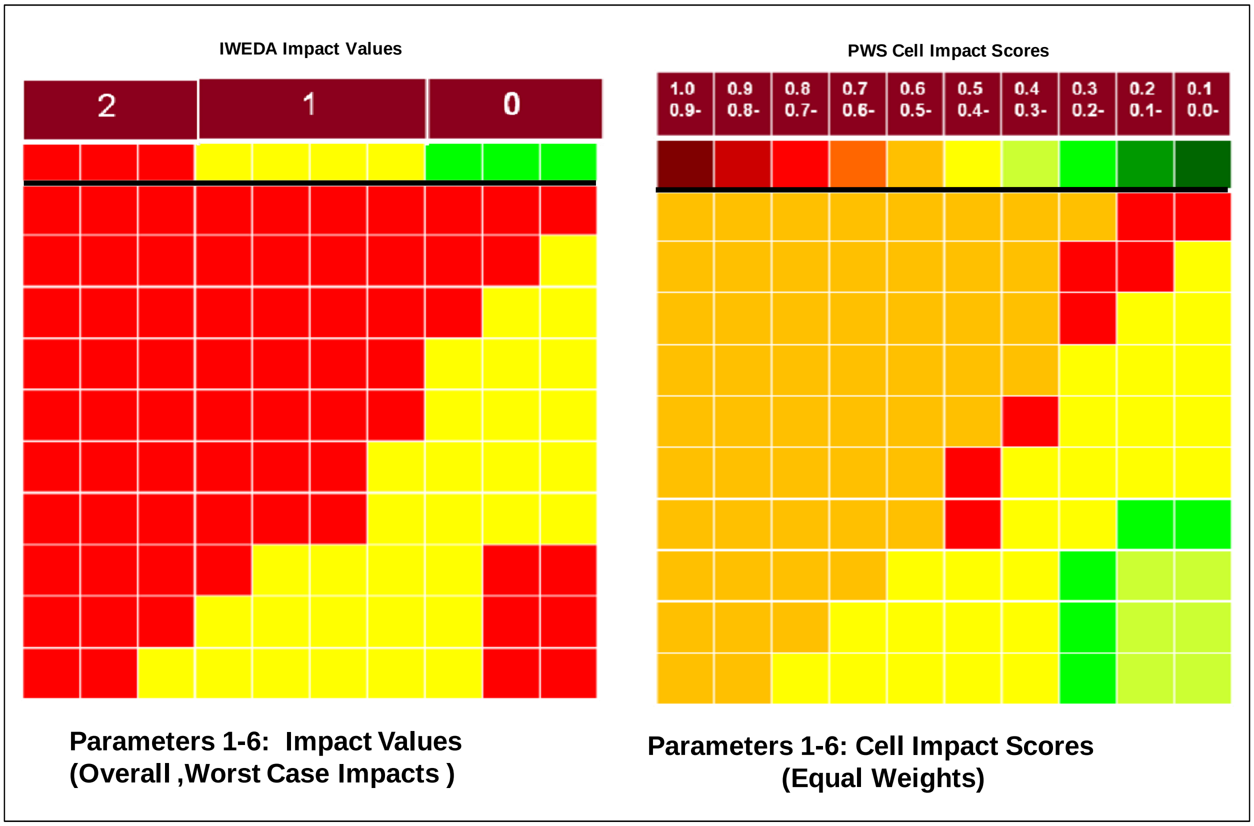

Figure 10. Original IWEDA IVs versus CIS for equally-weighted Parameters 1−6 (from figures 7−9).

The CIS grid on the right side of figure 10 clearly shows that only a few of the cells have a mission degradation of 70−80% (0.7 < CIS < 0.8, colored bright red). Most cells in the top-left half have a mission degradation of 50−60% (0.5 < CIS < 0.6, colored yellow-orange). This is because only two of the parameters involved in this scenario had IVs of “2”.

The comparison in figure 10 is striking, with the PWS producing significantly different results from those of the original IWEDA output. When factoring in how heavily each parameter is to be weighted, an even greater distinction occurs. In figure 11 the same original IWEDA output is shown on the left. For the PWS analysis on the right, however; Parameters 1−3 were lightly weighted, Parameter 4 was moderately weighted, and Parameters 5 and 6 were heavily weighted.

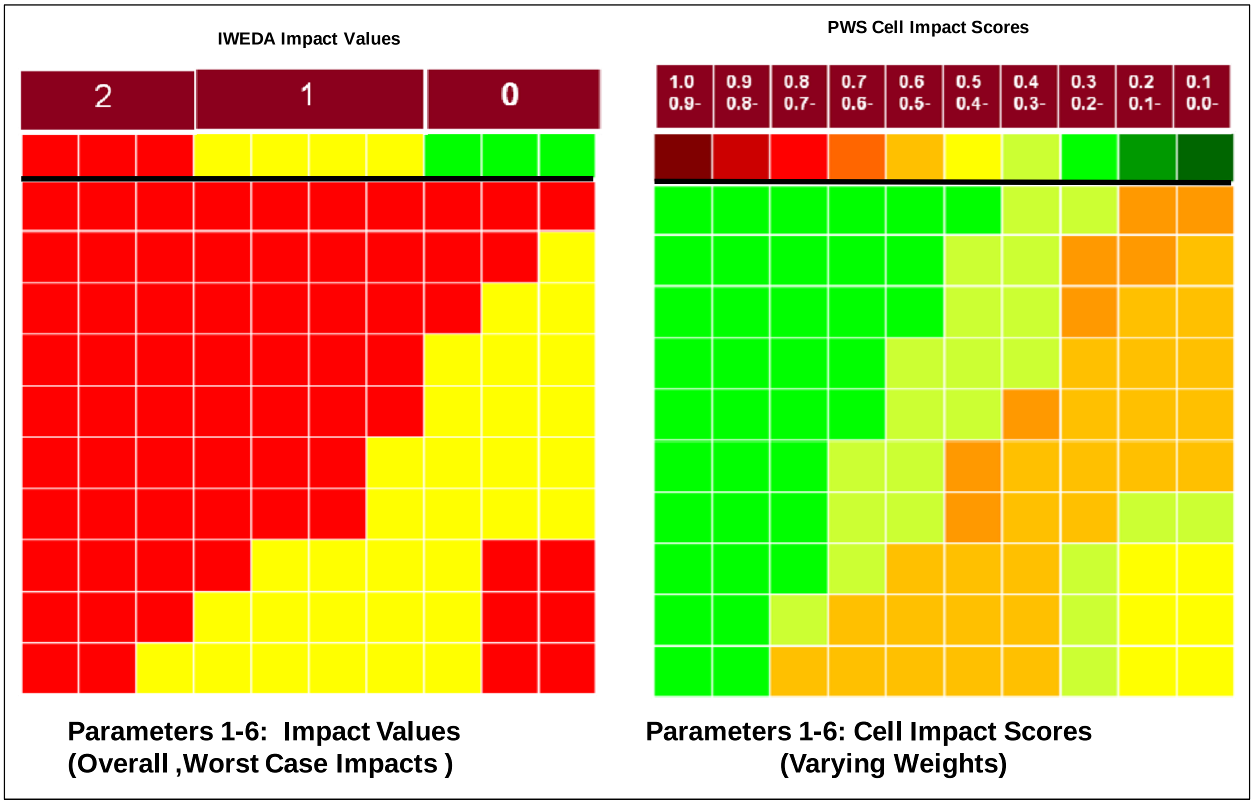

Figure 11. Original IWEDA IVs versus CIS for varying weights for Parameters 1−6.

Figure 11 depicts a "worst-case scenario" in which several parameters that were producing IVs equal to 2 (red) were lightly weighted, whereas two parameters that had exclusively green or amber IVs were heavily weighted. Clearly it is possible to weight the parameters in such a way that the CIS pattern tells a very different story than the original IWEDA IV grid. One concern is that by doing so, important weather impact information could be lost (or at least, smoothed over) when employing the CIS methodology. Several approaches are under consideration that might address this issue:

1. Plot a small symbol that would indicate if one or more of the parameters in the analysis of that cell had a red IV (regardless of the parameter's weight or what the overall CIS came out to be). In this case, the user could mouse-over the grid cell and immediately be shown which parameter (or parameters) had "fired red".

2. Derive an alternate CIS that is based upon some other computational methodology such as the geometric mean of the weighted IVs. A different approach might be found to retain more of the underlying IV information while still providing the benefits of the CIS methodology.

3. Modify the original IVs to indicate by how much the parameter threshold value was exceeded by the forecast. For example, if the surface wind speed "red" threshold is 40 knots, a forecast of 40 knots would produce an IV of 2.0, whereas a forecast of 50 knots

would produce an IV of 2.5. The modified IVs could be color-coded in a 10-step spectrum as are the prototype CIS values

4. Some combination of the above methods.

Additional research is required to assess which PWS appears to provide the optimum CIS value.

5. Conclusion

This report describes the use of an IWEDA PWS, where some key mission weather parameters (i.e., rules) are declared more significant or less significant than others in order to assess the total or overall mission impact due to adverse weather. A 10-step color code is then assigned based on the magnitude or degree of the impacts. The PWS provides a capability to quantify the output of IWEDA rules' degree of impact by describing/portraying "how red is red," "how amber is amber," or "how green is green" composite impact. When used with the Army "Mission Command" IWEDA rules set, the PWS prioritizes and weights the rules by utilizing the highest priority rules in conjunction with rules weighting. The PWS will be able to enhance the functionality and maximize the inherent capabilities of the next generation of IWEDA, the MyWIDA, under development by the ARL.

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List of Symbols, Abbreviations, and Acronyms

AOI	Area of Operations/Interest
ARL	Army Research Laboratory
CIS	Cell Impact Score
DG	Dark Green
DR	Dark Red
DY	Dark Yellow
eq	Equal
GFS	Global Forecast Model
GG	Green
GRIB	Gridded Binary
hvy	Heavy
IMETS	Integrated Meteorological System
IWEDA	Integrated Weather Effects Decision Aid
IV	Impact Value
JMBL	Joint METOC Broker Language
LG	Light Green
lgt	Light
LR	Light Red
METOC	Meteorological and Oceanographic
mod	Moderate
MSL	Mean Sea Level
MyWIDA	My Weather Impacts Decision Aid
num	Number
OO	Orange
param (s)	Parameter(s)
PWS	Parameter Weighting Scheme

RR	Red
sfc	Surface
SWIV	Sum of the Weighted Impact Values
tot	Total
TRADOC	US Army Training and Doctrine Command
USAIC & FH	United States Army Intelligence Center and Fort Huachuca
WIV	Weighted Impact Value
WRF	Weather Research and Forecasting (weather forecast model)
wt/wgt(d)	Weight/Weighted
YG	Yellow Green
YY	Yellow

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