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A LIBRARY OF FAILURE REGIONS

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A failure region is the set of all possible program inputs that will execute a specific fault and produce a result that varies from the specified or expected program result. The purpose of this report is to document a set of failure regions corresponding to the known faults in a set of redundant program versions. Each failure region is characterized in two ways: by identifying the fault that it reveals and by identifying the boolean conditions necessary and sufficient to consider a program input to be a member of the failure region. Other reports describe the region analysis technique and profile the regions detailed here.

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A Library of Failure Regions

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This report is a collection of the failure regions for the known faults in a collection of implementations of a combat simulation program. A failure region is the set of all possible program inputs that will execute a specific fault and produce a result that varies from the specified or expected result. A fault is an erroneous (possibly non-contiguous) section of program source code. The purpose of this report is to document a set of failure regions corresponding to the known faults in a set of redundant program versions.

Each failure regions is characterized in two ways: by identifying the fault that it reveals and by identifying the boolean conditions sufficient to consider a program input to be a member of the failure region. These boolean conditions are divided into three parts. Those labelled "Condition I" are the conditions that cause an input to execute the fault. Those labelled "Condition II" are the conditions that cause the execution of the fault to produce an erroneous internal state. Those labelled "Condition III" are the conditions that cause that erroneous internal state to be propagated to become part of a result. The process of determining these conditions is dealt with at length in a recent Master's Thesis[1].

There have been two simplifications made in the course of deriving the failure regions in this report. First, all uninitialized variables are assumed to have erroneous values. This simplification is made to avoid machine-dependent probablistic modeling of the conditions under which a coincidentally correct value may be found in an unitialized variable. Second, the effects that one failure region has on another have been neglected here. During the analysis process, each fault is considered in isolation of all other known faults in the code.

The failure regions in this report are for the known faults in eight implementations of `CONFLICT`, a simplified nonprobablistic combat simulation, that were developed in the course of a software experiment[2]. It is assumed that the reader is very familiar with the `CONFLICT` Specification[3]. All of the failure regions that follow arise from violations of that specification and all of the variables and many of the conditions described below are abstracted from the specification or from the implementations of that specification.

The regions in this report are profiled and analyzed in an accompanying document[4].

References

[1] Bolchoz, J. M., 'The Identification of Software Failure Regions', M.S. Thesis, Computer Science Dept., Naval Postgraduate School, Monterey, CA, 1990.

[2] Shimeall, T. J. and Leveson, N. G., 'An Empirical Comparison of Software Fault Tolerance and Fault Elimination', *IEEE Transactions on Software Engineering*, Vol. SE-17, No. 2, February 1991, pp. 173–182.

[3] Shimeall, T. J., '`CONFLICT` Specification', Technical Report No. NPSCS-91-001, Computer Science Dept., Naval Postgraduate School, Monterey, CA, 1991.

[4] Shimeall, T. J., Bolchoz, J. M. and Griffin, R., 'Analytical Derivation of Software Failure Regions'. Technical Report No. NPSCS-91-003, Computer Science Dept., Naval Postgraduate School, Monterey, CA, 1991.

Notation

In the descriptions that follow, the following conventions are used:

- So far as is possible, the conventions of the specification have been preserved.
- Text appearing in italics (e.g. '*Endurance*') are defined within the scope of this document, either globally or for a specific failure region.
- Text appearing in roman type (e.g. 'Army[].Endurance') are program variables for the implementations containg the fault. The only exception to this is the variable 'Mainloop', which is used to indicate the current simulation cycle, but may not appear in a specific version under that name. 'Mainloop' is normally defined within the *Active* predicate, implicitly existentially quantified.
- Due to the fact that program variables are more than one character in length, all multiplication is shown explicitly with the multiplication symbol $\times$.
- Due to the length of the formulae below, it is necessary to break formulae across more than one line. There are no matrix or vector operations appearing in this document, and parentheses are used strictly to delimit portions of formulae to improve readability or to indicate precedence of operations.
- All definitions within 'Condition I' of a failure region are assumed to extend over 'Condition II' and 'Condition III' of that failure region unless use of parentheses indicates otherwise. All definitions within 'Condition II' of a failure region are similarly assumed to extend over 'Condition III' of that failure region.
- The diacritical marks $'$ and $''$ are used strictly to distinguish between variables of similar name and role in a given failure region.

Time-Dependent Definitions

Endurance of Squadron (B, g, j) at time t:

$$\begin{aligned} Endurance(B,g,j,t) = &\text{Army}[B,g].\text{Endurance}[j] - \\ &\text{Army}[B,g].\text{Wear}[j] \times t - \\ &Damage(B,g,j,t-1) + Repair(B,g,j,t-1) \end{aligned}$$

Weapon Damage of Squadron(B,g,j) up to and including time t:

$$Damage(B,g,j,t) = \begin{cases} 0 & \text{if } t \leq 1 \\ Damage(B,g,j,t-1) + & \text{otherwise} \\ \sum_{e=1}^{\text{NArmy}[\neg B]} \left(\sum_{w=1}^{\text{Params.NumWTypes}} \left(\sum_{i=1}^{\text{Army}[\neg B,e].\text{Weapon}[w].\text{NumWeapon}} \right. \right. & \\ \left. \left. \begin{array}{l} \text{Army}[\neg B,e].\text{Weapon}[w].\text{Damage} \times \\ \text{Army}[\neg B,g].\text{WeapSensativity}[w] \times \\ \max\left(0, 1 - \frac{\sqrt{(x_{B,g,j}(t-1) - ax_{\neg B,e,w,i}(t-1))^2 + (y_{B,g,j}(t-1) - ay_{\neg B,e,w,i}(t-1))^2}}{\text{Army}[\neg B,e].\text{Weapon}[w].\text{Radius}}\right) \end{array} \right) \right) \end{cases}$$

Whether or not Squadron(B,g,j) is a casualty at time t:

$$\begin{aligned} Casualty(B,g,j,t) \equiv &(Endurance(B,g,j,t-1) > 0) \wedge \\ &\left(\frac{Endurance(B,g,j,t-1)}{\text{Army}[B,g].\text{Endurance}[j]} \leq 0.5\right) \end{aligned}$$

Repair applied to Squadron(B,g,j) up to and including time t:

$$Repair(B,g,j,t) = \begin{cases} 0 & \text{if } t \leq 1 \\ Repair(B,g,j,t-1) & \text{if } (t>1) \wedge \\ & \neg Casualty(B,g,j,t-1) \\ Repair(B,g,j,t-1) + & \text{otherwise} \\ \min(Suppl(B,g,t-1)/NumCas(B,g,t), & \\ \quad FixRate(B,g,t-1)/NumCas(B,g,t), & \\ \quad (\text{Army}[B,g].\text{Endurance}[j] & \\ \quad - Endurance(B,g,j,t-1) & \\ \quad - Repair(B,g,j,t-1) & \\ \quad + Repair(B,g,j,t-2))) & \end{cases}$$

Number of Casualties in Battalion B, g at time t:

$$NumCas(B,g,t) = \sum_{j=1}^{\text{Army}[B,g].\text{Squadrons}} \begin{cases} 1 \text{ if } Casualty(B,g,j,t-1) \\ 0 \quad \text{otherwise} \end{cases}$$

Rate of Repair available to any squadron of battalion B, g at time t:

$$FixRate(B,g,t) = \text{Army}[B,g].\text{FixRate} \times NumFix(B,g,t-1)$$

Number of Squadrons in battalion B, g dedicated to repair other squadrons at time t:

$$NumFix(B,g,t) = \text{Army}[B,g].\text{NumFixers} \times \frac{\sum_{j=1}^{\text{Army}[B,g].\text{Squadrons}} \begin{cases} 0 \text{ if } \neg Casualty(B,g,j,t) \\ 1 \quad \text{otherwise} \end{cases}}{\text{Army}[B,g].\text{Squadrons}}$$

Amount of supplies available in battalion B, g at time t:

$$Suppl(B,g,t) = \text{Army}[B,g].\text{FixSuppl} - \sum_{j=1}^{\text{Army}[B,g].\text{Squadrons}} Repair(B,g,j,t-1)$$

X Location of Battalion B, g at time t:

$$\begin{aligned} x_{B,g}(t) =& \text{Army}[B,g].\text{X} + \\ & \sum_{d=1}^{t} (V(B,g,d) \times \cos(\text{Army}[B,g].\text{Theta}) \\ & \quad \times TM(B,g,x_{B,g}(d-1), y_{B,g}(d-1), V(B,g,d-1)) \\ & \quad \times WM(B,g,x_{B,g}(d-1), y_{B,g}(d-1), d)) \end{aligned}$$

Y Location of Battalion B, g at time t:

$$\begin{aligned} y_{B,g}(t) =& \text{Army}[B,g].\text{Y} + \\ & \sum_{d=1}^{t} (V(B,g,d) \times \sin(\text{Army}[B,g].\text{Theta}) \\ & \quad \times TM(B,g,x_{B,g}(d-1), y_{B,g}(d-1), V(B,g,d-1)) \\ & \quad \times WM(B,g,x_{B,g}(d-1), y_{B,g}(d-1), d)) \end{aligned}$$

Velocity of Battalion B, g at time t:

$$V(B,g,t) = \min_{j=1}^{\text{Army}[B,g].\text{Squadrons}} \begin{cases} \infty & \text{if } Endurance(B,g,j,t-1) \leq 0 \\ \text{Army}[B,g].\text{V0}[j] \times \frac{Endurance(B,g,j,t-1)}{\text{Army}[B,g].\text{Endurance}[j]} & \text{otherwise} \end{cases}$$

Terrain effect on Movement of Battalion B, g at location x, y moving at velocity v:
Let x' and y' represent the end of the possible movement, p, q be the Terrain grid location of x, y:

$$x' = x + v \times \cos(\text{Army}[B,g].\text{Theta})$$
$$y' = y + v \times \sin(\text{Army}[B,g].\text{Theta})$$

$$p(x) = \left\lfloor \frac{x}{\text{Params.XDelta}} \right\rfloor$$

$$q(y) = \left\lfloor \frac{y}{\text{Params.YDelta}} \right\rfloor$$

$$TM(B,g,x,y,v) = \begin{cases} 0 & \text{if } v = 0 \\ \max\left(0, \frac{\text{Army}[B,g].\text{MaxSlope} - \frac{Alt(p(x'),q(y'),x',y') - Alt(p(x),q(y),x,y)}{\sqrt{(x'-x)^2+(y'-y)^2}}}{\text{Army}[B,g].\text{MaxSlope}}\right) & \text{otherwise} \end{cases}$$

Weather effect on Movement of Battalion B, g at location x, y at time t:
Let (WX_i, WY_i) be the center location of storm i at time t:

$$WX_i = \begin{cases} \text{Weather}[i].\text{WX0 if } t < \text{Weather}[i].\text{TStart} \vee t > \text{Weather}[i].\text{TEnd} \\ \text{Weather}[i].\text{WX0} + (t - \text{Weather}[i].\text{TStart}) \times \text{Weather}[i].\text{dWX otherwise} \end{cases}$$

$$WY_i = \begin{cases} \text{Weather}[i].\text{WY0 if } t < \text{Weather}[i].\text{TStart} \vee t > \text{Weather}[i].\text{TEnd} \\ \text{Weather}[i].\text{WY0} + (t - \text{Weather}[i].\text{TStart}) \times \text{Weather}[i].\text{dWY otherwise} \end{cases}$$

Let W be the total effect of storms on location (x, y) at time t:

$$W(x,y,t) = \sum_{i=1}^{\text{Params.NumWEvents}} \begin{cases} 0 & \text{if } t < \text{Weather}[i].\text{TStart} \vee t > \text{Weather}[i].\text{TEnd} \\ \max\left(0, \frac{\text{Weather}[i].\text{WRadius} - \sqrt{(x-WX_i)^2+(y-WY_i)^2}}{\text{Weather}[i].\text{WRadius}} \times \right. & \text{otherwise} \\ \left. \text{Weather}[i].\text{WSeverity}\right) & \end{cases}$$

$$WM(B,g,x,y,t) = \begin{cases} 1 & \text{if } W(x,y,t) = 0 \\ \text{Army}[B,g].\text{MWEffect} \times & \\ \left|\frac{W(x,y,t) - \text{Params.WMaxSeverity} \times \text{Params.NumWEvents}}{\text{Params.WMaxSeverity} \times \text{Params.NumWEvents}}\right| & \text{otherwise} \end{cases}$$

Weather effect on Observation at location (x, y) at time t:

$$WO(x,y,t) = \begin{cases} 0 & \text{if } W(x,y,t) = 0 \\ \left| \frac{W(x,y,t) - \text{Params.WMaxSeverity} \times \text{Params.NumWEvents}}{\text{Params.WMaxSeverity} \times \text{Params.NumWEvents}} \right| & \text{otherwise} \end{cases}$$

(X,Y) Location of Squadron B, g, j at time t:
Let s be the number of Squadrons in Battalion B, g prior to squadron j that have positive endurance at time t:

$$s(B,g,j,t) = \sum_{i=1}^{j-1} \begin{cases} 0 \text{ if } Endurance(B,g,i,t-1) \leq 0 \\ 1 \quad \text{otherwise} \end{cases}$$

$$x_{B,g,j}(t) = \begin{cases} x_{B,g}(t-1) + \text{Army}[B,g].\text{SquadSep} \times \\ \left(s(B,g,j,t) - \left\lfloor \frac{s(B,g,j,t)}{\text{Army}[B,g].\text{GRow}} \right\rfloor \times \text{Army}[B,g].\text{GRow}\right) - \\ \frac{\text{Army}[B,g].\text{GRow} \times \text{Army}[B,g].\text{SquadSep}}{2} \\ \qquad \text{if } s(B,g,\text{Army}[B,g].\text{Squadron}+1,t) - s(B,g,j,t) > \\ \qquad\qquad \text{Army}[B,g].\text{GRow} \\ x_{B,g}(t-1) + \text{Army}[B,g].\text{SquadSep} \times \\ \left(s(B,g,j,t) - \left\lfloor \frac{s(B,g,j,t)}{\text{Army}[B,g].\text{GRow}} \right\rfloor \times \text{Army}[B,g].\text{GRow}\right) - \\ \frac{s(B,g,\text{Army}[B,g].\text{Squadron}+1,t) - \left\lfloor \frac{s(B,g,\text{Army}[B,g].\text{Squadron}+1,t)}{\text{Army}[B,g].\text{GRow}} \right\rfloor \times \text{Army}[B,g].\text{GRow}}{2} \\ \times \text{Army}[B,g].\text{SquadSep} \\ \qquad\qquad \text{otherwise} \end{cases}$$

$$y_{B,g,j}(t) = y_{B,g}(t-1) + \text{Army}[B,g].\text{RowSep} \times \left\lfloor \frac{s(B,g,j,t)}{\text{Army}[B,g].\text{GRow}} \right\rfloor$$
$$-0.5 \times \left\lfloor \frac{s(B,g,\text{Army}[B,g].\text{Squadron}+1,t)}{\text{Army}[B,g].\text{GRow}} \right\rfloor \times \text{Army}[B,g].\text{RowSep}$$

Squadron B, g, j observes squadron $\neg B$, e, k at time t:

$$Observe(B,g,j,e,k,t) \equiv BigEnough(B,g,j,e,k,t) \wedge Clear(B,g,j,e,k,t) \\ \wedge Obvious(B,g,j,e,k,t)$$

Squadron $\neg B$, e, k is large enough to be seen at the distance from squadron B, g, j at time t:

$$\begin{array}{l} BigEnough(B,g,j,e,k,t) \equiv \\ \quad xgj = x_{B,g,j}(t-1) \wedge ygj = y_{B,g,j}(t-1) \wedge \\ \quad xek = x_{\neg B,e,k}(t-1) \wedge yek = y_{\neg B,e,k}(t-1) \wedge \\ \quad \left(\max\left\{\tan^{-1}\left(\frac{y'-y}{x'-x}\right) - \tan^{-1}\left(\frac{y''-y}{x''-x}\right)\right| \right. \\ \qquad (x',y'),(x'',y'') \in \{(xek \pm \text{Army}[\neg B,e].\text{SquadWidth}/2, \\ \qquad\quad yek \pm \text{Army}[\neg B,e].\text{SquadLength}/2)\} \\ \geq \text{Army}[B,g].\text{ObsMinAngle}[j]) \end{array}$$

No terrain blocks the view of squadron $\neg B$, e, k from the position of squadron B, g, j at time t:

$$\begin{array}{l} Clear(B,g,j,e,k,t) \equiv \\ \quad xgj = x_{B,g,j}(t-1) \wedge ygj = y_{B,g,j}(t-1) \wedge \\ \quad xek = x_{\neg B,e,k}(t-1) \wedge yek = y_{\neg B,e,k}(t-1) \wedge \\ \quad (\forall a,a',c,c',z,z', a = \left\lfloor \frac{xgj}{\text{Params.XDelta}} \right\rfloor \wedge a' = \left\lfloor \frac{xek}{\text{Params.XDelta}} \right\rfloor \wedge \\ \qquad c = \left\lfloor \frac{ygj}{\text{Params.YDelta}} \right\rfloor \wedge c' = \left\lfloor \frac{yek}{\text{Params.YDelta}} \right\rfloor \wedge \\ \qquad z = Alt(a,c,xgj,ygj) \wedge z' = Alt(a',c',xek,yek) \wedge \\ \quad (\forall n, 1 \leq n < \text{Params.SampleRate} - 1, \\ \qquad (\exists r,p,q, r = \frac{n}{\text{Params.SampleRate}-1}, p = \left\lfloor \frac{xgj + r \times (xek - xgj)}{\text{Params.XDelta}} \right\rfloor, q = \left\lfloor \frac{ygj + r \times (yek - ygj)}{\text{Params.YDelta}} \right\rfloor, \\ \qquad (z + r \times (z' - z)) > Alt(p,q, xgj + r \times (xek - xgj), ygj + r \times (yek - ygj)) \\ ) \;) \quad) \end{array}$$

Squadron $\neg B$, e, k differs enough from its background to be discerned by squadron B, g, j at time t:

$$
\begin{aligned}
&Obvious(B,g,j,e,k,t) \equiv \\
&\quad xgj = x_{B,g,j}(t-1) \wedge ygj = y_{B,g,j}(t-1) \wedge \\
&\quad xek = x_{\neg B,e,k}(t-1) \wedge yek = y_{\neg B,e,k}(t-1) \wedge \\
&\Bigg(\Bigg(\frac{BI(a',c',xek,yek) - \text{Army}[\neg B,e].\text{SquadIntensity}[k]}{BI(a',c',xek,yek)} \Bigg/ \\
&\quad \text{Params.SampleRate} \\
&\quad \sum_{n=1} \Bigg(\Big(WO\Big(xgj \times \frac{n \times (xek - xgj)}{\text{Params.SampleRate}}, ygj \times \frac{n \times (yek - ygj)}{\text{Params.SampleRate}}, \text{Mainloop}\Big) \times \\
&\qquad \text{Army}[B,g].\text{VWEffect}) + \\
&\qquad \sum_{e'=1}^{\text{NArmy}[\neg B]} \begin{cases} 0 \quad \text{if } \sqrt{\Big(x_{\neg B,e'}(\text{Mainloop}-1) - xgj \times \frac{n \times (xek - xgj)}{\text{Params.SampleRate}}\Big)^2 + \Big(y_{\neg B,e'}(\text{Mainloop}-1) - ygj \times \frac{n \times (yek - ygj)}{\text{Params.SampleRate}}\Big)^2} \\ \qquad > \text{Army}[\neg B,e'].\text{ObsJamRadius} \\ \dfrac{\sqrt{\Big(x_{\neg B,e'}(\text{Mainloop}-1) - xgj \times \frac{n \times (xek - xgj)}{\text{Params.SampleRate}}\Big)^2 + \Big(y_{\neg B,e'}(\text{Mainloop}-1) - ygj \times \frac{n \times (yek - ygj)}{\text{Params.SampleRate}}\Big)^2}}{\text{Army}[\neg B,e'].\text{ObsJamRadius}} \\ \qquad \times \text{Army}[\neg B,e'].\text{ObsJamEff otherwise} \end{cases} \\
&\Bigg)\Bigg) < \text{Army}[B,g].\text{ObsMinContrast}[j])
\end{aligned}
$$

Squadron $\neg B$, e, k is in range of the weapons of battalion B, g at time t:

$$
\begin{aligned}
&InRange(B,g,e,k,t) \equiv \\
&xek = x_{\neg B,e,k}(t-1) \wedge yek = y_{\neg B,e,k}(t-1) \wedge \\
&\sqrt{(xek - x_{B,g}(t-1))^2 + (yek - y_{B,g}(t-1))^2} < \text{Army}[B,g].\text{Weapon}[i].\text{Range}
\end{aligned}
$$

Number of Squadrons in battalion B, g dedicated to processing messages at time t:

$$NumProcess(B,g,t) = \text{Army}[B,g].\text{NumProcess} \times \frac{NumCas(B,g,t)}{\text{Army}[B,g].\text{Squadrons}}$$

Number of Squadrons in battalion B, g dedicated to receiving messages at time t:

$$NumRec(B,g,t) = \text{Army}[B,g].\text{NumReceive} \times \frac{NumCas(B,g,t)}{\text{Army}[B,g].\text{Squadrons}}$$

Number of Squadrons in battalion B, g dedicated to communications jamming at time t:

$$NumJam(B,g,t) = \text{Army}[B,g].\text{NumJammers} \times \frac{NumCas(B,g,t)}{\text{Army}[B,g].\text{Squadrons}}$$

Number of Squadrons in battalion B, g dedicated to sending communications at time t:

$$NumSend(B,g,t) = \text{Army}[B,g].\text{NumSend} \times \frac{NumCas(B,g,t)}{\text{Army}[B,g].\text{Squadrons}}$$

Number of functional weapons of type i in battalion B, g at time t:

$$NumWeapon(B,g,i,t) = \text{Army}[B,g].\text{Weapon}[i].\text{NumWeapon} \times \frac{NumCas(B,g,t)}{\text{Army}[B,g].\text{Squadrons}}$$

Target coordinates for weapon i of type w in Battalion B, g at time t:

$$ax_{B,g,w,i}(t) = x_{\neg B,e,k} \ni$$
$$\left(\left(\sum_{e'=1}^{e-1}\sum_{k'=1}^{\text{Army}}[\neg B,e'].\text{Squadrons}\begin{cases}1 \text{ if } \exists j, Observe(B,g,j,e',k',t-1)\\ 0 \text{ otherwise}\end{cases}\right)\right.$$
$$\left.+\left(\sum_{k'=1}^{k-1}\begin{cases}1 \text{ if } \exists j, Observe(B,g,j,e,k',t-1)\\ 0 \text{ otherwise}\end{cases}\right)\right) =$$
$$\left(\sum_{w'=1}^{w-1} NumWeapon(B,g,w',t)\right) + i - 1$$

$$ay_{B,g,w,i}(t) = y_{\neg B,e,k} \ni$$
$$\left(\left(\sum_{e'=1}^{e-1}\sum_{k'=1}^{\text{Army}}[\neg B,e'].\text{Squadrons}\begin{cases}1 \text{ if } \exists j, Observe(B,g,j,e',k',t-1)\\ 0 \text{ otherwise}\end{cases}\right)\right.$$
$$\left.+\left(\sum_{k'=1}^{k-1}\begin{cases}1 \text{ if } \exists j, Observe(B,g,j,e,k',t-1)\\ 0 \text{ otherwise}\end{cases}\right)\right) =$$
$$\left(\sum_{w'=1}^{w-1} NumWeapon(B,g,w',t)\right) + i - 1$$

Command Message m Implemented in Battalion B, g before time t:

$$Mimp(B,g,m,t) \equiv$$
$$((\text{Cmsgs}[B,m].\text{Time} + \text{Army}[B,g].\text{MediaDelay}$$
$$+RecDelay(B,g,RecT(B,g,m)) + QueDelay(B,g,m)$$
$$+\text{Army}[B,g].\text{ProcDelay}) < t) \wedge$$
$$(\text{Cmsgs}[B,m].\text{Dest} = g)$$

Delay due to message receipt at battalion B, g at time t:

$$RecDelay(B,g,t) = \begin{cases}\infty \text{ if } NumRec(B,g,t) - ComJam(B,g,t) \le 0\\ \\ \frac{\text{Army}[B,g].\text{RecRate}}{NumRec(B,g,t)-ComJam(B,g,t)} \text{ otherwise}\end{cases}$$

Number of jammed receivers in battalion B, g at time t:

$$ComJam(B,g,t) =$$
$$\sum_{\epsilon=1}^{\text{NArmy}[\neg B]} \min(NumJam(\neg B,e,t), \text{Army}[\neg B,\epsilon].\text{CommJamPriority}[g]) \times$$
$$\text{Army}[\neg B,\epsilon].\text{CommJamEff} \times$$
$$\max\left(0, \frac{\text{Army}[\neg B,\epsilon].\text{CommJamRadius} - \sqrt{(x_{\neg B,e}(t-1)-x_{B,g}(t-1))^2+(y_{\neg B,e}(t-1)-y_{B,g}(t-1))^2}}{\text{Army}[\neg B,\epsilon].\text{CommJamRadius}}\right)$$

Delay due to message queuing of command message m in Battalion B, g:

$$QueDelay(B,g,m) = \sum_{t=RecT(B,g,m)}^{\text{Duration}} \begin{cases}1 \text{ if } CmdSum(B,g,m,t) + ReptSum(B,g,m,t)\\ \quad \ge NumProcess(B,g,t-1)\\ \\ 0 \text{ otherwise}\end{cases}$$

Time command message m is received at battalion B, g:

$$RecT(B,g,m) = \text{Cmsgs}[B,m].\text{Time} + \text{Army}[B,g].\text{MediaDelay}$$

Time delay for report message from battalion B, f to be transmitted to battalion B, g:

$$RepT(B,g,f) = \text{Army}[B,f].\text{SendRate} + \text{Army}[B,g].\text{MediaDelay}$$

Number of command messages, other than m being processed by battalion B, g at time t:

$$CmdSum(B,g,m,t) = \sum_{n=1}^{\text{NCmsgs}[B]} \begin{cases} 0 \text{ if } (m = n) \vee (\text{Cmsgs}[B,n].\text{Dest} \neq g) \vee \\ \quad (t \leq RecT(B,g,n) \wedge \\ \quad \text{Cmsgs}[B,m].\text{Priority} > \text{Cmsgs}[B,n].\text{Priority}) \\ \quad \vee(\text{Cmsgs}[B,n].\text{Time} > t) \vee \\ \quad (RecT(B,g,n) + \text{Army}[B,g].\text{ProcDelay} < t) \\ \\ 1 \text{ otherwise} \end{cases}$$

Some opposing squadron exists and is observed by a squadron of B, g, at time t:

$$SomeObserve(B,g,t) \equiv$$
$$(\exists e, 1 \leq e \leq \text{Narmy}[\neg B], \text{Army}[\neg B, e].\text{Squadrons} > 0 \wedge EObserve(B,g,e,t))$$

Some opposing squadron in battalion $\neg B$, e, exists and is observed by some squadron of B, g at time t.

$$EObserve(B,g,e,t) \equiv$$
$$(\exists k, 1 \leq k \leq \text{Army}[\neg B, e].\text{Squadrons}, Endurance(\neg B, e, k, t) > 0 \wedge$$
$$(\exists j, 1 \leq j \leq \text{Army}[B,f].\text{Squadrons},$$
$$Endurance(B,f,j,t) > 0 \wedge Observe(B,g,j,e,k,t)))$$

Number of report messages being processed by battalion B, g at time t, while message m may be queued:

$$ReptSum(B,g,m,t) = \sum_{f=1}^{\text{NArmy}[B]} \begin{cases} 0 \text{ if } (\text{Army}[B,f].\text{Report} \neq g) \vee \\ \quad (\forall t', t - RepT(B,g,f) - \text{Army}[B,g].\text{ProcDelay} \\ \qquad \leq t' \leq t - RepT(B,g,f), \\ \quad \neg SomeObserve(B,f,t')) \vee \\ \quad (SomeObserve(B,f,t - RepT(B,g,f) \wedge \\ \quad \text{Army}[B,f].\text{Priority} < \text{Cmsgs}[B,m].\text{Priority}) \\ \\ 1 \text{ otherwise} \end{cases}$$

Global Definitions

Battalion B, g is active:

$$\begin{aligned} Active(B,g) \equiv & ((\text{Duration} > 0) \wedge (\text{Mainloop} \in \{0...\text{Duration}\}) \wedge \\ & (B \in \{\text{TRUE}, \text{FALSE}\}) \wedge (\text{NArmy}[B] > 0) \wedge \\ & (g \in \{1...\text{NArmy}[B]\}) \wedge (\text{Army}[B,g].\text{Squadrons} > 0) \wedge \\ & (\exists i, 1 \leq i \leq \text{Army}[B,g].\text{Squadrons}, \\ & \ Endurance(B,g,i,\text{Mainloop}) > 0)) \end{aligned}$$

Altitude at position (x,y) in Terrain grid (p,q):

$$\begin{aligned} Alt(p,q,x,y) = & \left(\frac{\begin{array}{l}\text{Terrain}[p,q] \quad -\text{Terrain}[p+1,q]- \\ \text{Terrain}[p,q+1]+\text{Terrain}[p+1,q+1]\end{array}}{\text{Params.XDelta} \times \text{Params.YDelta}} \times x \times y \right) + \\ & \left(\frac{\begin{array}{l}q(\text{Terrain}[p,q+1] \quad -\text{Terrain}[p+1,q+1])- \\ (q+1)(\text{Terrain}[p,q]-\text{Terrain}[p+1,q])\end{array}}{\text{Params.XDelta}} \times x \right) + \\ & \left(\frac{\begin{array}{l}p(\text{Terrain}[p+1,q] \quad -\text{Terrain}[p+1,q+1])- \\ (p+1)(\text{Terrain}[p,q]-\text{Terrain}[p,q+1])\end{array}}{\text{Params.YDelta}} \times y \right) + \\ & (p+1)((q+1)\text{Terrain}[p,q] - q\text{Terrain}[p,q+1])- \\ & p((q+1)\text{Terrain}[p+1,q] - q\text{Terrain}[p+1,q+1]) \end{aligned}$$

Background Intensity at position (x,y) in Terrain grid (p,q):

$$\begin{aligned} BI(p,q,x,y) = & \sqrt{\left(\frac{\begin{array}{l}\text{Terrain}[p,q+1] - \text{Terrain}[p,q] \quad + \\ \text{Terrain}[p+1,q+1] - \text{Terrain}[p+1,q]\end{array}}{2(\text{Params.XDelta})} \right)^2 + \left(\frac{\begin{array}{l}\text{Terrain}[p+1,q+1] - \text{Terrain}[p,q+1]+ \\ \text{Terrain}[p+1,q] - \text{Terrain}[p.q]\end{array}}{2(\text{Params.YDelta})} \right)^2} \\ & \times \text{Params.ISlopeFactor} + \\ & \text{Params.IAltFactor} \frac{\text{Params.IMeanAlt} - Alt(p,q,x,y)}{\text{Params.IMeanAlt}} + \\ & \text{Params.IX} \times x + \text{Params.IY} \times y + \text{Params.IC} \end{aligned}$$

Failure Regions in Version 1

1.1: Incorrect handling of NumCas when Army.Squadrons=0 initially

Condition I:

$$\text{Duration} > 0 \wedge (\exists B, B \in \{\text{true, false}\}, \text{NArmy}[B] > 0$$

Condition II:

$$(\exists g, 1 \leq g \leq \text{NArmy}[B], \text{Army}[B, g].\text{Squadrons} = 0))$$

Condition III: True

1.2: Update always implements commands ready at the same time in CMsgs array order

Condition I:

$$\begin{array}{l} Active(B, g) \wedge \\ (\exists m, n, 1 \leq m \leq \text{NCmsgs}[B], 1 \leq n \leq \text{NCmsgs}[B], m < n \wedge \\ \quad Mimp(B, g, m, \text{Mainloop}) \wedge \neg Mimp(B, g, m, \text{Mainloop} - 1) \wedge \\ \quad Mimp(B, g, n, \text{Mainloop}) \wedge \neg Mimp(B, g, n, \text{Mainloop} - 1) \end{array}$$

Condition II:

$$\text{Cmsgs}[B, m].\text{Priority} < \text{Cmsgs}[B, n].\text{Priority} \wedge \text{Cmsgs}[B, m].\text{msg} \neq \text{Cmsgs}[B, m].\text{msg}$$

Condition III:

$$\begin{array}{l} (\nexists i, 1 \leq i \leq \text{NCmsgs}[B], i \neq m \wedge i \neq n \wedge \\ Mimp(B, g, i, \text{Duration}) \wedge \neg Mimp(B, g, i, \text{Mainloop} - 1))) \end{array}$$

1.3: Over-restrictive check: positive dWX

Condition I: Params.NumWEvents > 0

Condition II:

$$\exists i, 1 \leq i \leq \text{Params.NumWEvents}, \text{Weather}[i].\text{dWX} < 0$$

Condition III: True

1.4: Over-restrictive check: positive dWY

Condition I: Params.NumWEvents > 0

Condition II:

$$\exists i, 1 \leq i \leq \text{Params.NumWEvents}, \text{Weather}[i].\text{dWY} < 0$$

Condition III: True

1.5: Garbage value in FixSuppl when Fix Supplies exhaused

Condition I:

$$Active(B, g) \wedge$$
$$(\exists j, 1 \leq j \leq \text{Army}[B, g].\text{Squadrons}, Casualty(B, g, j, \text{Mainloop}))$$

Condition II:

$$\left(\sum_{i=1}^{\text{Army}[B,g].\text{Squadrons}} Repair(B, g, i, \text{Mainloop}) \right) \geq \text{Army}[B, g].\text{FixSuppl}$$

Condition III:

$$(\nexists i, 1 \leq i \leq \text{NCmsgs}[B], Mimp(B, g, i, \text{Duration}) \wedge \neg Mimp(B, g, i, \text{Mainloop} - 1))$$

1.6: Spurious input check requiring IAF > 0

Condition I: True

Condition II: Params.IAltFactor ≤ 0

Condition III: True

1.7: Spurious Input check requiring NumWEvents > 0

Condition I: True

Condition II: Params.NumWEvents ≤ 0

Condition III: True

1.8: Negative NW value

Condition I:

$$\exists B,g,e,t, Active(B,g) \wedge Active(\neg B,e) \wedge 1 < t < \text{Mainloop} \wedge$$
$$(\exists j,k, 1 \leq k \leq \text{Army}[\neg B,e].\text{Squadrons} \wedge 1 \leq j \leq \text{Army}[B,g].\text{Squadrons} \wedge$$
$$Endurance(B,g,j,t) > 0 \wedge Endurance(\neg B,e,k,t) > 0 \wedge Observe(B,g,j,e,k,t)) \wedge$$
$$\text{Params.NumWTypes} > 1$$

Condition II:

$$\exists i, 1 \leq i \leq \text{Params.NumWTypes}, \text{Army}[B,g].\text{WeapPriority}[e,i] < 0 \vee$$
$$NumWeapon(B,g,i,\text{Mainloop})$$
$$< (NumWeapon(B,g,i,\text{Mainloop}-1) - NumWeapon(B,g,i,\text{Mainloop}) +$$
$$\left\lfloor \frac{\sum_{n=1}^{\text{Mainloop}} \sum_{e'=1}^{\text{NArmy}[\neg B]} \left(\min(|\{k' \ni \exists j, Observe(B,g,j,e',k',n-1)\}|, \text{Army}[B,g].\text{WeapPriority}[e',i], NumWeapon(B,g,i,n)) \right)}{NumWeapon(B,g,i,\text{Mainloop}-1)} \right\rfloor \Big)$$

Condition III:

$$(\nexists m, 1 \leq m \leq \text{NCmsgs}[B], Mimp(B,g,m,\text{Duration}) \wedge \neg Mimp(B,g,m,\text{Mainloop}-1)) \wedge$$
$$(\nexists m, 1 \leq m \leq \text{NCmsgs}[\neg B], Mimp(\neg B,e,m,\text{Duration}) \wedge$$
$$\neg Mimp(\neg B,e,m,\text{Mainloop}-1))$$

1.9: PSentListLoc sends out of range squadron to SquadAlive

Condition I:

$$Active(B,g) \wedge Active(\neg B,e) \wedge Active(B,f) \wedge \text{Army}[B,f].\text{Report} = g \wedge$$
$$(\exists t, 1 \leq t \leq \text{Duration},$$
$$t = \text{Mainloop} - RepT(B,f,g) - \text{Army}[B,g].\text{ProcDelay}$$
$$- \frac{\text{Army}[B,g].\text{RecRate}}{NumRec(B,g,\text{Mainloop}-\text{Army}[B,g].\text{ProcDelay}} \wedge$$
$$(\exists k, 1 \leq k \leq \text{Army}[\neg B,e].\text{Squadrons}, (\exists j, 1 \leq j \leq \text{Army}[B,f].\text{Squadrons},$$
$$Observe(B,f,j,e,k,t) \wedge Endurance(\neg B,e,k,t) > 0))$$

Condition II:

$$(\exists m, 1 \leq m \leq \text{NCmsgs}[\neg B], (\neg Mimp(\neg B,e,m,t)) \wedge Mimp(\neg B,e,m,\text{Mainloop}) \wedge$$
$$\text{Army}[\neg B,e].\text{Squadrons} > \text{Cmsgs}[\neg B,m].\text{msg.Squadrons}))$$

Condition III:True

1.10: Restriction that SquadIntensity>0

Condition I:

$$(\exists B, B \in \{\text{true, false}\}, \text{NArmy}[B] > 0 \wedge$$
$$(\exists g, g \in \{1...\text{NArmy}[B]\}, \text{Army}[B, g].\text{Squadrons} > 0$$
$$\wedge(\exists j, j \in \{1..\text{Army}[B, g].\text{Squadrons}\},$$

Condition II:

$$\text{Army}[B, g].\text{SquadIntensity}[j] \leq 0)))$$

Condition III: True

1.11: Restriction that FixSuppl $\geq$ 0

Condition I:

$$(\exists B, B \in \{\text{true, false}\}, \text{NArmy}[B] > 0 \wedge$$
$$(\exists g, g \in \{1...\text{NArmy}[B]\}, \text{Army}[B, g].\text{Squadrons} > 0$$

Condition II:

$$\text{Army}[B, g].\text{FixSuppl} < 0))$$

Condition III: True

1.12: Segmentation fault when squadron leaves Terrain grid

Condition I:$Active(B, g)$

Condition II:

$$(\exists j, 1 \leq j \leq \text{Army}[B, g].\text{Squadrons}, Endurance(B, g, j, \text{Mainloop}) > 0 \wedge$$
$$(X_{B,g,j}(\text{Mainloop}) < 0 \vee X_{B,g,j}(\text{Mainloop}) > \text{Params.XDelta} \times \text{MaxTerrain} \vee$$
$$Y_{B,g,j}(\text{Mainloop}) < 0 \vee Y_{B,g,j}(\text{Mainloop}) > \text{Params.YDelta} \times \text{MaxTerrain}))$$

Condition III: True

1.13: Weapon use functions misordered

Condition I:

$$\exists B, g, e, Active(B, g) \wedge Active(\neg B, e) \wedge$$
$$(\exists k, 1 \leq k \leq \text{Army}[\neg B, e].\text{Squadrons}, Endurance(\neg B, e, k, \text{Mainloop}) > 0 \wedge$$
$$(\exists j, 1 \leq j \leq \text{Army}[B, g].\text{Squadrons}, Observe(B, g, j, e, k, \text{Mainloop} - 1)))$$

Condition II: True

Condition III:

$$\{k' \mid (\exists j, Observe(B, g, j, e, k', \text{Mainloop}))\}$$
$$\neq \{k'' \mid (\exists j, Observe(B, g, j, e, k'', \text{Mainloop} - 1))\} \wedge$$
$$(\exists j, 1 \leq j \leq \text{Army}[B, g].\text{Squadrons}, Endurance(B, g, j, \text{Duration}) > 0) \wedge$$
$$(\exists k, 1 \leq k \leq \text{Army}[\neg B, e].\text{Squadrons}, Endurance(\neg B, e, k, \text{Duration}) > 0)$$

1.14: Observation list reversed, causes error in firing

and

1.15: Unneccesary addition of one to target list subscript in arguments to SetLLCoords

and

1.16: Unneccesary adding of one to weapon subscript in arguments to SetLLCoords

and

1.26: Improper targeting due to misordered observation list

Condition I:

$$
\begin{aligned}
&Active(B, g) \wedge Active(\neg B, e) \wedge \\
&(\exists k, 1 \leq k \leq \text{Army}[\neg B, e].\text{Squadrons}, Endurance(\neg B, e, k, \text{Duration}) > 0 \wedge \\
&(\exists j, 1 \leq j \leq \text{Army}[B, g].\text{Squadrons}, Endurance(B, g, j, \text{Mainloop}) > 0 \wedge \\
&Observe(B, g, j, e, k, \text{Mainloop} - 1))) \wedge \text{Params.NumWTypes} > 1
\end{aligned}
$$

Condition II:

$$
\begin{aligned}
&(\exists k', 1 \leq k' \leq \text{Army}[\neg B, e].\text{Squadrons}, Endurance(\neg B, e, k', \text{Mainloop} - 1) > 0 \wedge \\
&(\exists j, Observe(B, g, j, e, k', \text{Mainloop} - 1)) \wedge \\
&(x_{\neg B,e,k'}(\text{Mainloop}) \neq x_{\neg B,e,k}(\text{Mainloop}) \vee y_{\neg B,e,k'}(\text{Mainloop}) \neq y_{\neg B,e,k}(\text{Mainloop})))
\end{aligned}
$$

Condition III:

$$
\begin{aligned}
&| \{k \ni (\exists j, Observe(B, g, j, e, k, \text{Mainloop}))\} | > \\
&\min(\text{Army}[B, g].\text{WeapPriority}[e, 1], NumWeapon(B, g, 1, \text{Mainloop})) \wedge \\
&(\text{Army}[B, g].\text{Weapon}[1].\text{Damage} \neq \text{Army}[B, g].\text{Weapon}[2].\text{Damage} \vee \\
&\text{Army}[\neg B, e].\text{WeapSensativity}[1] \neq \text{Army}[\neg B, e].\text{WeapSensativity}[2]) \wedge \\
&(\nexists m, 1 \leq m \leq \text{NCmsgs}[\neg B], \\
&Mimp(\neg B, e, m, \text{Duration}) \wedge \neg Mimp(\neg B, e, m, \text{Mainloop}))
\end{aligned}
$$

1.17: Accepts Army.Squadrons=0 as valid data

Condition I:

$(\exists B, B \in \{\text{true, false}\}, \text{NArmy}[B] > 0$

Condition II: $\text{Army}[B, g].\text{Squadrons} = 0)$

Condition III: True

1.18: TerrMoveTM returns unstable value if battalion leaves terrain grid

Condition I: $Active(B, g)$

Condition II:

$(X_{B,g}(\text{Mainloop}) < 0 \vee X_{B,g}(\text{Mainloop}) > \text{Params.XDelta} \times \text{MaxTerrain} \vee$
$Y_{B,g}(\text{Mainloop}) < 0 \vee Y_{B,g}(\text{Mainloop}) > \text{Params.YDelta} \times \text{MaxTerrain})$

Condition III:

$\text{Duration} > \text{Mainloop} \wedge$
$(\nexists i, 1 \leq i \leq \text{NCmsgs}[B], Mimp(B, g, i, \text{Duration}) \wedge \neg Mimp(B, g, i, \text{Mainloop} - 1))$

1.19: NumCas not cleared by command message

Condition I:

$Active(B, g) \wedge$
$(\exists i, 1 \leq i \leq \text{NCmsgs}[B], Mimp(B, g, i, \text{Mainloop}) \wedge \neg Mimp(B, g, i, \text{Mainloop} - 1))$

Condition II:

$\exists j, 1 \leq j \leq \text{Army}[B, g].\text{Squadrons}, Casualty(B, g, j, \text{Mainloop})$

Condition III: True

1.20: NW>0 when KF≤0

Condition I:

$$
\begin{aligned}
&Active(B,g) \wedge \text{NArmy}[\neg B] > 0 \wedge \text{Params.NumWTypes} > 0 \wedge \\
&(\exists i, \quad 1 \leq i \leq \text{Params.NumWTypes}, \\
&\quad (\ \text{Army}[B,g].\text{Weapon}[i].\text{NumWeapon} > 0) \wedge \\
&\quad (\ \text{Army}[B,g].\text{Weapon}[i].\text{UseLimit} > 0) \wedge \\
&\quad (\ \text{Army}[B,g].\text{Weapon}[i].\text{Range} > 0) \wedge \\
&(\exists e, \quad 1 \leq e \leq \text{NArmy}[\neg B], \text{Army}[\neg B, e].\text{Squadrons} > 0 \wedge \\
&(\exists k, \quad 1 \leq k \leq \text{Army}[\neg B, e].\text{Squadrons}, \\
&(\exists j, \quad 1 \leq j \leq \text{Army}[B,g].\text{Squadrons}, \\
&\qquad Endurance(\neg B, e, k, \text{Mainloop}) > 0 \wedge \\
&\qquad Endurance(B, g, j, \text{Mainloop}) > 0 \wedge \\
&\qquad Observe(B, g, j, e, k, \text{Mainloop} - 1) \wedge InRange(B, g, i, e, k, \text{Mainloop})
\end{aligned}
$$

Condition II: $(\text{Army}[B,g].\text{Weapon}[i].\text{FireRate} \leq 0)$

Condition III:

$$
\begin{aligned}
&(\text{Army}[B,g].\text{Weapon}[i].\text{Damage} \neq 0) \wedge (\text{Army}[\neg B, e].\text{WeaponSensativity}[i] > 0) \wedge \\
&(\text{Duration} > \text{Mainloop}) \wedge \\
&(\nexists r, 1 \leq r \leq \text{NCmsgs}[\neg B], \\
&Mimp(\neg B, e, r, \text{Duration}) \wedge \neg Mimp(\neg B, e, r, \text{Mainloop} - 1))))
\end{aligned}
$$

1.22: Report Message processed ahead of command message with equal priority, receipt time

Condition I:

$$
\begin{aligned}
&Active(B,g) \wedge Active(\neg B,e) \wedge Active(B,f) \wedge \\
&(\exists i, 1 \leq i \leq \text{NCmsgs}[B], Mimp(B,g,i,\text{Mainloop}) \wedge \neg Mimp(B,g,i,\text{Mainloop}-1) \wedge \\
&\text{Army}[B,f].\text{Report} = g \wedge (\exists t, 1 \leq t \leq \text{Duration}, \\
&(t = \text{Mainloop} - \text{Army}[B,g].\text{ProcDelay} - \text{Army}[B,g].\text{MediaDelay} \\
&\qquad - \text{Army}[B,f].\text{SendRate} - 1) \wedge \\
&(\exists k, 1 \leq k \leq \text{Army}[\neg B,e].\text{Squadrons}, Endurance(\neg B,e,k,t) > 0 \wedge \\
&\qquad \exists j, 1 \leq j \leq \text{Army}[B,f].\text{Squadrons}, Observe(B,f,j,e,k,t)))
\end{aligned}
$$

Condition II: $\text{Army}[B,f].\text{Priority} = \text{Cmsgs}[B,i].\text{Priority}$

Condition III:

$$
\begin{aligned}
&\left(\sum_{m=1}^{\text{NCmsgs}[B]} \begin{cases} 1 \text{ if } Mimp(B,g,m,\text{Mainloop}) \wedge \neg Mimp(B,g,m,\text{Mainloop}-1) \\ 0 \qquad\qquad\qquad\qquad\qquad\qquad \text{otherwise} \end{cases} \right) \\
&\geq NumProcess(B,g,\text{Mainloop}))
\end{aligned}
$$

1.23: Invalid width, height when squadron leaves grid

Condition I: $Active(B,g)$

Condition II:

$$
\begin{aligned}
&(\exists j, 1 \leq j \leq \text{Army}[B,g].\text{Squadrons}, Endurance(B,g,j,\text{Mainloop}) > 0 \wedge \\
&\quad (X_{B,g,j}(\text{Mainloop}) < 0 \vee X_{B,g,j}(\text{Mainloop}) > \text{Params.XDelta} \times \text{MaxTerrain} \vee \\
&\quad Y_{B,g,j}(\text{Mainloop}) < 0 \vee Y_{B,g,j}(\text{Mainloop}) > \text{Params.YDelta} \times \text{MaxTerrain}))
\end{aligned}
$$

Condition III:

$$
(\nexists i, 1 \leq i \leq \text{NCmsgs}[B], Mimp(B,g,i,\text{Duration}) \wedge \neg Mimp(B,g,i,\text{Mainloop}-1))
$$

1.25: Observations and Weapon coordinates cleared by command messages

Condition I:

$$Active(B,g) \wedge$$
$$(\exists i, 1 \leq i \leq \text{NCmsgs}[B], Mimp(B,g,i,\text{Mainloop}) \wedge \neg Mimp(B,g,i,\text{Mainloop}-1))$$

Condition II:

$$Active(\neg B,e) \wedge$$
$$(\exists i,\ 1 \leq i \leq \text{Params.NumWTypes},$$
$$(NumWeapon(B,g,i,\text{Mainloop}) > 0 \wedge$$
$$(\text{Army}[B,g].\text{Weapon}[i].\text{FireRate} > 0) \wedge$$
$$(\text{Army}[B,g].\text{Weapon}[i].\text{UseLimit} > 0) \wedge$$
$$(\text{Army}[B,g].\text{Weapon}[i].\text{Range} > 0) \wedge$$
$$(\exists k,\ 1 \leq k \leq \text{Army}[\neg B,e].\text{Squadrons},$$
$$(\exists j,\ 1 \leq j \leq \text{Army}[B,g].\text{Squadrons},$$
$$Endurance(\neg B,e,k,\text{Mainloop}) > 0 \wedge$$
$$Endurance(B,g,j,\text{Mainloop}) > 0 \wedge$$
$$Observe(B,g,j,e,k,\text{Mainloop}-1) \wedge InRange(B,g,i,e,k,\text{Mainloop}-1)$$

Condition III:

$$(\text{Army}[B,g].\text{Weapon}[i].\text{Damage} \neq 0) \wedge (\text{Army}[\neg B,e].\text{WeaponSensativity}[i] > 0) \wedge$$
$$(\text{Duration} > \text{Mainloop}+1) \wedge (\neg Casualty(\neg B,e,k,\text{Mainloop})) \wedge$$
$$0.5 > \frac{Endurance(\neg B,e,k,\text{Mainloop}) - Damage(\neg B,e,k,\text{Mainloop}) + Damage(\neg B,e,k,\text{Mainloop}-1)}{\text{Army}[\neg B,e].\text{Endurance}[k]} \wedge$$
$$(\nexists r, 1 \leq r \leq \text{NCmsgs}[\neg B],$$
$$Mimp(\neg B,e,r,\text{Duration}) \wedge \neg Mimp(\neg B,e,r,\text{Mainloop}-1))))$$

1.27: Enemy instead of current position in observation jamming

Condition I:

$$Active(\neg B, e) \wedge Active(B, g) \wedge$$
$$(\exists k, 1 \leq k \leq \text{Army}[\neg B, e].\text{Squadrons},$$
$$(\exists j, 1 \leq j \leq \text{Army}[B, g].\text{Squadrons},$$
$$Endurance(\neg B, e, k, \text{Mainloop}) > 0 \wedge$$
$$Endurance(B, g, j, \text{Mainloop}) > 0 \wedge BigEnough(B, g, j, e, k, t) \wedge Clear(B, g, j, e, k, t)$$

Condition II:

$$\text{Params.SampleRate} > 2 \wedge$$
$$(x_{\neg B,e}(\text{Mainloop}) \neq x_{B,g}(\text{Mainloop}) \vee$$
$$y_{\neg B,e}(\text{Mainloop}) \neq y_{B,g}(\text{Mainloop})) \wedge$$
$$xgj = x_{B,g,j}(t-1) \wedge ygj = y_{B,g,j}(t-1) \wedge$$
$$xek = x_{\neg B,e,k}(t-1) \wedge yek = y_{\neg B,e,k}(t-1) \wedge$$
$$\left(\left(\frac{BI(a',c',xek,yek) - \text{Army}[\neg B,e].\text{SquadIntensity}[k]}{BI(a',c',xek,yek)}\right)^{\text{Params.SampleRate}} \right.$$
$$\sum_{n=1}^{} ((WO(xek, yek, \text{Mainloop}) \times \text{Army}[B, g].\text{VWEffect}) +$$
$$\sum_{e'=1}^{\text{NArmy}[\neg B]} \begin{cases} 0 & \text{if } \sqrt{(x_{\neg B,e'}(\text{Mainloop}-1) - xek)^2 + (y_{\neg B,e'}(\text{Mainloop}-1) - yek)^2} > \text{Army}[\neg B, e'].\text{ObsJamRadius} \\ \dfrac{\sqrt{(x_{\neg B,e'}(\text{Mainloop}-1) - xek)^2 + (y_{\neg B,e'}(\text{Mainloop}-1) - yek)^2}}{\text{Army}[\neg B,e'].\text{ObsJamRadius}} \times \text{Army}[\neg B, e'].\text{ObsJamEff} & \text{otherwise} \end{cases}$$
$$\left.\right)) < \text{Army}[B, g].\text{ObsMinContrast}[j])$$

Condition III: True

1.28: Allocated fixing exceeds NumFixers×FixRate

Condition I:

$$Active(B, g) \wedge (\exists j, 1 \leq j \leq \text{Army}[B, g].\text{Squadrons}, Casualty(B, g, j, \text{Mainloop})$$

Condition II:

$$(Endurace(B, g, j, \text{Mainloop}) - \text{Army}[B, g].\text{Endurance}[j]) >$$
$$(\text{Army}[B, g].\text{FixRate} \times NumFix(B, g, \text{Mainloop})$$

Condition III:

$$(Endurance(B, g, j, \text{Mainloop}) + \text{Army}[B, g].\text{FixRate} \times NumFix(B, g, \text{Mainloop}))$$
$$< \frac{\text{Army}[B,g].\text{Endurance}[j]}{2} \wedge$$
$$(\nexists m, 1 \leq m \leq \text{NCmsgs}[B], Mimp(B, g, m, \text{Duration}) \wedge \neg Mimp(B, g, m, \text{Mainloop}))$$

Failure Regions in Version 2

2.1: No check if report message destination is existing battalion

Condition I:

$Active(B, g) \wedge Active(\neg B, e) \wedge$
$(\exists k, 1 \leq k \leq \text{Army}[\neg B, e].\text{Squadrons},$
$(\exists j, 1 \leq j \leq \text{Army}[B, g].\text{Squadrons},$
$(\exists t, 1 \leq t \leq \text{Mainloop}, Observe(B, g, j, e, k, t))))$

Condition II: $0 > \text{Army}[B, g].\text{Report} \vee \text{NArmy}[B] < \text{Army}[B, g].\text{Report}$
Condition III: True

2.2: No check if command message destination is existing battalion

Condition I:

$\text{Duration} > 0 \wedge \exists t, 1 \leq t \leq \text{Duration},$
$\exists B, B \in \{\text{true}, \text{false}\}, \text{NArmy}[B] > 0$

Condition II:

$\exists m, 1 \leq m \leq \text{NCmsgs}[B], \text{Cmsgs}[B, m].\text{Time} = t \wedge$
$\text{Cmsgs}[B, m].\text{Army} = B \wedge (\text{Cmsgs}[B, m].\text{Dest} < 0 \vee \text{Cmsgs}[B, m].\text{Dest} > \text{NArmy}[B])$

Condition III: True

2.3: Message not queued for processing in next dt

Condition I:

$Active(B, g) \wedge (\exists m, 1 \leq m \leq \text{NCmsgs}[B], RecT(B, g, m) = \text{Mainloop}$

Condition II:

$CmdSum(B, g, m, \text{Mainloop}) + ReptSum(B, g, m, \text{Mainloop})$
$= NumProcess(B, g, \text{Mainloop} - 1)$

Condition III: True

2.4: Improper count of available receivers

Condition I:

$$Active(B, g) \wedge \exists j, 1 \leq j \leq \text{Army}[B, g].\text{Squadrons}, Casualty(B, g, j, \text{Mainloop})$$

Condition II:

$$NumRec(B, g, \text{Mainloop}) \neq NumRec(B, g, \text{Mainloop} - 1)$$

Condition III:

$$\exists m, 1 \leq m \leq \text{NCmsgs}[B], \text{Cmsgs}[B, g].\text{Dest} = g \wedge RecT(B, g, m) = \text{Mainloop}$$

2.5: Incomplete recalculation when command implemented

Condition I:

$$Active(B, g) \wedge (\exists m, 1 \leq m \leq \text{NCmsgs}[B], Mimp(B, g, m, \text{Mainloop}))$$

Condition II:

$$(\exists e, 1 \leq e \leq \text{NArmy}[\neg B], \text{Army}[\neg B, e].\text{Squadrons} > 0 \wedge$$
$$\exists k, 1 \leq k \leq \text{Army}[\neg B, e].\text{Squadrons}, Endurance(\neg B, e, k, \text{Mainloop}) > 0 \wedge$$
$$\exists j, 1 \leq j \leq \text{Army}[B, g].\text{Squadrons},$$
$$Endurance(B, g, j, \text{Mainloop}) > 0 \wedge Observe(B, g, j, e, k, \text{Mainloop} - 1))$$
$$\vee \text{Army}[B, g].\text{NumReceive} \neq \text{Cmsgs}[B, m].\text{msg.NumReceive}$$

Condition III:

$$(\exists m', 1 \leq m' \leq \text{NCmsgs}[B], Mimp(B, g, m, \text{Duration}) \wedge \neg Mimp(B, g, m, \text{Mainloop}))$$
$$\vee (\exists i, 1 \leq i \leq \text{Params.NumWTypes}, InRange(B, g, i, e, k, \text{Mainloop}))$$

2.6: Program fails when squadron exceeds Terrain boundaries

and

2.31: Use of borders to initialize w,h calculation causes problems

Condition I:(Duration > 0)

Condition II:

$$\exists B, g, Active(B, g) \wedge$$
$$(X_{B,g}(\text{Mainloop}) \geq \text{Params.XDelta} \times \text{MaxTerrain} \vee$$
$$Y_{B,g}(\text{Mainloop}) \geq \text{Params.YDelta} \times \text{MaxTerrain})$$

Condition III: True

2.7: Wrong points checked in subtended angle calculation

Condition I:

$$Active(B, g) \wedge Active(\neg B, e) \wedge$$
$$\exists j, 1 \leq j \leq \text{Army}[B, g].\text{Squadrons}, Endurance(B, g, j, \text{Mainloop}) > 0 \wedge$$
$$\exists k, 1 \leq k \leq \text{Army}[\neg B, e].\text{Squadrons}, Endurance(\neg B, e, k, \text{Mainloop}) > 0$$

Condition II:

$$(X_{B,g,j}(\text{Mainloop} - 1) > X_{\neg B,e,k}(\text{Mainloop} - 1) + \frac{\text{Army}[\neg B,e].\text{SquadWidth}}{2} \wedge$$
$$Y_{B,g,j}(\text{Mainloop} - 1) \leq Y_{\neg B,e,k}(\text{Mainloop} - 1) + \frac{\text{Army}[\neg B,e].\text{SquadLength}}{2}$$

Condition III:

$$\text{Army}[\neg B, e].\text{SquadWidth} > 0 \wedge \neg Observe(B, g, j, e, k, \text{Mainloop}) \wedge$$
$$Clear(B, g, j, e, k, \text{Mainloop}) \wedge Obvious(B, g, j, e, k, \text{Mainloop}) \wedge$$
$$(\forall t, 1 \leq t \leq \text{Duration},$$
$$\nexists j', 1 \leq j' \leq \text{Army}[B, g].\text{Squadrons}, Endurance(B, g, j', t) > 0 \wedge$$
$$\exists k', 1 \leq k' \leq \text{Army}[\neg B, e].\text{Squadrons}, Endurance(\neg B, e, k', t) > 0 \wedge$$
$$Observe(B, g, j', e, k', t))$$

2.8: Calculates the wrong angle if Observer, two corners are colinear

Condition I:

$$Active(B, g) \wedge Active(\neg B, e) \wedge$$
$$\exists j, 1 \leq j \leq \text{Army}[B, g].\text{Squadrons}, Endurance(B, g, j, \text{Mainloop}) > 0 \wedge$$
$$\exists k, 1 \leq k \leq \text{Army}[\neg B, e].\text{Squadrons}, Endurance(\neg B, e, k, \text{Mainloop}) > 0$$

Condition II:

$$((Y_{B,g,j}(\text{Mainloop} - 1) = Y_{\neg B,e,k}(\text{Mainloop} - 1) + \frac{\text{Army}[\neg B,e].\text{SquadLength}}{2}) \vee$$
$$(Y_{B,g,j}(\text{Mainloop} - 1) = Y_{\neg B,e,k}(\text{Mainloop} - 1) - \frac{\text{Army}[\neg B,e].\text{SquadLength}}{2})) \wedge$$
$$\mid X_{B,g,j}(\text{Mainloop} - 1) - X_{\neg B,e,k}(\text{Mainloop} - 1) \mid < \frac{\text{Army}[\neg B,e].\text{SquadWidth}}{2}$$

Condition III:

$$\text{Army}[\neg B, e].\text{SquadWidth} > 0 \wedge \neg Observe(B, g, j, e, k, \text{Mainloop}) \wedge$$
$$Clear(B, g, j, e, k, \text{Mainloop}) \wedge Obvious(B, g, j, e, k, \text{Mainloop}) \wedge$$
$$(\forall t, 1 \leq t \leq \text{Duration},$$
$$\nexists j', 1 \leq j' \leq \text{Army}[B, g].\text{Squadrons}, Endurance(B, g, j', t) > 0 \wedge$$
$$\exists k', 1 \leq k' \leq \text{Army}[\neg B, e].\text{Squadrons}, Endurance(\neg B, e, k', t) > 0 \wedge$$
$$Observe(B, g, j', e, k', t))$$

2.10: No check ifParams.XDelta = 0

Condition I: True
Condition II: Params.XDelta = 0
Condition III: True

2.11: No check if Params.YDelta = 0

Condition I: True
Condition II: Params.YDelta = 0
Condition III: True

2.12: No check if Params.SampleRate < 2

Condition I: True
Condition II: Params.SampleRate < 2
Condition III: True

2.13: Infinite velocity if E0 = 0

Condition I:

$$\text{Duration} > 0 \wedge \exists B, B \in \{\text{true}, \text{false}\}, \text{NArmy}[B] > 0 \wedge$$
$$\exists g, 1 \leq g \leq \text{NArmy}[B], \text{Army}[B, g].\text{Squadrons} > 0$$

Condition II: $\nexists j, 1 \leq j \leq \text{Army}[B, g].\text{Squadrons}, \text{Army}[B, g].\text{Endurance}[j] > 0$

Condition III:

$$(\nexists i, 1 \leq i \leq \text{NCmsgs}[B], Mimp(B, g, i, \text{Duration}) \wedge \neg Mimp(B, g, i, \text{Mainloop} - 1))$$

2.14: No check if Army.NumFixers > Army.Squadrons

Condition I:(Duration ≥ 0)

Condition II:

$(\exists B, B \in \{1...\text{NArmy}[\text{true}]\},$
$\quad \text{Army}[\text{true}, B].\text{NumFixers} > \text{Army}[\text{true}, B].\text{Squadrons}) \vee$
$(\exists B, B \in \{1...\text{NArmy}[\text{false}]\},$
$\quad \text{Army}[\text{false}, B].\text{NumFixers} > \text{Army}[\text{false}, B].\text{Squadrons})$

Condition III: True

2.15: No check if Army.NumJammers > Army.Squadrons

Condition I:(Duration ≥ 0)

Condition II:

$(\exists B, B \in \{1...\text{NArmy}[\text{true}]\},$
$\quad \text{Army}[\text{true}, B].\text{NumJammers} > \text{Army}[\text{true}, B].\text{Squadrons}) \vee$
$(\exists B, B \in \{1...\text{NArmy}[\text{false}]\},$
$\quad \text{Army}[\text{false}, B].\text{NumJammers} > \text{Army}[\text{false}, B].\text{Squadrons})$

Condition III: True

2.16: No check if Army.NumProcess > Army.Squadrons

Condition I:(Duration ≥ 0)

Condition II:

$(\exists B, B \in \{1...\text{NArmy}[\text{true}]\},$
$\quad \text{Army}[\text{true}, B].\text{NumProcess} > \text{Army}[\text{true}, B].\text{Squadrons}) \vee$
$(\exists B, B \in \{1...\text{NArmy}[\text{false}]\},$
$\quad \text{Army}[\text{false}, B].\text{NumProcess} > \text{Army}[\text{false}, B].\text{Squadrons})$

Condition III: True

2.17: No check if Army.NumReceive > Army.Squadrons

Condition I:(Duration ≥ 0)

Condition II:

$(\exists B, B \in \{1...\text{NArmy[true]}\},$
$\quad \text{Army[true}, B].\text{NumReceive} > \text{Army[true}, B].\text{Squadrons}) \vee$
$(\exists B, B \in \{1...\text{NArmy[false]}\},$
$\quad \text{Army[false}, B].\text{NumReceive} > \text{Army[false}, B].\text{Squadrons})$

Condition III: True

2.18: No check if Army.NumSend > Army.Squadrons

Condition I:(Duration ≥ 0)

Condition II:

$(\exists B, B \in \{1...\text{NArmy[true]}\},$
$\quad \text{Army[true}, B].\text{NumSend} > \text{Army[true}, B].\text{Squadrons}) \vee$
$(\exists B, B \in \{1...\text{NArmy[false]}\},$
$\quad \text{Army[false}, B].\text{NumSend} > \text{Army[false}, B].\text{Squadrons})$

Condition III: True

2.19: No check if Cmsgs.msg.NumFixers > Cmsgs.msg.Squadrons

Condition I:

$\exists B, \quad B \in \{\text{true}, \text{false}\},$
$\quad (\exists f, 1 \leq f \leq \text{NArmy}[B],$
$\quad\quad (\exists m, m \in \{1...\text{NCmsgs}[B]\}, Mimp(B, f, m, \text{Duration})))$

Condition II:

$\text{Cmsgs}[B, m].\text{Msg.NumFixers} > \text{Cmsgs}[B, m].\text{Msg.Squadrons}$

Condition III: True

2.20: No check if Cmsgs.msg.NumJammers > Cmsgs.msg.Squadrons

Condition I:

$\exists B, \quad B \in \{\text{true}, \text{false}\},$
$\quad (\exists f, 1 \leq f \leq \text{NArmy}[B],$
$\quad\quad (\exists m, m \in \{1...\text{NCmsgs}[B]\}, Mimp(B, f, m, \text{Duration})))$

Condition II:

$\text{Cmsgs}[B, m].\text{msg.NumJammers} > \text{Cmsgs}[B, m].\text{msg.Squadrons}$

Condition III: True

2.21: No check if Cmsgs.msg.NumProcess > Cmsgs.msg.Squadrons

Condition I:

$$\exists B, \quad B \in \{\text{true}, \text{false}\},$$
$$(\exists f, 1 \leq f \leq \text{NArmy}[B],$$
$$(\exists m, m \in \{1...\text{NCmsgs}[B]\}, Mimp(B, f, m, \text{Duration})))$$

Condition II:

$$\text{Cmsgs}[B, m].\text{msg.NumProcess} > \text{Cmsgs}[B, m].\text{msg.Squadrons}$$

Condition III: True

2.22: No check if Cmsgs.msg.NumReceive > Cmsgs.msg.Squadrons

Condition I:

$$\exists B, \quad B \in \{\text{true}, \text{false}\},$$
$$(\exists f, 1 \leq f \leq \text{NArmy}[B],$$
$$(\exists m, m \in \{1...\text{NCmsgs}[B]\}, Mimp(B, f, m, \text{Duration})))$$

Condition II:

$$\text{Cmsgs}[B, m].\text{msg.NumReceive} > \text{Cmsgs}[B, m].\text{msg.Squadrons}$$

Condition III: True

2.23: No check if Cmsgs.msg.NumSend > Cmsgs.msg.Squadrons

Condition I:

$$\exists B, \quad B \in \{\text{true}, \text{false}\},$$
$$(\exists f, 1 \leq f \leq \text{NArmy}[B],$$
$$(\exists m, m \in \{1...\text{NCmsgs}[B]\}, Mimp(B, f, m, \text{Duration})))$$

Condition II:

$$\text{Cmsgs}[B, m].\text{msg.NumSend} > \text{Cmsgs}[B, m].\text{msg.Squadrons}$$

Condition III: True

2.25: Multiple Reports processed in queue order

Condition I:

$$Active(\neg B, e) \wedge Active(B, g) \wedge Active(B, f) \wedge Active(B, f') \wedge f \neq f' \wedge$$
$$\exists k, 1 \leq k \leq \text{Army}[\neg B, e].\text{Squadrons}, (Endurance(\neg B, e, \text{Mainloop}) > 0) \wedge$$
$$(\exists t, t = \text{Mainloop} - \text{Army}[B, f].\text{SendRate} - \text{Army}[B, g].\text{MediaDelay} - \frac{\text{Army}[B,g].\text{RecRate}}{\text{Army}[B,g].\text{NumReceive}} - \text{Army}[B, g].\text{ProcDelay}$$
$$\exists j, 1 \leq j \leq \text{Army}[B, f].\text{Squadrons}, Endurance(B, f, j, t) > 0 \wedge Observe(B, f, j, e, k, t)) \wedge$$
$$(\exists t', t' = \text{Mainloop} - RepT(B, f', g) - \text{Army}[B, g].\text{ProcDelay} - \frac{\text{Army}[B,g].\text{RecRate}}{NumRec(B,g,\text{Mainloop}-\text{Army}[B,g].\text{ProcDelay})}$$
$$\exists j', 1 \leq j' \leq \text{Army}[B, f'].\text{Squadrons}, Endurance(B, f', j', t') > 0$$
$$\wedge Observe(B, f', j', e, k, t'))$$

Condition II:

$$\text{Army}[B, f].\text{Priority} > \text{Army}[B, f'].\text{Priority} \wedge$$
$$\text{Army}[B, f].\text{SendRate} > \text{Army}[B, f'].\text{SendRate}$$

Condition III:

$$(\exists i, 1 \leq i \leq \text{Params.NumWTypes}, InRange(B, g, i, e, k, \text{Mainloop} + 1)) \wedge$$
$$(\forall t, 1 \leq t \leq \text{Duration},$$
$$\nexists j', 1 \leq j' \leq \text{Army}[B, g].\text{Squadrons}, Endurance(B, g, j', t) > 0 \wedge$$
$$\exists k', 1 \leq k' \leq \text{Army}[\neg B, e].\text{Squadrons}, Endurance(\neg B, e, k', t) > 0 \wedge$$
$$Observe(B, g, j', e, k', t))$$

2.26: gold observes when version does not

Condition I: $Active(B, g) \wedge Active(\neg B, e)$

Condition II:

$$SomeObserve(\neg B, e, g, 2) \wedge (\exists m, 1 \leq m \leq \text{NCmsgs}[B], Mimp(B, g, m, 1))$$

Condition II: True

2.30: Alt poorly defined when battalion leaves terrain grid

Condition I: (Duration > 0)

Condition II:

$$\exists B, g, Active(B, g) \wedge$$
$$(X_{B,g}(\text{Mainloop}) \leq 0 \vee Y_{B,g}(\text{Mainloop}) \leq 0)$$

Condition III: True

Failure Regions in Version 3

3.1: Improper count on number of busy processors in procedure ReceiveMessages

Condition I:

$$
\begin{aligned}
&(\exists B, (\exists f, Active(B,f) \wedge \\
&\qquad (\text{Army}[B,f].\text{NumReceive} > 0) \wedge \\
&\qquad (\text{NCmsgs}[B] > 0) \wedge \\
&\qquad (\exists i, 1 \le i \le \text{NCmsgs}[B], \text{PTR}\hat{}.\text{CMessage} = i))) \\
&\wedge (\text{PTR} \neq \text{nil}) \wedge (\text{PTR}\hat{}.\text{DestArmy} = B) \wedge (\text{PTR}\hat{}.\text{DestBatt} = f)
\end{aligned}
$$

Condition II: $(\text{PTR}\hat{}.\text{Processed} = \text{recd}) \wedge (\text{PTR}\hat{}.\text{TimeRecd} = \text{Mainloop})$

Condition III:

$$
\begin{aligned}
&\left(\sum_{M=\text{HeadQueue}}^{M\hat{}.\text{next}=\text{null}} \begin{cases} 1 & \text{if}(M\hat{}.\text{DestArmy} = B) \wedge (M\hat{}.\text{DestBatt} = f) \wedge \\ & \quad (M\hat{}.\text{Processed} = \text{recd}) \wedge (M\hat{}.\text{TimeRecd} \ge \text{Mainloop}) \\ 0 & \text{otherwise} \end{cases} \right) \\
&\ge \text{Army}[B,f].\text{NumProcess} \wedge \\
&\left(\sum_{M=\text{HeadQueue}}^{M\hat{}.\text{next}=\text{nil}} \begin{cases} 1 & \text{if}(M\hat{}.\text{DestArmy} = B) \wedge (M\hat{}.\text{DestBatt} = f) \wedge \\ & \quad (M\hat{}.\text{Processed} = \text{recd}) \wedge (M\hat{}.\text{TimeRecd} > \text{Mainloop}) \\ 0 & \text{otherwise} \end{cases} \right) \\
&< \text{Army}[B,f].\text{NumProcess} \wedge \\
&(\exists M, M \in \{\text{HeadQueue}, \ldots, \text{nil}\}, \\
&(M\hat{}.\text{DestArmy} = B) \wedge (M\hat{}.\text{DestBatt} = f) \wedge \\
&(M\hat{}.\text{Processed} = \text{arrvd}) \wedge (M\hat{}.\text{TimeSent} \le \text{Duration})) \vee \\
&(\exists M, M \in \text{Cmsgs}[B], (M.\text{Dest} = f) \wedge (M.\text{Time} > \text{Mainloop}) \wedge \\
&(M.\text{Time} < \text{Duration} \wedge (M.\text{mesg} \neq \text{CMsgs}[B][\text{PTR}\hat{}.\text{CMessage}])))
\end{aligned}
$$

3.2: Violation of queue structure when messages of equal priority are ready for processing

Condition I:

$$Active(B,f) \wedge (\text{Army}[B,f].\text{NumReceive} > 0) \wedge$$
$$(\text{NCmsgs}[B] > 0) \wedge (\exists i, 1 \leq i \leq \text{NCmsgs}[B], \text{Rec}\hat{}.\text{CMessage} = i) \wedge$$
$$(\text{HeadQueue} \neq \text{nil})$$

$$(\ \exists M, M \in \{\text{HeadQueue}...\text{nil}\},$$
$$(M\hat{}.\text{CMessage} \neq \text{Rec}\hat{}.\text{CMessage}) \wedge$$
$$(M\hat{}.\text{DestArmy} = B) \wedge (M\hat{}.\text{DestBatt} = f))$$

Condition II:$(\exists \text{place}, \text{place} \in \{\text{HeadQueue}...\text{nil}\}, \text{place}\hat{}.\text{priority} < \text{Rec}\hat{}.\text{priority})$
Condition III: True

3.3: Message implemented in destroyed battalions in procedure FollowCommandMessages

Condition I:

$$(\ \text{Duration} > 0) \wedge (\text{Mainloop} \in \{0...\text{Duration}\})$$
$$\wedge(((B = \text{True}) \wedge (\text{NArmy}[B] > 0) \wedge (f \in \{1...\text{NArmy}[B]\}) \wedge$$
$$(\text{Army}[B,f].\text{Squadrons} > 0) \wedge$$
$$(\text{Army}[B,f].\text{NumReceive} > 0) \wedge$$
$$(\exists i, 1 \leq i \leq \text{Army}[B,f].\text{Squadrons},$$
$$Endurance(B,f,i,\text{Mainloop}) > 0) \wedge$$
$$(\text{NCmsgs}[B] > 0) \wedge$$
$$(\exists i, 1 \leq i \leq \text{NCmsgs}[B], \text{Match}\hat{}.\text{CMessage} = i)) \vee$$
$$((B = \text{False}) \wedge (\text{NArmy}[B] > 0) \wedge (f \in \{1...\text{NArmy}[B]\}) \wedge$$
$$(\text{Army}[B,f].\text{Squadrons} > 0) \wedge$$
$$(\text{Army}[B,f].\text{NumReceive} > 0) \wedge$$
$$(\exists i, 1 \leq i \leq \text{Army}[B,f].\text{Squadrons},$$
$$Endurance(B,f,i,\text{Mainloop}) > 0) \wedge$$
$$(\text{NCmsgs}[B] > 0) \wedge$$
$$(\exists i, 1 \leq i \leq \text{NCmsgs}[B], \text{Match}\hat{}.\text{CMessage} = i)))$$
$$\wedge \left(K = \sum_{s=1}^{\text{Army}[B,f].\text{Squadrons}} \begin{cases} 1 \text{ if } Endurance(B,f,s,\text{Mainloop}) \leq 0 \\ 0 \text{ otherwise} \end{cases} \right)$$
$$\wedge \text{Match} \neq \text{NIL}$$

Condition II:

$$\text{Army}[B,f].\text{Squadrons} - K \leq 0$$

Condition III: True

3.4: Initial Endurance <= 0 reported erroneous in command messages

Condition I:

$$\exists B,\quad B \in \{\text{true}, \text{false}\},$$
$$(\exists f, 1 \leq f \leq \text{NArmy}[B],$$
$$(\exists m, m \in \{1...\text{NCmsgs}[B]\}, Mimp(B, f, m, \text{Duration})))$$

Condition II:

$$\exists j, 1 \leq j \leq \text{Cmsgs}[B, m].\text{Msg.Squadrons}, \text{Cmsgs}[B, m].\text{Msg.Endurance}[s] \leq 0$$

Condition III:True

3.5: Initial velocity counted incorrect if Endurance <= 0

Condition I:

$$(\text{ArmyNum} \in \{\text{true}, \text{false}\}) \wedge (\text{Batt} \in \{1...\text{NArmy}[\text{ArmyNum}]\}) \wedge$$
$$(\text{Army}[\text{ArmyNum}, \text{Batt}].\text{Squadrons} > 0)$$

Condition II:

$$(\exists s, s \in \{1...\text{Army}[\text{ArmyNum}, \text{Batt}].\text{Squadrons}\},$$
$$\text{Army}[\text{ArmyNum}, \text{Batt}].\text{Endurance}[s] \leq 0) \wedge$$
$$(\exists i, i \in \{1...\text{Army}[\text{ArmyNum}, \text{Batt}].\text{Squadrons}\}, \text{Army}[\text{ArmyNum}, \text{Batt}].\text{V0}[i] \neq 0)$$

Condition III:

$$(\nexists s', s' \in \{1...\text{Army}[\text{ArmyNum}, \text{Batt}].\text{Squadrons}\},$$
$$(\text{Army}[\text{ArmyNum}, \text{Batt}].\text{V0}[s'] <$$
$$\text{Army}[\text{ArmyNum}, \text{Batt}].\text{V0}[s]) \wedge$$
$$(\text{Army}[\text{ArmyNum}, \text{Batt}].\text{Endurance}[s'] \leq 0))$$
$$((\ \text{Duration} = 0) \vee$$
$$(\ \nexists m, m \in \{1...\text{NCmsgs}[\text{ArmyNum}]\},$$
$$Mimp(\text{ArmyNum}, \text{Batt}, m, \text{Duration})))$$

3.6: Array range violations in BatPosition lead to setting of wrong battalion's squad positions

Condition I: $\exists B, \exists g, Active(B, g)$

Condition II:

$$Endurance(B, g, \text{Army}[B, g].\text{Squadrons}, \text{Mainloop}) \leq 0$$

Condition III: True

3.7: KU equations not supported

and

3.8: dNK equations not supported

Condition I:

$$(\exists B, (\exists g, Active(B, g) \wedge (\text{Params.NumWTypes} > 0)))$$

$$(\exists i,\ 1 \leq i \leq \text{Params.NumWTypes},\ (\text{Army}[B, g].\text{Weapon}[i].\text{NumWeapon} > 0) \wedge (\text{Army}[B, g].\text{Weapon}[i].\text{FireRate} > 0) \wedge (\text{Army}[B, g].\text{Weapon}[i].\text{UseLimit} > 0) \wedge (\text{Army}[B, g].\text{Weapon}[i].\text{Range} > 0) \wedge$$

$$(\exists e,\ 1 \leq e \leq \text{NArmy}[\neg B], (\exists k,\ 1 \leq k \leq \text{Army}[\neg B, e].\text{Squadrons}, (\exists j,\ 1 \leq j \leq \text{Army}[B, g].\text{Squadrons}, Endurance\epsilon(\neg B, e, k, \text{Mainloop}) > 0 \wedge Endurance(B, g, j, \text{Mainloop}) > 0 \wedge Observe\epsilon(B, g, j, e, k, \text{Mainloop}) \wedge InRange\epsilon(B, g, i, e, k, \text{Mainloop})))))$$

Condition II: True

Condition III:

$$(\nexists m, 1 \leq m \leq \text{NCmsgs}[B], Mimp(B, g, m, \text{Duration}) \wedge \neg Mimp(B, g, m, \text{Mainloop}))$$

3.9: Wrong Sx,Sy used in calculation of K

Condition I:

$$
\begin{aligned}
&Active(B,g) \wedge Active(\neg B,e) \wedge \\
&(\exists i,\ 1 \leq i \leq \text{Params.NumWTypes}, \\
&\quad (\text{Army}[B,g].\text{Weapon}[i].\text{NumWeapon} > 0) \wedge \\
&\quad (\text{Army}[B,g].\text{Weapon}[i].\text{FireRate} > 0) \wedge \\
&\quad (\text{Army}[B,g].\text{Weapon}[i].\text{UseLimit} > 0) \wedge \\
&\quad (\text{Army}[B,g].\text{Weapon}[i].\text{Range} > 0) \wedge \\
\\
&(\exists k,\ 1 \leq k \leq \text{Army}[\neg B,e].\text{Squadrons}, \\
&(\exists j,\ 1 \leq j \leq \text{Army}[B,g].\text{Squadrons}, \\
&\quad Endurance(\neg B,e,k,\text{Mainloop}) > 0 \wedge \\
&\quad Endurance(B,g,j,\text{Mainloop}) > 0 \wedge \\
&\quad Observe(B,g,j,e,k,\text{Mainloop}) \wedge InRange(B,g,i,e,k,\text{Mainloop}) \wedge \\
&\quad xek = x_{\neg B,e,k}(\text{Mainloop}-1) \wedge yek = y_{\neg B,e,k}(\text{Mainloop}-1) \\
&) \quad)
\end{aligned}
$$

Condition II:$(\text{Army}[B,g].\text{X} \neq xek) \wedge (\text{Army}[B,g].\text{Y} \neq yek)$

Condition III:

$$
\begin{aligned}
&(\text{Duration} > \text{Mainloop}+1) \wedge Casualty(\neg B,e,k,\text{Mainloop}+1) \wedge \\
&0.5 < \frac{\begin{array}{l} Endurance(\neg B,e,k,\text{Mainloop}) + Damage(\neg B,e,k,\text{Mainloop}) - \\ Damage(\neg B,e,k,\text{Mainloop}-1) \end{array}}{\text{Army}[\neg B,e].\text{Endurance}[k]} \\
&\wedge (\nexists m, 1 \leq m \leq \text{NCmsgs}[\neg B], Mimp(\neg B,e,m,\text{Duration}) \wedge \neg Mimp(\neg B,e,m,\text{Mainloop})))
\end{aligned}
$$

3.10: Duration=0 considered erroneous

Condition I:True

Condition II:Duration = 0

Condition III:True

3.11: M>MaxTerrain instead if M>=MaxTerrain in findA

and

3.20: N>MaxTerrain instead if N>=MaxTerrain in findA

Condition I:(Duration > 0)
Condition II:

$$\exists B, g, Active(B, g) \wedge$$
$$X_{B,g}(\text{Mainloop}) = \text{Params.XDelta} \times \text{MaxTerrain } [\textit{for 3.11}] \vee$$
$$Y_{B,g}(\text{Mainloop}) = \text{Params.YDelta} \times \text{MaxTerrain } [\textit{for 3.20}])$$

Condition III: True

3.12: TM undefined when Dist=0

Condition I:$Active(B, g)$
Condition II:$V(B, g, \text{Mainloop}) = 0$
Condition III:

$$(\text{Duration} > \text{Mainloop}) \wedge$$
$$(x_{B,g}(\text{Mainloop}) \neq x_{B,g}(\text{Mainloop} - 1) \vee$$
$$y_{B,g}(\text{Mainloop}) \neq y_{B,g}(\text{Mainloop} - 1))$$
$$\wedge(\nexists m, 1 \leq m \leq \text{NCmsgs}[B], Mimp(B, g, m, \text{Duration}) \wedge \neg Mimp(B, g, m, \text{Mainloop}))$$

3.13: Observation from side uses wrong points in angle calculation

Condition I:

$$Active(B, g) \wedge Active(\neg B, e) \wedge$$
$$(\exists j, 1 \leq j \leq \text{Army}[B, g].\text{Squadrons}, (\exists k, 1 \leq k \leq \text{Army}[\neg B, e].\text{Squadrons},$$
$$(x_{B,g,j}(\text{Mainloop} - 1) > x_{\neg B,e,k}(\text{Mainloop} - 1) \wedge$$
$$y_{B,g,j}(\text{Mainloop} - 1) = y_{\neg B,e,k}(\text{Mainloop} - 1)) \vee$$
$$(x_{B,g,j}(\text{Mainloop} - 1) < x_{\neg B,e,k}(\text{Mainloop} - 1) \wedge$$
$$y_{B,g,j}(\text{Mainloop} - 1) = y_{\neg B,e,k}(\text{Mainloop} - 1)) \vee$$
$$(x_{B,g,j}(\text{Mainloop} - 1) = x_{\neg B,e,k}(\text{Mainloop} - 1))$$

Condition II:$\text{Army}[\neg B, e].\text{SquadLength} > 0 \vee \text{Army}[\neg B, e].\text{SquadWidth} > 0$
Condition III:

$$Clear(B, g, j, e, k, \text{Mainloop}) \wedge Obvious(B, g, j, e, k, \text{Mainloop})))$$

3.15: Assumes that velocity never exceeds 99999

Condition I: Duration > 0

Condition II:

$\exists B, g, B \in \{\text{true}, \text{false}\}, 1 \leq g \leq \text{NArmy}[B],$
$(\exists s, 1 \leq s \leq \text{Army}[B, g].\text{Squadrons},$
$Endurance(B, g, s, \text{Mainloop}) > 0 \wedge \text{Army}[B, g].\text{V0}[s] > 99999) \vee$
$(\exists m, 1 \leq m \leq \text{NCmsgs}[B], Mimp(B, g, m, \text{Duration}) \wedge$
$(\exists s, 1 \leq s \leq \text{Cmsgs}[B, m].\text{Msg.Squadrons},$
$\text{Cmsgs}[B, m].\text{Msg.Endurance}[s] > 0 \wedge \text{Cmsgs}[B][m].\text{Msg.V0}[s] > 99999))$

Condition III: True

3.16: SegViolation in FindA when battalion leaves defined terrain

Condition I:(Duration > 0)

Condition II:

$\exists B, g, Active(B, g) \wedge$
$(X_{B,g}(\text{Mainloop}) \geq \text{Params.XDelta} \times \text{MaxTerrain} \vee$
$Y_{B,g}(\text{Mainloop}) \geq \text{Params.YDelta} \times \text{MaxTerrain} \vee$
$X_{B,g}(\text{Mainloop}) \leq 0 \vee Y_{B,g}(\text{Mainloop}) \leq 0)$

Condition III: True

3.17: Result variables not set if Duration<0

Condition I: True

Condition II:(Duration < 0) $\wedge$ ((NArmy[true] > 0) $\vee$ (NArmy[false] > 0))

Condition III: True

3.18: N undefined in WeaponsSighting at first occurance
and

3.19: M undefined in WeaponsSighting at first occurance
Condition I:$(\exists B, (\exists g, Active(B, g)))$
Condition II: True
Condition III:

$(\exists i,\ 1 \leq i \leq \text{Params.NumWTypes},$
$(\text{Army}[B, g].\text{Weapon}[i].\text{NumWeapon} > 0) \wedge (\text{Army}[B, g].\text{Weapon}[i].\text{FireRate} > 0) \wedge$
$(\text{Army}[B, g].\text{Weapon}[i].\text{UseLimit} > 0) \wedge (\text{Army}[B, g].\text{Weapon}[i].\text{Range} > 0) \wedge$

$(\exists e,\ 1 \leq e \leq \text{NArmy}[\neg B],$
$(\exists k,\ 1 \leq k \leq \text{Army}[\neg B, e].\text{Squadrons},$
$(\exists j,\ 1 \leq j \leq \text{Army}[B, g].\text{Squadrons},$
$Endurance(\neg B, e, k, \text{Mainloop}) > 0 \wedge Endurance(B, g, j, \text{Mainloop}) > 0 \wedge$
$Observe(B, g, j, e, k, \text{Mainloop}) \wedge InRange(B, g, i, e, k, \text{Mainloop})))))$

3.21: Does not reject NArmy<0
Condition I:$(\text{Duration} \geq 0)$
Condition II:$(\text{NArmy}[\text{true}] < 0) \vee (\text{NArmy}[\text{false}] < 0)$
Condition III: True

3.22: Restoration allotted when FS<0
Condition I:$Active(B, g) \wedge (\exists j, 1 \leq j \leq \text{Army}[B, g].\text{Squadrons}, Casualty(B, g, j, \text{Mainloop}))$
Condition II:$Suppl(B, g, \text{Mainloop}) < 0$
Condition III: True

3.23: Messages lost if NumProcess goes transiently to 0

Condition I:

$$Active(B, g) \wedge$$
$$(\exists m, 1 \leq m \leq \text{NCmsgs}[B], ((\text{Cmsgs}[B, m].\text{Time} + \text{Army}[B, g].\text{MediaDelay}$$
$$+\text{Army}[B, g].\text{ProcDelay}) = \text{Mainloop}) \wedge$$
$$(\text{Cmsgs}[B, m].\text{Dest} = g))$$

Condition II:

$$0 = NumProcess(B, g, \text{Mainloop})$$

Condition III:

$$0 < NumProcess(B, g, \text{Mainloop} + 1)$$

$$(\exists m', 1 \leq m' \leq \text{NCmsgs}[B], (\neg Mimp(B, g, m', \text{Mainloop})) \wedge Mimp(B, g, m', \text{Duration}))$$

3.24: Positions not initialized when Duration=0

Condition I:

$$(\text{ArmyNum} \in \{\text{true}, \text{false}\}) \wedge (\text{Batt} \in \{1...\text{NArmy}[\text{ArmyNum}]\}) \wedge$$
$$(\text{Army}[\text{ArmyNum}, \text{Batt}].\text{Squadrons} > 0)$$

Condition II: True
Condition III:$(\text{Duration} = 0)$

3.25: Positions centered on current, not previous, battalion x,y

Condition I:$Active(B, g)$
Condition II:

$$(\exists j, 1 \leq j \leq \text{Army}[B, g].\text{Squadrons},$$
$$\text{Army}[B, g].\text{V0}[j] > 0 \wedge Endurance(B, g, j, \text{Mainloop}) > 0)$$

Condition III: True

3.26: Initally destroyed squadrons not in "Killed"

Condition I:

$$(\text{ArmyNum} \in \{\text{true}, \text{false}\}) \wedge (\text{Batt} \in \{1...\text{NArmy}[\text{ArmyNum}]\}) \wedge$$
$$(\text{Army}[\text{ArmyNum}, \text{Batt}].\text{Squadrons} > 0)$$

Condition II:

$$(\exists s, s \in \{1...\text{Army}[\text{ArmyNum}, \text{Batt}].\text{Squadrons}\},$$
$$\text{Army}[\text{ArmyNum}, \text{Batt}].\text{Endurance}[s] \leq 0)$$

Condition III:

$$((\text{Duration} = 0) \vee$$
$$(\nexists m, m \in \{1...\text{NCmsgs}[\text{ArmyNum}]\},$$
$$Mimp(\text{ArmyNum}, \text{Batt}, m, \text{Duration})))$$

3.28: FindA returns poorly defined value if X<0

Condition I:

$$Active(B, g)$$

Condition II:

$$x_{B,g}(\text{Mainloop}) < 0 \vee$$
$$(\exists j, 1 \leq j \leq \text{Army}[B, g].\text{Squadrons}, x_{B,g,j}(\text{Mainloop}) < 0$$

Condition III:

$$\nexists m, m \in \{1...\text{NCmsgs}[B]\}, Mimp(B, g, m, \text{Duration})$$

3.32: Does not reject Army.Squadrons=0

Condition I:$(\text{Duration} \geq 0)$

Condition II:

$$(\exists B, B \in \{1...\text{NArmy}[\text{true}]\},$$
$$\text{Army}[\text{true}, B].\text{Squadrons} = 0) \vee$$
$$(\exists B, B \in \{1...\text{NArmy}[\text{false}]\},$$
$$\text{Army}[\text{false}, B].\text{Squadrons} = 0)$$

Condition III: True

3.33: Does not reject Army.NumFixers > Army.Squadrons

Condition I:(Duration ≥ 0)
Condition II:

$(\exists B, B \in \{1...\text{NArmy[true]}\},$
$\quad \text{Army[true}, B\text{].NumFixers} > \text{Army[true}, B\text{].Squadrons}) \vee$
$(\exists B, B \in \{1...\text{NArmy[false]}\},$
$\quad \text{Army[false}, B\text{].NumFixers} > \text{Army[false}, B\text{].Squadrons})$

Condition III: True

3.34: Does not reject Army.NumJammers > Army.Squadrons

Condition I:(Duration ≥ 0)
Condition II:

$(\exists B, B \in \{1...\text{NArmy[true]}\},$
$\quad \text{Army[true}, B\text{].NumJammers} > \text{Army[true}, B\text{].Squadrons}) \vee$
$(\exists B, B \in \{1...\text{NArmy[false]}\},$
$\quad \text{Army[false}, B\text{].NumJammers} > \text{Army[false}, B\text{].Squadrons})$

Condition III: True

3.35: Does not reject Army.NumProcess > Army.Squadrons

Condition I:(Duration ≥ 0)
Condition II:

$(\exists B, B \in \{1...\text{NArmy[true]}\},$
$\quad \text{Army[true}, B\text{].NumProcess} > \text{Army[true}, B\text{].Squadrons}) \vee$
$(\exists B, B \in \{1...\text{NArmy[false]}\},$
$\quad \text{Army[false}, B\text{].NumProcess} > \text{Army[false}, B\text{].Squadrons})$

Condition III: True

3.36: Does not reject Army.NumReceive > Army.Squadrons

Condition I:(Duration ≥ 0)
Condition II:

$(\exists B, B \in \{1...\text{NArmy[true]}\},$
$\quad \text{Army[true}, B\text{].NumReceive} > \text{Army[true}, B\text{].Squadrons}) \vee$
$(\exists B, B \in \{1...\text{NArmy[false]}\},$
$\quad \text{Army[false}, B\text{].NumReceive} > \text{Army[false}, B\text{].Squadrons})$

Condition III: True

3.37: Does not reject Army.NumSend > Army.Squadrons

Condition I:(Duration ≥ 0)

Condition II:

$(\exists B, B \in \{1...\text{NArmy[true]}\},$
$\quad \text{Army[true}, B].\text{NumSend} > \text{Army[true}, B].\text{Squadrons}) \vee$
$(\exists B, B \in \{1...\text{NArmy[false]}\},$
$\quad \text{Army[false}, B].\text{NumSend} > \text{Army[false}, B].\text{Squadrons})$

Condition III: True

3.38: Does not reject Cmsgs.msg.NumFixers > Cmsgs.msg.Squadrons

Condition I:

$\exists B, \quad B \in \{\text{true}, \text{false}\},$
$\quad (\exists f, 1 \leq f \leq \text{NArmy}[B],$
$\quad\quad (\exists m, m \in \{1...\text{NCmsgs}[B]\}, Mimp(B, f, m, \text{Duration})))$

Condition II:

$\text{Cmsgs}[B, m].\text{msg.NumFixers} > \text{Cmsgs}[B, m].\text{msg.Squadrons}$

Condition III: True

3.39: Does not reject Cmsgs.msg.NumJammers > Cmsgs.msg.Squadrons

Condition I:

$\exists B, \quad B \in \{\text{true}, \text{false}\},$
$\quad (\exists f, 1 \leq f \leq \text{NArmy}[B],$
$\quad\quad (\exists m, m \in \{1...\text{NCmsgs}[B]\}, Mimp(B, f, m, \text{Duration})))$

Condition II:

$\text{Cmsgs}[B, m].\text{msg.NumJammers} > \text{Cmsgs}[B, m].\text{msg.Squadrons}$

Condition III: True

3.40: Does not reject Cmsgs.msg.NumProcess > Cmsgs.msg.Squadrons

Condition I:

$\exists B, \quad B \in \{\text{true}, \text{false}\},$
$(\exists f, 1 \leq f \leq \text{NArmy}[B],$
$(\exists m, m \in \{1...\text{NCmsgs}[B]\}, Mimp(B, f, m, \text{Duration})))$

Condition II:

$\text{Cmsgs}[B, m].\text{msg.NumProcess} > \text{Cmsgs}[B, m].\text{msg.Squadrons}$

Condition III:True

3.41: Does not reject Cmsgs.msg.NumReceive > Cmsgs.msg.Squadrons

Condition I:

$\exists B, \quad B \in \{\text{true}, \text{false}\},$
$(\exists f, 1 \leq f \leq \text{NArmy}[B],$
$(\exists m, m \in \{1...\text{NCmsgs}[B]\}, Mimp(B, f, m, \text{Duration})))$

Condition II:

$\text{Cmsgs}[B, m].\text{msg.NumReceive} > \text{Cmsgs}[B, m].\text{msg.Squadrons}$

Condition III:True

3.42: Does not reject Cmsgs.msg.NumSend > Cmsgs.msg.Squadrons

Condition I:

$\exists B, \quad B \in \{\text{true}, \text{false}\},$
$(\exists f, 1 \leq f \leq \text{NArmy}[B],$
$(\exists m, m \in \{1...\text{NCmsgs}[B]\}, Mimp(B, f, m, \text{Duration})))$

Condition II:

$\text{Cmsgs}[B, m].\text{msg.NumSend} > \text{Cmsgs}[B, m].\text{msg.Squadrons}$

Condition III:True

3.43: Observes when SR<2.

Condition I:

$(\exists B, \exists g, Active(B, g) \wedge$
$(\exists e, \quad 1 \leq e \leq \text{NArmy}[\neg B],$
$(\exists k, \quad 1 \leq k \leq \text{Army}[\neg B, e].\text{Squadrons},$
$(\exists j, \quad 1 \leq j \leq \text{Army}[B, g].\text{Squadrons},$
$Endurance(\neg B, e, k, \text{Mainloop}) > 0 \wedge$
$Endurance(B, g, j, \text{Mainloop}) > 0 \wedge$
$BigEnough(B, g, j, e, k, \text{Mainloop})$

Condition II:

$\text{Params.SampleRate} < 2$

Condition III: True

3.44: NW>0 when KF=0

Condition I:

$(\exists B, (\exists g, Active(B, g) \wedge$
$(\text{Params.NumWTypes} > 0)$

$(\exists i, \ 1 \leq i \leq \text{Params.NumWTypes},$
$(\text{Army}[B, g].\text{Weapon}[i].\text{NumWeapon} > 0) \wedge$
$(\text{Army}[B, g].\text{Weapon}[i].\text{UseLimit} > 0) \wedge$
$(\text{Army}[B, g].\text{Weapon}[i].\text{Range} > 0) \wedge$

$(\exists e, \quad 1 \leq e \leq \text{NArmy}[\neg B],$
$(\exists k, \quad 1 \leq k \leq \text{Army}[\neg B, e].\text{Squadrons},$
$(\exists j, \quad 1 \leq j \leq \text{Army}[B, g].\text{Squadrons},$
$Endurance(\neg B, e, k, \text{Mainloop}) > 0 \wedge$
$Endurance(B, g, j, \text{Mainloop}) > 0 \wedge$
$Observe(B, g, j, e, k, \text{Mainloop}) \wedge InRange(B, g, i, e, k, \text{Mainloop})$
)))

Condition II:$(\text{Army}[B, g].\text{Weapon}[i].\text{FireRate} = 0))))$
Condition III: True

3.45: Ax,Ay set in destroyed battalion

Condition I:

$$
\begin{aligned}
&(\text{Duration} > 0) \wedge (0 < \text{Mainloop} < \text{Duration}) \\
&(\exists B, (\exists g, (\text{Army}[B,g].\text{Squadrons} > 0) \wedge \\
&\quad (\exists j, 1 \leq j \leq \text{Army}[B,g].\text{Squadrons}, \mathit{Endurance}(B,g,j,\text{Mainloop}-1) > 0))) \wedge \\
&(\text{Params.NumWTypes} > 0)
\end{aligned}
$$

$$
\begin{aligned}
&(\exists i,\ 1 \leq i \leq \text{Params.NumWTypes}, \\
&\quad (\text{Army}[B,g].\text{Weapon}[i].\text{NumWeapon} > 0) \wedge \\
&\quad (\text{Army}[B,g].\text{Weapon}[i].\text{FireRate} > 0) \wedge \\
&\quad (\text{Army}[B,g].\text{Weapon}[i].\text{UseLimit} > 0) \wedge \\
&\quad (\text{Army}[B,g].\text{Weapon}[i].\text{Range} > 0) \wedge \\
&(\exists e,\ 1 \leq e \leq \text{NArmy}[\neg B], \mathit{Active}(\neg B, e) \wedge \\
&(\exists k,\ 1 \leq k \leq \text{Army}[\neg B, e].\text{Squadrons}, \\
&(\exists j,\ 1 \leq j \leq \text{Army}[B,g].\text{Squadrons}, \\
&\quad \mathit{Endurance}(\neg B, e, k, \text{Mainloop}) > 0 \wedge \\
&\quad \mathit{Endurance}(B, g, j, \text{Mainloop}-1) > 0 \wedge \\
&\quad \mathit{Observe}(B, g, j, e, k, \text{Mainloop}-1) \wedge \mathit{InRange}(B, g, i, e, k, \text{Mainloop})
\end{aligned}
$$

Condition II: $\neg \mathit{Active}(B, g)$

Condition III:

$$
\begin{aligned}
&(\text{Duration} > \text{Mainloop} + 1) \wedge \mathit{Casualty}(\neg B, e, k, \text{Mainloop}+1) \wedge \\
&0.5 < \frac{\mathit{Endurance}(\neg B, e, k, \text{Mainloop}) + \mathit{Damage}(\neg B, e, k, \text{Mainloop}) - \mathit{Damage}(\neg B, e, k, \text{Mainloop}-1)}{\text{Army}[\neg B, e].\text{Endurance}[k]} \\
&\wedge (\not\exists m, 1 \leq m \leq \text{NCmsgs}[\neg B], \mathit{Mimp}(\neg B, e, m, \text{Duration})_l \\
&\wedge \neg \mathit{Mimp}(\neg B, e, m, \text{Mainloop}))))
\end{aligned}
$$

Failure Regions in Version 4

4.1: Uninitialized field in pointer

Condition I:

$$Active(B,g) \wedge Active(\neg B,e) \wedge Active(B,f) \wedge \text{Army}[B,f].\text{Report} = g \wedge$$
$$(\exists t, 0 \leq t < \text{Duration},$$
$$t = \text{Mainloop} - RepT(B,g,f) - \text{Army}[B,g].\text{ProcDelay} - \frac{\text{Army}[B,g].\text{RecRate}}{NumRec(B,g,\text{Mainloop}-\text{Army}[B,g].\text{ProcDelay})} \wedge$$
$$EObserve(B,f,e,t) \wedge$$
$$(\exists t', 0 \leq t' < t, EObserve(B,g,e,t')))$$

Condition II: True
Condition III: True

4.2: No check for legal range of subscripts for Terrain

Condition I:$\text{Duration} > 0 \wedge Active(B,g)$
Condition II:

$$(\exists j, 1 \leq j \leq \text{Army}[B,g].\text{Squadrons}, Endurance(B,g,j,\text{Mainloop}) > 0 \wedge$$
$$(X_{B,g,j}(\text{Mainloop}) < 0 \vee X_{B,g,j}(\text{Mainloop}) > \text{Params.XDelta} \times \text{MaxTerrain} \vee$$
$$Y_{B,g,j}(\text{Mainloop}) < 0 \vee Y_{B,g,j}(\text{Mainloop}) > \text{Params.YDelta} \times \text{MaxTerrain}))$$

Condition III: True

4.3: Wrong Battalion WeapSensativity used in Damage calculation

Condition I:

$$Active(B,g) \wedge Active(\neg B,e) \wedge$$
$$(\exists w, 1 \leq w \leq \text{Params.NumWTypes}, NumWeapon(\neg B,e,w,\text{Mainloop}) > 0 \wedge$$
$$(\exists i, 1 \leq i \leq NumWeapon(\neg B,e,w,\text{Mainloop}),$$
$$(\exists j, 1 \leq j \leq \text{Army}[B,g].\text{Squadrons}, Endurance(B,g,j,\text{Mainloop}) > 0 \wedge$$
$$\left(\sqrt{(X_{B,g,j}(\text{Mainloop}) - ax_{\neg B,e,w,i}(\text{Mainloop}))^2 + (Y_{B,g,j}(\text{Mainloop}) - ay_{\neg B,e,w,i}(\text{Mainloop}))^2}\right.$$
$$\left. < \text{Army}[\neg B,e].\text{Weapon}[w].\text{Radius}\right)$$

Condition II:$\text{Army}[B,g].\text{WeapSensativity}[w] \neq \text{Army}[\neg B,e].\text{WeapSensativity}[w]$
Condition III:

$$(\text{Army}[\neg B,e].\text{Weapon}[w].\text{Damage} > 0) \wedge$$
$$(\nexists m, 1 \leq m \leq \text{NCmsgs}[B], Mimp(B,g,m,\text{Duration})$$
$$\wedge \neg Mimp(B,g,m,\text{Mainloop}-1)))))$$

4.4: Wrong Battalion VWEffect used in Observation Jamming

Condition I:

$$Active(B,g) \wedge Active(\neg B,e) \wedge \text{Params.SampleRate} > 2 \wedge$$
$$(\exists k, 1 \leq k \leq \text{Army}[\neg B,e].\text{Squadrons}, Endurance(\neg B,e,k,\text{Mainloop}) > 0 \wedge$$
$$(\exists j, 1 \leq j \leq \text{Army}[B,g].\text{Squadrons}, Endurance(B,g,j,\text{Mainloop}) > 0 \wedge$$
$$BigEnough(B,g,j,e,k,\text{Mainloop}) \wedge Clear(B,g,j,e,k,\text{Mainloop})$$

Condition II:

$$\text{Army}[B,g].\text{VWEffect} \neq \text{Army}[\neg B,e].\text{VWEffect} \wedge$$
$$(\exists x', y', x'', y'', x' = X_{B,g,j}(\text{Mainloop}-1) \wedge y' = Y_{B,g,j}(\text{Mainloop}-1) \wedge$$
$$x'' = X_{\neg B,e,k}(\text{Mainloop}-1) \wedge y'' = Y_{\neg B,e,k}(\text{Mainloop}-1) \wedge$$
$$(\exists n, 1 \leq n \leq \text{Params.SampleRate},$$
$$WO\left(x' \times \frac{n \times (x'-x'')}{\text{Params.SampleRate}}, y' \times \frac{n \times (y'-y'')}{\text{Params.SampleRate}}, \text{Mainloop}\right) > 0))$$

Condition III:

$$(Obvious(B,g,j,e,k,\text{Mainloop}) \wedge$$
$$(\nexists t, 0 \leq t < \text{Duration}, t \neq \text{Mainloop} \wedge EObserve(B,g,e,t))) \vee$$
$$(\neg Obvious(B,g,j,e,k,\text{Mainloop}) \wedge$$
$$(\forall t, 0 \leq t < \text{Duration}, t \neq \text{Mainloop} \wedge \neg EObserve(B,g,e,t))))$$

4.5: No Check for Destroyed Squad before Initializing Location Intensity

and

4.6: No Check for Destroyed Squad before Observation

Condition I: $Active(B,g) \wedge Active(\neg B,e)$

Condition II:

$$(\exists j, 1 \leq j \leq \text{Army}[B,g].\text{Squadrons}, Endurance(B,g,j,\text{Mainloop}) \leq 0 \wedge$$
$$(\exists k, 1 \leq k \leq \text{Army}[\neg B,e].\text{Squadrons}, Endurance(\neg B,e,k,\text{Mainloop}) > 0 \wedge$$
$$Observe(B,g,j,e,k,\text{Mainloop})))$$

Condition III: True

4.7: Wrong ArmyId in Check for Destroyed Battalion in Observation

Condition I: $Active(B, g) \wedge Active(\neg B, e)$

Condition II:

$(\exists k, 1 \leq k \leq \text{Army}[\neg B, e].\text{Squadrons}, Endurance(\neg B, e, k, \text{Mainloop}) > 0 \wedge$
$(\exists j, 1 \leq j \leq \text{Army}[B, g].\text{Squadrons}, j = k \wedge Endurance(B, g, j, \text{Mainloop}) \leq 0$

Condition III:

$(\exists k', 1 \leq k' \leq \text{Army}[\neg B, e].\text{Squadrons}, Endurance(\neg B, e, k, \text{Mainloop}) > 0 \wedge$
$Observe(\neg B, e, k', g, j, \text{Mainloop})) \wedge (\forall t, 0 \leq t < \text{Duration}, \neg EObserve(\neg B, e, g, t))))$

4.8: Counting loop runs off end of Observation List

Condition I:

$Active(B, g) \wedge Active(\neg B, e) \wedge EObserve(B, g, e, \text{Mainloop} - 1) \wedge$
$(\exists w, 1 \leq w \leq \text{Params.NumWTypes}, NumWeapon(B, g, w, \text{Mainloop}) > 0 \wedge$
$\text{Army}[B, g].\text{WeapPriority}[e, w] > 0)$

Condition II:

$|\{k \ni 1 \leq k \leq \text{Army}[\neg B, e].\text{Squadrons} \wedge Endurance(\neg B, e, k, \text{Mainloop} - 1) > 0 \wedge$
$(\exists j, 1 \leq j \leq \text{Army}[B, g].\text{Squadrons}, Endurance(B, g, j, \text{Mainloop}) > 0 \wedge$
$Observe(B, g, j, e, k, \text{Mainloop} - 1))\}| = 1$

Condition III: True

4.9: Wrong initialization of Observation List

Condition I:

$Active(B, g) \wedge Active(\neg B, e) \wedge$
$(\exists j, 1 \leq j \leq \text{Army}[B, g].\text{Squadrons}, Endurance(B, g, j, \text{Mainloop}) > 0 \wedge$
$(\exists k, 1 \leq k \leq \text{Army}[\neg B, e].\text{Squadrons}, Endurance(\neg B, e, k, \text{Mainloop}) > 0 \wedge$
$Observe(B, g, j, e, k, \text{Mainloop})$

Condition II:

$(\exists k', 1 \leq k' \leq \text{Army}[\neg B, e].\text{Squadrons}, Endurance(\neg B, e, k', \text{Mainloop}) > 0 \wedge k \neq k' \wedge$
$(\exists j', 1 \leq j' \leq \text{Army}[B, g].\text{Squadrons}, Endurance(B, g, j', \text{Mainloop}) > 0 \wedge$
$Observe(B, g, j', e, k', \text{Mainloop}))))$

Condition III: True

4.10: Spurious Check for Casualty Squadrons in Observation

Condition I: $Active(B, g) \wedge Active(\neg B, e)$

Condition II:

$(\exists j, 1 \leq j \leq \text{Army}[B, g].\text{Squadrons}, Endurance(B, g, j, \text{Mainloop}) > 0 \wedge$
$Casualty(B, g, j, \text{Mainloop}) \wedge$
$(\exists k, 1 \leq k \leq \text{Army}[\neg B, e].\text{Squadrons}, Endurance(\neg B, e, k, \text{Mainloop} > 0 \wedge$
$Observe(B, g, j, e, k, \text{Mainloop})$

Condition III:

$(\nexists j', 1 \leq j' \leq \text{Army}[B, g].\text{Squadrons}, Endurance(B, g, j', \text{Mainloop}) > 0 \wedge$
$\neg Casualty(B, g, j', \text{Mainloop}) \wedge Observe(B, g, j', \text{Mainloop}))))) \wedge$
$(\nexists t, 1 \leq t \leq \text{Duration}, t \neq \text{Mainloop} \wedge EObserve(B, g, e, t))$

4.11: Incomplete Command Message Implementation

Condition I:

$Active(B, g) \wedge$
$(\exists m, 1 \leq m \leq \text{NCmsgs}[B], Mimp(B, g, m, \text{Mainloop}) \wedge \neg Mimp(B, g, m, \text{Mainloop} - 1))$

Condition II:

$(\exists j, 1 \leq j \leq \text{Army}[B, g].\text{Squadrons}, Endurance(B, g, j, \text{Mainloop} - 1) > 0 \wedge$
$Casualty(B, g, j, \text{Mainloop} - 1))$

Condition III:

$(NumJam(B, g, \text{Mainloop} - 1) = 0 \wedge \text{Army}[B, g].\text{CommJamEff} > 0 \wedge$
$(\exists e, Active(\neg B, e),$
$\sqrt{(X_{\neg B,e}(\text{Mainloop} - 1) - X_{B,g}(\text{Mainloop} - 1))^2 +}$
$\sqrt{(Y_{\neg B,e}(\text{Mainloop} - 1) - Y_{B,g}(\text{Mainloop} - 1))^2}$
$< \text{Army}[B, g].\text{CommJamRadius}) \wedge \text{Army}[B, g].\text{CommJamPriority}[e] > 0) \vee$
$(NumWeapon(B, g, 1, \text{Mainloop} - 1)$
$< |\{k \ni \exists e, j, Observe(B, g, j, e, k, \text{Mainloop} - 1)\}| \wedge$
$\text{Army}[B, g].\text{Weapon}[1].\text{Damage} \neq \text{Army}[B, g].\text{Weapon}[2].\text{Damage})$

4.12: Misordered Observation functions

Condition I: $Active(B, g) \wedge Active(\neg B, e)$

Condition II:

$(\exists k, 1 \leq k \leq \text{Army}[\neg B, e].\text{Squadrons}, Endurance(\neg B, e, k, \text{Mainloop}) > 0 \wedge$
$(X_{\neg B,e,k}(\text{Mainloop}) \neq X_{\neg B,e,k}(\text{Mainloop} - 1) \vee$
$Y_{\neg B,e,k}(\text{Mainloop}) \neq Y_{\neg B,e,k}(\text{Mainloop} - 1))$

Condition III:

$(\exists j, 1 \leq j \leq \text{Army}[B, g].\text{Squadrons}, Endurance(B, g, j, \text{Mainloop}) > 0 \wedge$
$\neg Observe(B, g, j, e, k, \text{Mainloop} - 1) \wedge Observe(B, g, j, e, k, \text{Mainloop})))$

4.13: Spurous check in Message Processing

Condition I:

$Active(B, g) \wedge Active(\neg B, e) \wedge Active(B, f) \wedge \text{Army}[B, f].\text{Report} = g \wedge$
$(\exists d, d = RepT(B, g, f) + \frac{\text{Army}[B,g].\text{RecRate}}{NumRec(B,g,\text{Mainloop})},$
$(\exists t, t + d < \text{Mainloop} < t + d + \text{Army}[B, g].\text{ProcDelay}, EObserve(B, f, e, t)$

Condition II:

$(\exists f', Active(B, f'), \text{Army}[B, f'].\text{Report} = g \wedge$
$(\exists t', t' = \text{Mainloop} - (d + \text{Army}[B, f'].\text{SendRate} - \text{Army}[B, f].\text{SendRate}),$
$(\exists e', Active(\neg B, e') \wedge e \neq e', EObserve(B, f', e', t')$

Condition III:

$(\nexists t'', 1 \leq t'' \leq \text{Duration}, EObserve(B, g, e', t'') \vee$
$(t'' \neq t' \wedge (\exists f'', Active(B, f'') \wedge \text{Army}[B, f''].\text{Report} = g,$
$EObserve(B, f'', e', t'')))))))))$

4.14: Wrong index in Message Processing

Condition I:

$$Active(B,g) \wedge Active(\neg B,e) \wedge Active(B,f) \wedge \text{Army}[B,f].\text{Report} = g \wedge$$
$$(\exists d, d = RepT(B,g,f) + \frac{\text{Army}[B,g].\text{RecRate}}{NumRec(B,g,\text{Mainloop})},$$
$$(\exists t, t + d < \text{Mainloop} < t + d + \text{Army}[B,g].\text{ProcDelay}, EObserve(B,f,e,t)$$

Condition II:

$$(\exists f', Active(B,f'), \text{Army}[B,f'].\text{Report} = g \wedge$$
$$\text{Army}[B,f'].\text{Priority} < \text{Army}[B,f].\text{Priority} \wedge$$
$$(\exists e', Active(\neg B,e') \wedge e \neq e', EObserve(B,f',e',t)$$

Condition III:

$$(\nexists t', 1 \leq t' \leq \text{Duration}, EObserve(B,g,e',t') \vee$$
$$(t' < t \wedge (\exists f'', Active(B,f'') \wedge \text{Army}[B,f''].\text{Report} = g,$$
$$EObserve(B,f'',e',t')))))))$$

4.15: No Check for Engaged before Observed from Reports

Condition I:

$$Active(B,g) \wedge Active(B,f) \wedge Active(\neg B,e) \wedge \text{Army}[B,f].\text{Report} = g \wedge$$
$$(\exists t, 0 \leq t < \text{Duration},$$
$$t = \text{Duration} - RepT(B,g,f) - \text{Army}[B,g].\text{ProcDelay} -$$
$$\frac{\text{Army}[B,g].\text{RecRate}}{NumRec(B,g,\text{Duration} - \text{Army}[B,g].\text{ProcDelay})} \wedge$$
$$EObserve(B,f,e,t-1))$$

Condition II:

$$(\exists t', 0 \leq t' < \text{Duration}, EObserve(B,g,e,t-1) \wedge$$
$$(\exists w, 1 \leq w \leq \text{Params.NumWTypes}, NumWeapon(B,g,w,t) > 0 \wedge$$
$$\text{Army}[B,g].\text{WeapPriority}[e,w] > 0 \wedge InRange(B,g,e,w,t)))$$

Condition III: True

4.16: Spurious Check for ObsJamEff=0

Condition I:

$$Active(B, g) \wedge Active(\neg B, e) \wedge$$
$$(\exists j, 1 \leq j \leq \text{Army}[B, g].\text{Squadrons}, Endurance(B, g, j, \text{Mainloop}) > 0 \wedge$$
$$(\exists k, 1 \leq k \leq \text{Army}[\neg B, e].\text{Squadrons}, Endurance(\neg B, e, k, \text{Mainloop}) > 0 \wedge$$
$$BigEnough(B, g, j, e, k, \text{Mainloop}) \wedge Clear(B, g, j, e, k, \text{Mainloop})$$

Condition II:

$$(\exists e', 1 \leq e' \leq \text{NArmy}[\neg B], \text{Army}[\neg B, e'].\text{Squadrons} > 0 \wedge$$
$$\text{Army}[\neg B, e'].\text{ObsJamEff} = 0)$$

Condition III:

$$\neg Obvious(B, g, j, e, k, \text{Mainloop}) \wedge$$
$$(\nexists t, 1 \leq t \leq \text{Duration}, SomeObserve(B, g, e, k, t))))$$

4.18: Reversed Parameters in Observation

Condition I: $Active(B, g) \wedge Active(\neg B, e) \wedge EObserve(B, g, e, \text{Mainloop})$
Condition II: $g \neq e \wedge \neg EObserve(B, e, g, \text{Mainloop})$
Condition III: $e > \text{NArmy}[B] \vee \text{Duration} > \text{Mainloop} + 1$

4.19: Abort in SetCoordinates when Battalion leaves Terrain

and

4.20: Abort in SlopeIntensity when Battalion leaves Terrain

Condition I: $Active(B, g)$
Condition II:

$$(X_{B,g}(\text{Mainloop}) \leq 0 \vee X_{B,g}(\text{Mainloop}) \geq \text{Params.XDelta} \times \text{MaxTerrain}) \wedge$$
$$(Y_{B,g}(\text{Mainloop}) \leq 0 \vee Y_{B,g}(\text{Mainloop}) \geq \text{Params.YDelta} \times \text{MaxTerrain})$$

Condition III: True

4.21: NumFixers Exceeds Maximum Value

Condition I: $Active(B, g)$

Condition II:

$$\left(\sum_{j=1}^{\text{Army}[B,g].\text{Squadrons}} \begin{cases} 1 \text{ if } \neg Casualty(B, g, j, \text{Mainloop} - 2) \wedge \\ \quad Endurance(B, g, j, \text{Mainloop} - 1) \leq 0 \\ \\ 0 \text{ otherwise} \end{cases} \right)$$
$$> s(B, g, \text{Mainloop}) - NumFix(B, g, \text{Mainloop} - 1)$$

Condition III:

$$(\exists j, 1 \leq j \leq \text{Army}[B, g].\text{Squadrons}, Casualty(B, g, j, \text{Mainloop}) \wedge$$
$$(\exists r, r = \frac{\text{Army}[B,g].\text{FixRate} \times NumFix(B,g,j,\text{Mainloop}-1)}{\left(\sum_{j'=1}^{\text{Army}[B,g].\text{Squadrons}} \begin{cases} 1 \text{ if } Casualty(B, g, j', \text{Mainloop}) \\ \\ 0 \text{ otherwise} \end{cases} \right)},$$
$$r > Suppl(B, g, \text{Mainloop}) \wedge$$
$$r > (\text{Army}[B, g].\text{Endurance} - Endurance(B, g, j, \text{Mainloop})))$$

4.22: Observation when Params.SampleRete < 2

Condition I:

$$(\exists B, \exists g, Active(B, g) \wedge$$
$$(\exists e, \quad 1 \leq e \leq \text{NArmy}[\neg B],$$
$$(\exists k, \quad 1 \leq k \leq \text{Army}[\neg B, e].\text{Squadrons},$$
$$(\exists j, \quad 1 \leq j \leq \text{Army}[B, g].\text{Squadrons},$$
$$Endurance(\neg B, e, k, \text{Mainloop}) > 0 \wedge$$
$$Endurance(B, g, j, \text{Mainloop}) > 0 \wedge$$
$$BigEnough(B, g, j, e, k, \text{Mainloop})$$

Condition II:

$$\text{Params.SampleRate} < 2$$

Condition III: True

4.24: Wrong parameter declaration in Command Message Processing

Condition I:

$Active(B, g)$
$(\exists m, 1 \leq m \leq \text{NCmsgs}[B], Mimp(B, g, m, \text{Mainloop}) \wedge \neg Mimp(B, g, m, \text{Mainloop} - 1)$

Condition II:

$(\exists n, 1 \leq n \leq \text{NCmsgs}[B] \wedge m \neq n,$
$Mimp(B, g, n, \text{Mainloop}) \wedge \neg Mimp(B, g, n, \text{Mainloop} - 1)))$

Condition III: True

4.26: Priority Queue not Preserved in Message Processing

Condition I:

$Active(B, g)$
$(\exists m, 1 \leq m \leq \text{NCmsgs}[B], Mimp(B, g, m, \text{Mainloop}) \wedge \neg Mimp(B, g, m, \text{Mainloop} - 1) \wedge$
$(\exists n, 1 \leq n \leq \text{NCmsgs}[B] \wedge m \neq n,$
$Mimp(B, g, n, \text{Mainloop}) \wedge \neg Mimp(B, g, n, \text{Mainloop} - 1)$

Condition II:

$(\text{Cmsgs}[B, m].\text{Priority} > \text{Cmsgs}[B, n].\text{Priority}) \wedge$
$(\text{Cmsgs}[B, m].\text{msg} \neq \text{Cmsgs}[B, n].\text{msg})))$

Condition III: True

Failure Regions in Version 5

5.1: Bad list manipulation

Condition I:

$$Active(B,g) \wedge Active(\neg B,e) \wedge$$
$$\exists j, 1 \leq k \leq \text{Army}[B,g].\text{Squadrons}, Endurance(B,g,j,\text{Mainloop}) > 0 \wedge$$
$$\exists k, 1 \leq k \leq \text{Army}[\neg B,e].\text{Squadrons}, Endurance(\neg B,e,k,\text{Mainloop}) > 0 \wedge$$
$$BigEnough(B,g,j,e,k,\text{Mainloop}) \wedge \neg Clear(B,g,j,e,k,\text{Mainloop})$$

Condition II:

$$\exists k', 1 \leq k' < k, Endurance(\neg B,e,k',\text{Mainloop}) > 0 \wedge Observe(B,g,j,e,k',\text{Mainloop})$$

Condition III: True

5.2: $\neq$ instead of $\geq$ in check for busy processors

Condition I:

$$Active(B,g) \wedge \text{NCmsgs}[B] > 0$$
$$\exists, m, 1 \leq m \leq \text{NCmsgs}[B],$$
$$RecT(B,g,m) + RecDelay(B,g,RecT(B,g,m)) + QueDelay(B,g,m) = \text{Mainloop} \wedge$$
$$NumProcess(B,g,\text{Mainloop}) > 0$$

Condition II:

$$\left(\sum_{n=1}^{\text{NCmsgs}[B]} \begin{cases} 0 \text{ if } (n=m) \vee \text{Cmsgs}[B,n].\text{Dest} \neq g \vee \\ \quad RecT(B,g,n) + RecDelay(B,g,RecT(B,g,n)) + \\ \quad QueDelay(B,g,n) > \text{Mainloop} \\ \\ 1 \text{ otherwise} \end{cases} \right)$$
$$+ \left(\sum_{f=1}^{\text{NArmy}[B]} \begin{cases} 0 \text{ if Army}[B,f].\text{Report} \neq g \vee \\ \quad (\forall t, 1 \leq t \leq \text{Mainloop} - RepT(B,g,f) \\ \qquad - RecDelay(B,g,RepT(B,g,f)), \\ \quad \neg SomeObserve(B,f,t)) \\ \\ 1 \text{ otherwise} \end{cases} \right)$$
$$\geq NumProcess(B,g,\text{Mainloop})$$

Condition III:$Mimp(B,g,m,\text{Duration}) \wedge \text{Cmsgs}[B,m].\text{msg} \neq \text{Army}[B,g]$

5.3: Squadrons with initial endurance ≤ 0 not destroyed

Condition I: True

Condition II:

$\exists B, B \in \{\text{false}, \text{true}\}, \text{NArmy}[B] > 0 \wedge$
$\exists g, 1 \leq g \leq \text{NArmy}[B], \text{Army}[B, g].\text{Squadrons} > 0$
$\exists j, 1 \leq j \leq \text{Army}[B, g].\text{Squadrons},$
$\text{Army}[B, g].\text{Endurance}[j] \leq 0$

Condition III: Duration = 0

5.4: Squadrons with command endurance ≤ 0 not destroyed

Condition I:

$Active(B, g) \wedge \text{NCmsgs}[B] > 0 \wedge$
$\exists m, 1 \leq m \leq \text{NCmsgs}[B], Mimp(B, g, m, \text{Mainloop})$

Condition II:

$\exists j, 1 \leq j \leq \text{Cmsgs}[B, m].\text{msg.Squadrons},$
$\text{Cmsgs}[B, m].\text{msg.Endurance}[j] \leq 0$

Condition III: Duration = Mainloop

5.5: Position and PreArmy values set before Army values finalized

Condition I:

$Active(B, g) \wedge \text{NCmsgs}[B] > 0 \wedge$
$(\exists m, 1 \leq m \leq \text{NCmsgs}[B],$
$Mimp(B, g, m, \text{Mainloop}) \wedge \neg Mimp(B, g, m, \text{Mainloop} - 1))$

Condition II: True

Condition III: Duration = Mainloop

5.6: Improperly rejected Duration = 0

and

5.14: Positions not initialized if Duration = 0

Condition I: True
Condition II: Duration = 0
Condition III: True

5.7: Improperly rejected NArmy = 0

Condition I: True
Condition II:$\exists B, B \in \{\text{false}, \text{true}\}, \text{NArmy}[B] = 0$
Condition III: True

5.8: Dequeues messages for existing, not available, processors

Condition I:

$$
\begin{aligned}
&Active(B,g) \wedge \text{NCmsgs}[B] > 0 \wedge NumProcess(B,g,\text{Mainloop}) > 0 \wedge \\
&\exists t, t = \text{Mainloop} - \text{Army}[B,g].\text{ProcDelay} - RepT(B,g,f) \\
&\quad - RecDelay(B,g,RepT(B,g,f)), 1 \le t \le \text{Duration} \wedge \\
&\exists n, n = \left(\sum_{m=1}^{\text{NCmsgs}[B]} \begin{cases} 1 \text{ if } \text{Cmsgs}[B,m].\text{Dest} = g \wedge \\ \quad RecT(B,g,m) + RecDelay(B,g,RecT(B,g,m)) \le \text{Mainloop} \wedge \\ \quad \neg Mimp(B,g,m,\text{Mainloop}) \\ 0 \text{ otherwise} \end{cases} \right) \\
&\qquad + \left(\sum_{f=1}^{\text{NArmy}[B]} \begin{cases} \left(\sum_{t'=t}^{\text{Mainloop}-RepT(B,g,f)} \begin{cases} 1 \text{ if } SomeObserve(B,f,t') \\ 0 \text{ otherwise} \end{cases} \right) \\ \qquad \text{if } \text{Army}[B,g].\text{Report} = g \\ 0 \text{ otherwise} \end{cases} \right)
\end{aligned}
$$

Condition II:$n > NumProcess(B,g,\text{Mainloop})$
Condition III: True

5.9: Improperly rejected Weather Start > Duration

Condition I: True
Condition II:$\exists w, 1 \le w \le \text{Params.NumWEvents}, \text{Weather}[w].\text{TStart} > \text{Duration}$
Condition III: True

5.10: Improperly rejected Weather End > Duration

Condition I: True
Condition II:$\exists w, 1 \leq w \leq \text{Params.NumWEvents}, \text{Weather}[w].\text{TEnd} > \text{Duration}$
Condition III: True

5.11: Improperly rejected CommJamRadius = 0

Condition I: True
Condition II:

$$\exists B, B \in \{\text{false}, \text{true}\}, \text{NArmy}[B] > 0 \wedge$$
$$\exists g, 1 \leq g \leq \text{NArmy}[B], \text{Army}[B, g].\text{CommJamRadius} = 0$$

Condition III: True

5.12: Improperly rejected ObsJamRadius = 0

Condition I: True
Condition II:

$$\exists B, B \in \{\text{false}, \text{true}\}, \text{NArmy}[B] > 0 \wedge$$
$$\exists g, 1 \leq g \leq \text{NArmy}[B], \text{Army}[B, g].\text{ObsJamRadius} = 0$$

Condition III: True

5.13: Segmentation violation when battalion leaves terrain grid

and

5.41: Altitude and IntnstyLoc poorly defined when Battalion leaves Terrain grid

and

5.42: Use of borders to initialize maximum and minimum for W,H calc causes problems when squadrons leave Terrain-defined area

Condition I:(Duration > 0)
Condition II:

$$\exists B, g, \mathit{Active}(B, g) \wedge$$
$$(X_{B,g}(\text{Mainloop}) \geq \text{Params.XDelta} \times \text{MaxTerrain} \vee$$
$$Y_{B,g}(\text{Mainloop}) \geq \text{Params.YDelta} \times \text{MaxTerrain} \vee$$
$$X_{B,g}(\text{Mainloop}) < 0 \vee Y_{B,g}(\text{Mainloop}) < 0)$$

Condition III: True

5.15: No check to see if NW = 0 before setting Action to Engaged

Condition I:

$$
\begin{aligned}
&Active(B,g) \wedge Active(\neg B,e) \wedge \text{Mainloop} > 1 \wedge \text{Params.NumWTypes} > 0 \wedge \\
&\exists j, 1 \leq j \leq \text{Army}[B,g].\text{Squadrons}, Endurance(B,g,j,\text{Mainloop}) > 0 \wedge \\
&\exists k, 1 \leq k \leq \text{Army}[\neg B,e].\text{Squadrons}, Endurance(\neg B,e,k,\text{Mainloop}) > 0 \wedge \\
&Observe(B,g,j,e,k,\text{Mainloop}-1) \wedge \\
&\exists w, 1 \leq w \leq \text{Params.NumWTypes}, \\
&\text{Army}[B,g].\text{Weapon}[w].\text{Range} \geq \\
&\sqrt{(X_{B,g}(\text{Mainloop}) - X_{\neg B,e,k}(\text{Mainloop}-1))^2 + \\
&(Y_{B,g}(\text{Mainloop}) - Y_{\neg B,e,k}(\text{Mainloop}-1))^2}
\end{aligned}
$$

Condition II:

$$
\begin{aligned}
&\text{Army}[B,g].\text{Weapon}[w].\text{FireRate} \leq 0 \vee \\
&\text{Army}[B,g].\text{WeapPriority}[e,w] \leq 0 \vee \\
&\text{Army}[B,g].\text{Weapon}[w].\text{UseLimit} \leq 0 \vee \\
&NumWeapon(B,g,w,\text{Mainloop}) \leq 0 \vee \\
&\text{Army}[B,g].\text{Weapon}[w].\text{UseLimit} \leq \\
&\left(\sum_{t=2}^{\text{Mainloop}} \sum_{i=1}^{NumWeapon(B,g,w,t)} \begin{cases} 1 \text{ if } ax_{B,g,w,i}(t) \neq \infty \\ \\ 0 \text{ otherwise} \end{cases} \right)
\end{aligned}
$$

Condition III:

$$
\begin{aligned}
&\forall t, 1 \leq t \leq \text{Duration}, \forall w', 1 \leq w \leq \text{Params.NumWTypes}, \\
&NumWeapon(B,g,w',t) > 0 \wedge \forall i, 1 \leq i \leq NumWeapon(B,g,w',t), \\
&\forall k', 1 \leq k' \leq \text{Army}[\neg B,e].\text{Squadrons}, \\
&(ax_{B,g,w',i}(t) \neq X_{\neg B,e,k'}(t) \vee ay_{B,g,w',i}(t) \neq Y_{\neg B,e,k'}(t)) \wedge \\
&\nexists m, 1 \leq m \leq \text{NCmsgs}[B], Mimp(B,g,m,\text{Duration}) \wedge \neg Mimp(B,g,m,\text{Mainloop}-1)
\end{aligned}
$$

5.16: Improper treatment of case where KF = 0

Condition I:

$$
\begin{aligned}
&Active(B,g) \wedge Active(\neg B,e) \wedge \text{Mainloop} > 1 \wedge \text{Params.NumWTypes} > 0 \wedge \\
&\exists j, 1 \leq j \leq \text{Army}[B,g].\text{Squadrons}, Endurance(B,g,j,\text{Mainloop}) > 0 \wedge \\
&\exists k, 1 \leq k \leq \text{Army}[\neg B,e].\text{Squadrons}, Endurance(\neg B,e,k,\text{Mainloop}) > 0 \wedge \\
&Observe(B,g,j,e,k,\text{Mainloop}-1) \wedge \\
&\exists w, 1 \leq w \leq \text{Params.NumWTypes}, \\
&\text{Army}[B,g].\text{Weapon}[w].\text{Range} \geq \\
&\sqrt{(X_{B,g}(\text{Mainloop}) - X_{\neg B,e,k}(\text{Mainloop}-1))^2 + \\
&(Y_{B,g}(\text{Mainloop}) - Y_{\neg B,e,k}(\text{Mainloop}-1))^2}
\end{aligned}
$$

Condition II: $\text{Army}[B,g].\text{Weapon}[w].\text{FireRate} \leq 0$

Condition III:

$$
\begin{aligned}
&\text{Army}[B,g].\text{WeapPriority}[e,w] > 0 \wedge \\
&\text{Army}[B,g].\text{Weapon}[w].\text{UseLimit} > \\
&\left(\sum_{t=2}^{\text{Mainloop}} \sum_{i=1}^{NumWeapon(B,g,w,t)} \begin{cases} 1 \text{ if } ax_{B,g,w,i}(t) \neq \infty \\ \\ 0 \text{ otherwise} \end{cases} \right) \wedge \\
&NumWeapon(B,g,w,\text{Mainloop}) > 0 \wedge \forall t, 1 \leq t \leq \text{Duration}, \\
&\forall w', 1 \leq w' \leq \text{Params.NumWTypes}, NumWeapon(B,g,w',t) > 0 \wedge \\
&\forall i, 1 \leq i \leq NumWeapon(B,g,w',t), \\
&\forall k', 1 \leq k' \leq \text{Army}[\neg B,e].\text{Squadrons}, \\
&(ax_{B,g,w',i}(t) \neq X_{\neg B,e,k'}(t) \vee ay_{B,g,w',i}(t) \neq Y_{\neg B,e,k'}(t)) \wedge \\
&\nexists m, 1 \leq m \leq \text{NCmsgs}[B], Mimp(B,g,m,\text{Duration}) \wedge \neg Mimp(B,g,m,\text{Mainloop}-1)
\end{aligned}
$$

5.17: Improper Observation when H = Z

Condition I: $Active(B, g) \wedge Active(\neg B, e)$

Condition II:

$$\exists j, 1 \leq j \leq \text{Army}[B, g].\text{Squadrons}, Endurance(B, g, j, \text{Mainloop}) > 0 \wedge$$
$$\exists k, 1 \leq k \leq \text{Army}[\neg B, e].\text{Squadrons}, Endurance(\neg B, e, k, \text{Mainloop}) > 0 \wedge$$
$$BigEnough(B, g, j, e, k, \text{Mainloop}) \wedge Obvious(B, g, j, e, k, \text{Mainloop}) \wedge$$
$$\neg Clear(B, g, j, e, k, \text{Mainloop}) \wedge$$
$$xgj = x_{B,g,j}(\text{Mainloop} - 1) \wedge ygj = y_{B,g,j}(\text{Mainloop} - 1) \wedge$$
$$xek = x_{\neg B,e,k}(\text{Mainloop} - 1) \wedge yek = y_{\neg B,e,k}(\text{Mainloop} - 1) \wedge$$
$$(\forall a, a', c, c', z, z', a = \left\lfloor \frac{xgj}{\text{Params.XDelta}} \right\rfloor \wedge a' = \left\lfloor \frac{xek}{\text{Params.XDelta}} \right\rfloor \wedge$$
$$c = \left\lfloor \frac{ygj}{\text{Params.YDelta}} \right\rfloor \wedge c' = \left\lfloor \frac{yek}{\text{Params.YDelta}} \right\rfloor \wedge$$
$$z = Alt(a, c, xgj, ygj) \wedge z' = Alt(a', c', xek, yek) \wedge$$
$$(\forall n, 1 \leq n < \text{Params.SampleRate} - 1,$$
$$(\exists r, p, q, r = \frac{n}{\text{Params.SampleRate}}, p = \left\lfloor \frac{xgj + r \times (xek - xgj)}{\text{Params.XDelta}} \right\rfloor, q = \left\lfloor \frac{ygj + r \times (yek - ygj)}{\text{Params.YDelta}} \right\rfloor,$$
$$(z + r \times (z' - z)) \geq Alt(p, q, xgj + r \times (xek - xgj), ygj + r \times (yek - ygj)))))$$

Condition III: $\forall t, 1 \leq t \leq \text{Duration}, \neg EObserve(B, g, e, t)$

5.18: Does not reject Army.NumFixers > Army.Squadrons

Condition I: (Duration ≥ 0)

Condition II:

$(\exists B, B \in \{1...\text{NArmy[true]}\},$
Army[true, B].NumFixers > Army[true, B].Squadrons) $\vee$
$(\exists B, B \in \{1...\text{NArmy[false]}\},$
Army[false, B].NumFixers > Army[false, B].Squadrons)

Condition III: True

5.19: Does not reject Cmsgs.msg.NumFixers > Cmsgs.msg.Squadrons

Condition I:

$\exists B,\quad B \in \{\text{true}, \text{false}\},$
$(\exists f, 1 \leq f \leq \text{NArmy}[B],$
$(\exists m, m \in \{1...\text{NCmsgs}[B]\}, Mimp(B, f, m, \text{Duration})))$

Condition II:

$\text{Cmsgs}[B, m].\text{msg.NumFixers} > \text{Cmsgs}[B, m].\text{msg.Squadrons}$

Condition III: True

5.20: Does not reject Army.NumJammers > Army.Squadrons

Condition I:$(\text{Duration} \geq 0)$

Condition II:

$(\exists B, B \in \{1...\text{NArmy[true]}\},$
$\text{Army[true}, B].\text{NumJammers} > \text{Army[true}, B].\text{Squadrons}) \vee$
$(\exists B, B \in \{1...\text{NArmy[false]}\},$
$\text{Army[false}, B].\text{NumJammers} > \text{Army[false}, B].\text{Squadrons})$

Condition III: True

5.21: Does not reject Cmsgs.msg.NumJammers > Cmsgs.msg.Squadrons

Condition I:

$\exists B,\quad B \in \{\text{true}, \text{false}\},$
$(\exists f, 1 \leq f \leq \text{NArmy}[B],$
$(\exists m, m \in \{1...\text{NCmsgs}[B]\}, Mimp(B, f, m, \text{Duration})))$

Condition II:

$\text{Cmsgs}[B, m].\text{msg.NumJammers} > \text{Cmsgs}[B, m].\text{msg.Squadrons}$

Condition III: True

5.22: Does not reject Army.NumProcess > Army.Squadrons

Condition I:(Duration ≥ 0)

Condition II:

$(\exists B, B \in \{1...\text{NArmy[true]}\},$
$\quad \text{Army[true}, B].\text{NumProcess} > \text{Army[true}, B].\text{Squadrons}) \vee$
$(\exists B, B \in \{1...\text{NArmy[false]}\},$
$\quad \text{Army[false}, B].\text{NumProcess} > \text{Army[false}, B].\text{Squadrons})$

Condition III: True

5.23: Does not reject Cmsgs.msg.NumProcess > Cmsgs.msg.Squadrons

Condition I:

$\exists B, \quad B \in \{\text{true}, \text{false}\},$
$\quad (\exists f, 1 \leq f \leq \text{NArmy}[B],$
$\quad\quad (\exists m, m \in \{1...\text{NCmsgs}[B]\}, Mimp(B, f, m, \text{Duration})))$

Condition II:

$\text{Cmsgs}[B, m].\text{msg.NumProcess} > \text{Cmsgs}[B, m].\text{msg.Squadrons}$

Condition III: True

5.24: Does not reject Army.NumReceive > Army.Squadrons

Condition I:(Duration ≥ 0)

Condition II:

$(\exists B, B \in \{1...\text{NArmy[true]}\},$
$\quad \text{Army[true}, B].\text{NumReceive} > \text{Army[true}, B].\text{Squadrons}) \vee$
$(\exists B, B \in \{1...\text{NArmy[false]}\},$
$\quad \text{Army[false}, B].\text{NumReceive} > \text{Army[false}, B].\text{Squadrons})$

Condition III: True

5.25: Does not reject Cmsgs.msg.NumReceive > Cmsgs.msg.Squadrons

Condition I:

$$\exists B, \quad B \in \{\text{true}, \text{false}\},$$
$$(\exists f, 1 \leq f \leq \text{NArmy}[B],$$
$$(\exists m, m \in \{1...\text{NCmsgs}[B]\}, Mimp(B, f, m, \text{Duration})))$$

Condition II:

$$\text{Cmsgs}[B, m].\text{msg.NumReceive} > \text{Cmsgs}[B, m].\text{msg.Squadrons}$$

Condition III: True

5.26: Does not reject Army.NumSend > Army.Squadrons

Condition I:$(\text{Duration} \geq 0)$

Condition II:

$$(\exists B, B \in \{1...\text{NArmy}[\text{true}]\},$$
$$\text{Army}[\text{true}, B].\text{NumSend} > \text{Army}[\text{true}, B].\text{Squadrons}) \vee$$
$$(\exists B, B \in \{1...\text{NArmy}[\text{false}]\},$$
$$\text{Army}[\text{false}, B].\text{NumSend} > \text{Army}[\text{false}, B].\text{Squadrons})$$

Condition III: True

5.27: Does not reject Cmsgs.msg.NumSend > Cmsgs.msg.Squadrons

Condition I:

$$\exists B, \quad B \in \{\text{true}, \text{false}\},$$
$$(\exists f, 1 \leq f \leq \text{NArmy}[B],$$
$$(\exists m, m \in \{1...\text{NCmsgs}[B]\}, Mimp(B, f, m, \text{Duration})))$$

Condition II:

$$\text{Cmsgs}[B, m].\text{msg.NumSend} > \text{Cmsgs}[B, m].\text{msg.Squadrons}$$

Condition III: True

5.28: Improperly rejected SampleRate = 1

Condition I: True
Condition II: Params.SampleRate = 1
Condition III: True

5.30: Improperly rejected Army.Weapon.Range = 0

Condition I:

$\exists B, B \in \{\text{false}, \text{true}\}, \text{NArmy}[B] > 0 \wedge$
$\exists g, 1 \leq g \leq \text{NArmy}[B], \text{Params.NumWTypes} > 0$

Condition II: $\exists w, 1 \leq w \leq \text{Params.NumWTypes}, \text{Army}[B, g].\text{Weapon}[w].\text{Range} = 0$
Condition III: True

5.31: KA initialized to 0 not NK

Condition I: $Active(B, g) \wedge \text{Params.NumWTypes} > 0$
Condition II:

$\exists w, 1 \leq w \leq \text{Params.NumWTypes}, \text{Army}[B, g].\text{Weapon}[w].\text{NumWeapon} > 0$

Condition III:

$Active(\neg B, e) \wedge \text{Params.SampleRate} > 1 \wedge$
$\exists j, 1 \leq j \leq \text{Army}[B, g].\text{Squadrons}, Endurance(B, g, j, \text{Mainloop}) > 0 \wedge$
$\exists k, 1 \leq k \leq \text{Army}[\neg B, e].\text{Squadrons}, Endurance(\neg B, e, k, \text{Mainloop}) > 0 \wedge$
$Observe(B, g, j, e, k, \text{Mainloop} - 1) \wedge InRange(B, g, w, e, k, \text{Mainloop} - 1) \wedge$
$NumWeapon(B, g, w, \text{Mainloop}) > 0 \wedge \text{Army}[B, g].\text{WeapPriority}[e, w] > 0 \wedge$
$\text{Army}[B, g].\text{Weapon}[w].\text{UseLimit} > 0$

5.32: Weather movement components improperly rejected if negative

Condition I: Params.NumWEvents > 0

Condition II:

$\exists w, 1 \leq w \leq$ Params.NumWEvents,
Weather$[w]$.dWX $< 0 \vee$ Weather$[w]$.dWY < 0

Condition III: True

5.33: Command implemented in destroyed battalion

Condition I:

$1 \leq$ Mainloop $\leq$ Duration $\wedge \exists B, B \in \{\text{true}, \text{false}\}$,
NArmy$[B] > 0 \wedge$ NCmsgs$[B] > 0 \wedge$
$\exists m, 1 \leq m \leq$ NCmsgs$[B], 1 \leq$ Cmsgs$[B, m]$.Dest $\leq$ NArmy$[B] \wedge$
$\exists g, g =$ Cmsgs$[B, m]$.Dest, Army$[B, g]$.Squadrons $> 0 \wedge$
$(\exists j, 1 \leq j \leq$ Army$[B, g]$.Squadrons, $Endurance(B, g, j,$ Cmsgs$[B, m]$.Time$) > 0) \wedge$
$Mimp(B, g, m,$ Mainloop$) \wedge \neg Mimp(B, g, m,$ Mainloop $- 1)$

Condition II:

$(\nexists j, 1 \leq j \leq$ Army$[B, g]$.Squadrons, $Endurance(B, g, j,$ Mainloop$) > 0) \wedge$
(Cmsgs$[B, m]$.msg.Squadrons $\neq$ Army$[B, g]$.Squadrons$\vee$
$(\exists j, 1 \leq j \leq$ Cmsgs$[B, m]$.msg.Squadrons, Cmsgs$[B, m]$.msg.Endurance$[j] > 0) \vee$
Cmsgs$[B, m]$.msg.X $\neq X_{B,g}$(Mainloop) $\vee$ Cmsgs$[B, m]$.msg.Y $\neq Y_{B,g}$(Mainloop))

Condition III: True

5.34: V calculated using possible destroyed squadrons with command

Condition I:

$Active(B, g) \wedge$ NCmsgs$[B] > 0 \wedge$
$\exists m, 1 \leq m \leq$ NCmsgs$[B], Mimp(B, g, m,$ Mainloop$) \wedge \neg Mimp(B, g, m,$ Mainloop $- 1) \wedge$
Cmsgs$[B, m]$.msg.Squadrons > 0

Condition II:

$\exists j, 1 \leq j \leq$ Cmsgs$[B, m]$.msg.Squadrons, Cmsgs$[B, m]$.msg.Endurance$[j] \leq 0 \wedge$
$(\nexists j', 1 \leq j' \leq$ Cmsgs$[B, m]$.msg.Squadrons, Cmsgs$[B, m]$.msg.Endurance$[j'] > 0 \wedge$
Cmsgs$[B, m]$.msg.V0$[j'] >$ Cmsgs$[B, m]$.msg.V0$[j]) \wedge$
Cmsgs$[B, m]$.msg.V0$[j] > 0$

Condition III:

$\nexists m', 1 \leq m' \leq$ NCmsgs$[B]$,
$Mimp(B, g, m,$ Duration$) \wedge \neg Mimp(B, g, m,$ Mainloop $- 1)$

5.35: NumFixers can be greater than original value

Condition I:

$$Active(B,g) \wedge NumFix(B,g,\text{Mainloop}-1) > 0 \wedge$$
$$(\exists j, 1 \leq j \leq \text{Army}[B,g].\text{Squadrons}, Endurance(B,g,j,\text{Mainloop}) > 0 \wedge$$
$$Casualty(B,g,j,\text{Mainloop}-1) \wedge \neg Casualty(B,g,j,\text{Mainloop}))$$

Condition II:

$$(NumFix(B,g,\text{Mainloop}-1) +$$
$$(NumCas(B,g,\text{Mainloop}-1) - NumCas(B,g,\text{Mainloop}) \times \tfrac{NumFix(B,g,\text{Mainloop}-1)}{s(B,g,\text{Mainloop}-1)})$$
$$> s(B,g,\text{Mainloop}-1)$$

Condition III:

$$\nexists m, 1 \leq m \leq \text{NCmsgs}[B],$$
$$Mimp(B,g,m,\text{Duration}) \wedge \neg Mimp(B,g,m,\text{Mainloop}-1) \wedge$$
$$\text{Duration} > \text{Mainloop}+1 \wedge NumCas(B,g,\text{Mainloop}) > 0$$

5.37: gold observes when version does not

and

5.43: Version fails to engage

Condition I:

$$Active(B,g) \wedge Active(\neg B,e) \wedge Active(B,f) \wedge$$
$$\text{Army}[B,f].\text{Report} = g \wedge \text{Mainloop} > \text{Army}[B,f].\text{ObsXpire} \wedge$$
$$NumSend(B,g,\text{Mainloop} - \text{Army}[B,f].\text{ObsXpire}) > 0$$

Condition II:

$$EObserve(B,f,e,\text{Mainloop} - \text{Army}[B,f].\text{ObsXpire}) \wedge$$
$$\text{Army}[B,f].\text{ObsXpire} = RepT(B,f,g) + \text{Army}[B,g].\text{ProcDelay} +$$
$$RecDelay(B,g,\text{Mainloop} - \text{Army}[B,f].\text{ObsXpire} + RepT(B,f,g))$$

Condition III:

$$(\nexists f', Active(B,f') \wedge \text{Army}[B,f'].\text{Report} = g,$$
$$\exists t, 1 \leq t \leq \text{Duration}, EObserve(B,f',e,t)) \wedge$$
$$(\nexists t, 1 \leq t \leq \text{Duration}, EObserve(B,g,e,t))$$

5.39: Current, not previous, observations sent in report messages

Condition I:

$$Active(B,g) \wedge Active(B,f) \wedge Active(\neg B,e) \wedge \text{Army}[B,f].\text{Report} = g \wedge$$
$$(\exists j, 1 \leq j \leq \text{Army}[B,f].\text{Squadrons}, Endurance(B,f,j,\text{Mainloop}) > 0 \wedge$$
$$(\exists k, 1 \leq k \leq \text{Army}[\neg B,e].\text{Squadrons}, Endurance(\neg B,e,k,\text{Mainloop}) > 0 \wedge$$
$$Observe(B,f,j,e,k,\text{Mainloop}) \wedge \text{Army}[B,f].\text{NumSend} > 0$$

Condition II: $\neg Observe(B,f,j,e,k,\text{Mainloop}-1))$

Condition III:

$$(\forall t, 0 \leq t \leq \text{Duration}, \neg EObserve(B,g,e,t))$$

5.40: Messages implemented out of order

Condition I:

$$Active(B,g) \wedge \text{NCmsgs}[B] > 0$$
$$\exists m, 1 \leq m \leq \text{NCmsgs}[B], \text{Cmsgs}[B,m].\text{Dest} = g \wedge l$$
$$RecT(B,g,m) = \text{Mainloop}$$

Condition II:

$$(\exists n, 1 \leq n \leq \text{NCmsgs}[B], m \neq n \wedge \text{Cmsgs}[B,n].\text{Dest} = g \wedge$$
$$RecT(B,g,n) \leq \text{Mainloop} \wedge \neg Mimp(B,g,n,\text{Mainloop}) \wedge$$
$$\text{Cmsgs}[B,n].\text{Priority} = \text{Cmsgs}[B,m].\text{Priority}) \vee$$
$$(\exists f, Active(B,f), \text{Army}[B,f].\text{Report} = g \wedge \text{Army}[B,f].\text{Priority} = \text{Cmsgs}[B,m].\text{Priority} \wedge$$
$$\exists t, \text{Mainloop} - RepT(B,f,g) - RecDelay(B,g,\text{Mainloop} - \text{Army}[B,g].\text{ProcDelay})$$
$$-\text{Army}[B,g].\text{ProcDelay}$$
$$< t \leq \text{Mainloop} - RepT(B,f,g) - RecDelay(B,g,\text{Mainloop} - \text{Army}[B,g].\text{ProcDelay}),$$
$$SomeObserve(B,f,t))$$

Condition III: True

Failure Regions in Version 6

6.1: Reversed Parameters in UpdatLOSList

Condition I:

$$Active(B, g) \wedge Active(\neg B, e) \wedge$$
$$\exists j, 1 \leq j \leq \text{Army}[B, g].\text{Squadrons}, Endurance(B, g, j, \text{Mainloop}) > 0 \wedge$$
$$\exists k, 1 \leq k \leq \text{Army}[\neg B, e].\text{Squadrons}, Endurance(\neg B, e, k, \text{Mainloop}) > 0 \wedge$$
$$BigEnough(B, g, j, e, k, \text{Mainloop}) \wedge \text{Params.SampleRate} > 2$$

Condition II:

$$X_{B,g,j}(\text{Mainloop} - 1) \neq X_{\neg B,e,k}(\text{Mainloop} - 1) \vee$$
$$Y_{B,g,j}(\text{Mainloop} - 1) \neq Y_{\neg B,e,k}(\text{Mainloop} - 1)$$

Condition III:

$$(\neg Clear(B, g, j, e, k, \text{Mainloop})) \wedge Obvious(B, g, j, e, k, \text{Mainloop}) \wedge$$
$$(\nexists t, 0 \leq t \leq \text{Duration}, EObserve(B, g, e, t))$$

6.2: No check on send time for commands of equal priority

Condition I:

$$Active(B, g) \wedge \text{NCmsgs}[B] > 0 \wedge NumProcess(B, g, \text{Mainloop}) > 0 \wedge$$
$$\exists m, 1 \leq m \leq \text{NCmsgs}[B], Mimp(B, g, m, \text{Mainloop}) \wedge$$
$$\neg Mimp(B, g, m, \text{Mainloop} - 1) \wedge$$
$$\exists n, 1 \leq n \leq \text{NCmsgs}[B], m \neq n \wedge Mimp(B, g, n, \text{Mainloop}) \wedge$$
$$\neg Mimp(B, g, n, \text{Mainloop} - 1)$$

Condition II:

$$m < n \wedge \text{Cmsgs}[B, m].\text{Time} > \text{Cmsgs}[B, n].\text{Time} \wedge$$
$$\text{Cmsgs}[B, m].\text{Priority} = \text{Cmsgs}[B, n].\text{Priority}$$

Condition III: $\text{Cmsgs}[B, m].\text{msg} \neq \text{Cmsgs}[B, n].\text{msg}$

6.3: Improper calculation of LOS list point separation

Condition I:

$Active(B, g) \wedge Active(\neg B, e) \wedge$
$\exists j, 1 \leq j \leq \text{Army}[B, g].\text{Squadrons}, Endurance(B, g, j, \text{Mainloop}) > 0 \wedge$
$\exists k, 1 \leq k \leq \text{Army}[\neg B, e].\text{Squadrons}, Endurance(\neg B, e, k, \text{Mainloop}) > 0 \wedge$
$BigEnough(B, g, j, e, k, \text{Mainloop}) \wedge \text{Params.SampleRate} > 2$

Condition II:

$\exists i, i \in \{\text{True}, \text{False}\},$
$xgj = x_{B,g,j}(\text{Mainloop} - 1) \wedge ygj = y_{B,g,j}(\text{Mainloop} - 1) \wedge$
$xek = x_{\neg B,e,k}(\text{Mainloop} - 1) \wedge yek = y_{\neg B,e,k}(\text{Mainloop} - 1) \wedge$
$i = (\forall a, a', c, c', z, z', a = \left\lfloor \frac{xgj}{\text{Params.XDelta}} \right\rfloor \wedge a' = \left\lfloor \frac{xek}{\text{Params.XDelta}} \right\rfloor \wedge$

$c = \left\lfloor \frac{ygj}{\text{Params.YDelta}} \right\rfloor \wedge c' = \left\lfloor \frac{yek}{\text{Params.YDelta}} \right\rfloor \wedge$

$z = Alt(a, c, xgj, ygj) \wedge z' = Alt(a', c', xek, yek) \wedge$
$(\forall n, 1 \leq n < \text{Params.SampleRate} - 1,$
$(\exists r, p, q, r = \frac{n}{\text{Params.SampleRate}}, p = \left\lfloor \frac{xgj + r \times (xek - xgj)}{\text{Params.XDelta}} \right\rfloor, q = \left\lfloor \frac{ygj + r \times (yek - ygj)}{\text{Params.YDelta}} \right\rfloor,$

$(z + r \times (z' - z)) > Alt(p, q, xgj + r \times (xek - xgj), ygj + r \times (yek - ygj)))))$

Condition III:

$(((\neg i) \wedge Clear(B, g, j, e, k, \text{Mainloop})) \vee (i \wedge \neg Clear(B, g, j, e, k, \text{Mainloop}))) \wedge$
$Obvious(B, g, j, e, k, \text{Mainloop}) \wedge$
$(\forall t, 0 \leq t \leq \text{Duration}, t \neq \text{Mainloop} \rightarrow \neg EObserve(B, g, e, t))$

6.4: Program infinite loops when Duration=0

Condition I: True
Condition II: Duration = 0
Condition III: True

6.5: Improper calculation of Available Weapons

Condition I:

$Active(B, g) \wedge \text{Params.NumWTypes} > 0 \wedge$
$\exists w, 1 \leq w \leq \text{Params.NumWTypes}, NumWeapon(B, g, w, \text{Mainloop}) > 0 \wedge$
$\exists i, 1 \leq i \leq NumWeapon(B, g, w, \text{Mainloop}),$
$(ax_{B,g,w,i}(\text{Mainloop}) \neq \infty \vee ay_{B,g,w,i}(\text{Mainloop}) \neq \infty$

Condition II: True
Condition III:

$\exists e, Active(\neg B, e),$
$(\forall t, 0 \leq t < \text{Mainloop}, \neg EObserve(B, g, e, t)) \wedge EObserve(B, g, e, \text{Mainloop}) \wedge$
$\exists k, 1 \leq k \leq \text{Army}[\neg B, e].\text{Squadrons}, Endurance(\neg B, e, k, \text{Mainloop}) > 0 \wedge$
$InRange(B, g, w, e, k, \text{Mainloop}) \wedge$
$(\forall w', 1 \leq w' \leq \text{Params.NumWTypes}, w' \neq w \rightarrow$
$(\neg InRange(B, g, w', e, k, \text{Mainloop}) \vee NumWeapon(B, g, w', \text{Mainloop}) \leq 0)$

6.6: Divide by Zero when assigning target coordinates

Condition I:

$Active(B, g) \wedge Active(\neg B, e) \wedge \text{Params.NumWTypes} > 0 \wedge$
$EObserve(B, g, e, \text{Mainloop} - 1)$

Condition II:$NumWeapon(B, g, 1, \text{Mainloop}) \leq 0$
Condition III: True

6.7: Non-reinitialized pointer in SufferAttrition

Condition I:

$Active(B, g) \wedge Active(\neg B, e) \wedge \text{Params.NumWTypes} > 0 \wedge \text{Mainloop} > 2 \wedge$
$\exists i, 1 \leq i \leq \text{Params.NumWTypes}, \text{Army}[B, g].\text{Weapon}[i].\text{UseLimit} > 0 \wedge$
$NumWeapon(B, g, i, \text{Mainloop}) > 0 \wedge \text{Army}[B, g].\text{Weapon}[i].\text{FireRate} > 0 \wedge$
$\text{Army}[B, g].\text{WeapPriority}[e, i] > 0 \wedge$
$\exists j, 1 \leq j \leq \text{Army}[B, g].\text{Squadrons}, Endurance(B, g, j, \text{Mainloop} - 2) > 0 \wedge$
$\exists k, 1 \leq k \leq \text{Army}[\neg B, e].\text{Squadrons}, Endurance(\neg B, e, k, \text{Mainloop} - 2) > 0 \wedge$
$Observe(B, g, j, e, k, \text{Mainloop} - 2) \wedge InRange(B, g, w, e, k, \text{Mainloop} - 2)$

Condition II: True
Condition III: True

6.8: Undefined pointer reference in SufferAttrition

Condition I:

$$Active(B,g) \wedge Active(\neg B,e) \wedge \text{Params.NumWTypes} > 0 \wedge \text{Mainloop} > 2 \wedge$$
$$\exists i, 1 \leq i \leq \text{Params.NumWTypes}, \text{Army}[B,g].\text{Weapon}[i].\text{UseLimit} > 0 \wedge$$
$$NumWeapon(B,g,i,\text{Mainloop}) > 0 \wedge \text{Army}[B,g].\text{Weapon}[i].\text{FireRate} > 0 \wedge$$
$$\text{Army}[B,g].\text{WeapPriority}[e,i] > 0 \wedge$$
$$\exists j, 1 \leq j \leq \text{Army}[B,g].\text{Squadrons}, Endurance(B,g,j,\text{Mainloop}-1) > 0 \wedge$$
$$\exists k, 1 \leq k \leq \text{Army}[\neg B,e].\text{Squadrons}, Endurance(\neg B,e,k,\text{Mainloop}-1) > 0 \wedge$$
$$Observe(B,g,j,e,k,\text{Mainloop}-1) \wedge InRange(B,g,w,e,k,\text{Mainloop}-1)$$

Condition II: True
Condition III: True

6.9: No initialization of Observations.NumObserved

Condition I:$Active(B,g) \wedge Active(\neg B,e) \wedge EObserved(B,g,e,1)$
Condition II: True
Condition II:

$$\text{Params.NumWTypes} > 0 \wedge$$
$$\exists w, 1 \leq w \leq \text{Params.NumWTypes}, \text{Army}[B,g].\text{WeapPriority}[e,w] > 0 \wedge$$
$$NumWeapon(B,g,w,2) > 0 \wedge \text{Army}[B,g].\text{Weapon}[w].\text{FireRate} > 0 \wedge$$
$$\text{Army}[B,g].\text{Weapon}[w].\text{UseLimit} > 0 \wedge$$
$$\text{Army}[B,g].\text{Weapon}[w].\text{Range} > \sqrt{(X_{B,g}(1) - X_{\neg B,e}(1))^2 + (Y_{B,g}(1) - Y_{\neg B,e}(1))^2}$$

6.11: Command message improperly dropped from Commands-Finished list

Condition I:

$$Active(B,g) \wedge \text{NCmsgs}[B] > 0 \wedge$$
$$\exists m, 1 \leq m \leq \text{NCmsgs}[B], Mimp(B,g,m,\text{Mainloop}) \wedge \neg Mimp(B,g,m,\text{Mainloop}-1) \wedge$$
$$\exists n, 1 \leq n \leq \text{NCmsgs}[B], m < n \wedge Mimp(B,g,n,\text{Mainloop}) \wedge$$
$$\neg Mimp(B,g,n,\text{Mainloop}-1) \wedge \text{Cmsgs}[B,m].\text{Priority} \geq \text{Cmsgs}[B,n].\text{Priority}$$

Condition II: True
Condition III: True

6.12: Substitution of ComJamEff for ComJamRadius

Condition I:

$$
\begin{aligned}
&Active(B,g) \wedge Active(\neg B,e) \wedge NumRec(B,g,\text{Mainloop}) > 0 \wedge \\
&(\text{NCmsgs}[B] > 0 \wedge \exists m, 1 \leq m \leq \text{NCmsgs}[B], RecT(B,g,m) = \text{Mainloop}) \vee \\
&(Active(B,f) \wedge \text{Army}[B,f].\text{Report} = g \wedge NumSend(B,f,\text{Mainloop}) > 0 \wedge \\
&SomeObserve(B,f,\text{Mainloop} - RepT(B,f,g)) \wedge \text{Army}[\neg B,e].\text{ComJamEff} > 0
\end{aligned}
$$

Condition II: $\text{Army}[\neg B,e].\text{ComJamEff} \neq \text{Army}[\neg B,e].\text{ComJamRadius}$
Condition III: True

6.13: Command messages implemented in destroyed battalions

Condition I:

$$
\begin{aligned}
&\exists B, B \in \{\text{True}, \text{False}\}, \text{NArmy}[B] > 0 \wedge \text{NCmsgs}[B] > 0 \wedge \\
&\exists \text{Mainloop}, 1 \leq \text{Mainloop} < \text{Duration}, \\
&\exists m, 1 \leq m \leq \text{NCmsgs}[B], 1 \leq \text{Cmsgs}[B,m].\text{Dest} \leq \text{NArmy}[B] \wedge \\
&s(B, \text{Cmsgs}[B,m].\text{Dest}, \text{Cmsgs}[B,m].\text{Time}) > 0 \wedge \\
&Mimp(B, \text{Cmsgs}[B,m].\text{Dest}, m, \text{Mainloop}) \wedge \\
&\neg Mimp(B, \text{Cmsgs}[B,m].\text{Dest}, m, \text{Mainloop} - 1)
\end{aligned}
$$

Condition II: $s(B, \text{Cmsgs}[B,m].\text{Dest}, \text{Mainloop}) \leq 0$
Condition III: $\text{Cmsgs}[B,m].\text{msg} \neq \text{Army}[B, \text{Cmsgs}[B,m].\text{Dest}]$

6.14: InOwnObsv in UpdateLL is not initialized

Condition I:

$$
\begin{aligned}
&Active(B,g) \wedge Active(\neg B,e) \wedge Active(B,f) \wedge \text{Army}[B,f].\text{Report} = g \wedge \\
&\exists j, 1 \leq j \leq \text{Army}[B,g].\text{Squadrons}, Endurance(B,g,j,\text{Mainloop}) > 0 \wedge \\
&\exists k, 1 \leq k \leq \text{Army}[\neg B,e].\text{Squadrons}, Endurance(\neg B,e,k,\text{Mainloop}) > 0 \wedge \\
&Observe(B,g,j,e,k,\text{Mainloop}) \wedge \\
&\exists t, 0 \leq t = \text{Mainloop} - RepT(B,f,g) - \text{Army}[B,g].\text{ProcDelay} - \frac{\text{Army}[B,g].\text{RecRate}}{NumRec(B,g,\text{Mainloop} - \text{Army}[B,g].\text{ProcDelay})}, \\
&\exists j', 1 \leq j' \leq \text{Army}[B,f].\text{Squadrons}, Endurance(B,f,j',t) > 0 \wedge \\
&Observe(B,f,j',e,k,t)
\end{aligned}
$$

Condition II: True
Condition III: $X_{\neg B,e,k}(\text{Mainloop}) \neq X_{\neg B,e,k}(t) \vee Y_{\neg B,e,k}(\text{Mainloop}) \neq Y_{\neg B,e,k}(t)$

6.15: NewArmy not updated after command message

Condition I:

$Active(B, g) \wedge \text{Mainloop} = \text{Duration} \wedge \text{NCmsgs}[B] > 0 \wedge$
$\exists m, 1 \leq m \leq \text{NCmsgs}[B], Mimp(B, g, m, \text{Duration}) \wedge \neg Mimp(B, g, m, \text{Duration} - 1)$

Condition II: $\text{Cmsgs}[B, m].\text{msg} \neq \text{Army}[B, g]$
Condition III: True

6.16: Observe blocked when Params.SampleRate = 2

Condition I:

$Active(B, g) \wedge Active(\neg B, e) \wedge$
$\exists j, 1 \leq j \leq \text{Army}[B, g].\text{Squadrons}, Endurance(B, g, j, \text{Mainloop}) > 0 \wedge$
$\exists k, 1 \leq k \leq \text{Army}[\neg B, e].\text{Squadrons}, Endurance(\neg B, e, k, \text{Mainloop}) > 0 \wedge$
$BigEnough(B, g, j, e, k, \text{Mainloop})$

Condition II: $\text{Params.SampleRate} = 2$
Condition III: True

6.17: NumWeapons>0 when Army.Weapon.FireRate=0

Condition I:

$Active(B, g) \wedge Active(\neg B, e) \wedge \text{Params.NumWTypes} > 0 \wedge$
$\exists j, 1 \leq j \leq \text{Army}[B, g].\text{Squadrons}, Endurance(B, g, j, \text{Mainloop}) > 0 \wedge$
$\exists k, 1 \leq k \leq \text{Army}[\neg B, e].\text{Squadrons}, Endurance(\neg B, e, k, \text{Mainloop}) > 0 \wedge$
$Observe(B, g, j, e, k, \text{Mainloop} - 1) \wedge$
$\exists w, 1 \leq w \leq \text{Params.NumWTypes}, NumWeapon(B, g, w, \text{Mainloop}) > 0 \wedge$
$InRange(B, g, w, e, k, \text{Mainloop}) \wedge \text{Army}[B, g].\text{Weapon}[w].\text{UseLimit} > 0 \wedge$
$\text{Army}[B, g].\text{WeapPriority}[e, w] > 0$

Condition II: $\text{Army}[B, g].\text{Weapon}[w].\text{FireRate} = 0$
Condition III:

$\nexists t, 0 < t \leq \text{Duration},$
$\exists j', 1 \leq j' \leq \text{Army}[B, g].\text{Squadrons}, Endurance(B, g, j', t) > 0 \wedge$
$\exists k', 1 \leq k' \leq \text{Army}[\neg B, e].\text{Squadrons}, Endurance(\neg B, e, k', t) > 0 \wedge$
$Observe(B, g, j', e, k', t - 1) \wedge$
$\exists w', 1 \leq w' \leq \text{Params.NumWTypes}, NumWeapon(B, g, w', t) > 0 \wedge$
$InRange(B, g, w', e, k', t) \wedge \text{Army}[B, g].\text{Weapon}[w'].\text{UseLimit} > 0 \wedge$
$\text{Army}[B, g].\text{WeapPriority}[e, w'] > 0 \wedge \text{Army}[B, g].\text{Weapon}[w'.\text{FireRate} > 0$

6.18: Report messages blocked by bad condition

Condition I:

$$Active(B,g) \wedge Active(\neg B,e) \wedge Active(B,f) \wedge \text{Army}[B,f].\text{Report} = g \wedge$$
$$\exists t, 0 < t = \text{Mainloop} - RepT(B,f,g) - \text{Army}[B,g].\text{ProcDelay} - \frac{\text{Army}[B,g].\text{RecRate}}{NumRec(B,g,\text{Mainloop}-\text{Army}[B,g].\text{ProcDelay})},$$
$$EObserve(B,f,e,t-1) \wedge NumSend(B,f,t) > 0 \wedge \text{Army}[B,f].\text{ObsXpire} > 0$$

Condition II: True

Condition III: $\nexists t', 0 \leq t' \leq \text{Duration}, EObserve(B,g,e,t')$

6.20: Destroyed battalions not initialized

Condition I: True

Condition II:

$$\exists B, B \in \{\text{True}, \text{False}\}, \text{NArmy}[B] > 0 \wedge$$
$$\exists g, 1 \leq g \leq \text{NArmy}[B], \text{Army}[B,g].\text{Squadrons} \leq 0$$

Condition II: True

6.23: UseLimit not checked until after first weapon use

Condition I:

$$Active(B,g) \wedge Active(\neg B,e) \wedge \text{Params.NumWTypes} > 0 \wedge$$
$$\exists j, 1 \leq j \leq \text{Army}[B,g].\text{Squadrons}, Endurance(B,g,j,\text{Mainloop}) > 0 \wedge$$
$$\exists k, 1 \leq k \leq \text{Army}[\neg B,e].\text{Squadrons}, Endurance(\neg B,e,k,\text{Mainloop}) > 0 \wedge$$
$$Observe(B,g,j,e,k,\text{Mainloop}-1) \wedge$$
$$\exists w, 1 \leq w \leq \text{Params.NumWTypes}, NumWeapon(B,g,w,\text{Mainloop}) > 0 \wedge$$
$$InRange(B,g,w,e,k,\text{Mainloop}) \wedge \text{Army}[B,g].\text{Weapon}[w].\text{FireRate} > 0 \wedge$$
$$\text{Army}[B,g].\text{WeapPriority}[e,w] > 0$$

Condition II: $\text{Army}[B,g].\text{Weapon}[w].\text{UseLimit} = 0$

Condition III:

$$\nexists t, 0 < t \leq \text{Duration},$$
$$\exists j', 1 \leq j' \leq \text{Army}[B,g].\text{Squadrons}, Endurance(B,g,j',t) > 0 \wedge$$
$$\exists k', 1 \leq k' \leq \text{Army}[\neg B,e].\text{Squadrons}, Endurance(\neg B,e,k',t) > 0 \wedge$$
$$Observe(B,g,j',e,k',t-1) \wedge$$
$$\exists w', 1 \leq w' \leq \text{Params.NumWTypes}, NumWeapon(B,g,w',t) > 0 \wedge$$
$$InRange(B,g,w',e,k',t) \wedge \text{Army}[B,g].\text{Weapon}[w'].\text{UseLimit} > 0 \wedge$$
$$\text{Army}[B,g].\text{WeapPriority}[e,w'] > 0 \wedge \text{Army}[B,g].\text{Weapon}[w'.\text{FireRate} > 0$$

6.24: Available processors don't include just finished commands and reports

Condition I:

$$
\begin{aligned}
&Active(B,g) \wedge ((\text{NCmsgs}[B] > 0 \wedge \\
&\exists m, 1 \leq m \leq \text{NCmsgs}[B], Mimp(B,g,m,\text{Mainloop}) \wedge \\
&\neg Mimp(B,g,m,\text{Mainloop}-1)) \vee \\
&(Active(B,f) \wedge Active(\neg B,e) \wedge \text{Army}[B,f].\text{Report} = g \wedge \\
&\exists t, 0 < t = \text{Mainloop} - RepT(B,f,g) - \text{Army}[B,g].\text{ProcDelay} - \\
&\qquad \frac{\text{Army}[B,g].\text{RecRate}}{NumRec(B,g,\text{Mainloop}-\text{Army}[B,g].\text{ProcDelay})}, \\
&EObserve(B,f,e,t-1) \wedge NumSend(B,f,t) > 0))
\end{aligned}
$$

Condition II:

$$
\begin{aligned}
&CmdSum(B,g,-1,\text{Mainloop}) + ReptSum(B,g,-1,\text{Mainloop}) \\
&\quad > NumProcess(B,g,\text{Mainloop})
\end{aligned}
$$

Condition III: True

Failure Regions in Version 7

7.1: VisableSquad return upredictable on destroyed squadrons

Condition I: $Active(B, g) \wedge Active(\neg B, e)$

Condition II:

$$(\exists j, 1 \leq j \leq \text{Army}[B, g].\text{Squadrons}, Endurance(B, g, j, \text{Mainloop}) \leq 0) \vee$$
$$(\exists k, 1 \leq k \leq \text{Army}[\neg B, e].\text{Squadrons}, Endurance(\neg B, e, k, \text{Mainloop}) \leq 0)$$

Condition III: $\nexists t, 0 \leq t \leq \text{Duration}, EObserve(B, g, e, t)$

7.2: Division by zero NumWeapon in InflictAttrition

Condition I:

$$Active(B, g) \wedge Active(\neg B, e) \wedge \text{Params.NumWTypes} > 0 \wedge$$
$$\exists k, 1 \leq k \leq \text{Army}[\neg B, e].\text{Squadrons}, Endurance(\neg B, e, k, \text{Mainloop} - 2) > 0 \wedge$$
$$(\exists j, 1 \leq j \leq \text{Army}[B, e].\text{Squadrons}, Endurance(B, g, j, \text{Mainloop} - 2) > 0 \wedge$$
$$Observe(B, g, j, e, k, \text{Mainloop} - 2)) \wedge$$
$$\exists w, 1 \leq w \leq \text{Params.NumWTypes}, InRange(B, g, w, e, k, \text{Mainloop} - 1) \wedge$$
$$\text{Army}[B, g].\text{WeapPriority}[e, w] > 0 \wedge NumWeapon(B, g, w, \text{Mainloop} - 1) > 0 \wedge$$
$$\text{Army}[B, g].\text{Weapon}[w].\text{FireRate} > 0 \wedge \text{Army}[B, g].\text{Weapon}[w].\text{UseLimit} > 0$$

Condition II: $NumWeapon(B, g, w, \text{Mainloop}) = 0$

Condition III: True

7.3:Division by zero NumObservArray in InflictAttrition

Condition I:

$$Active(B, g) \wedge Active(\neg B, e) \wedge \text{Params.NumWTypes} > 0 \wedge$$
$$\exists k, 1 \leq k \leq \text{Army}[\neg B, e].\text{Squadrons}, Endurance(\neg B, e, k, \text{Mainloop} - 2) > 0 \wedge$$
$$(\exists j, 1 \leq j \leq \text{Army}[B, e].\text{Squadrons}, Endurance(B, g, j, \text{Mainloop} - 2) > 0 \wedge$$
$$Observe(B, g, j, e, k, \text{Mainloop} - 2)) \wedge$$
$$\exists w, 1 \leq w \leq \text{Params.NumWTypes}, InRange(B, g, w, e, k, \text{Mainloop} - 1) \wedge$$
$$\text{Army}[B, g].\text{WeapPriority}[e, w] > 0 \wedge NumWeapon(B, g, w, \text{Mainloop}) > 0 \wedge$$
$$\text{Army}[B, g].\text{Weapon}[w].\text{FireRate} > 0 \wedge \text{Army}[B, g].\text{Weapon}[w].\text{UseLimit} > 0$$

Condition II: $\neg EObserve(B, g, e, \text{Mainloop})$

Condition III: True

7.4: Bad count of busy command processing squadrons

Condition I:

$$
\begin{aligned}
&Active(B,g) \wedge ((\text{NCmsgs}[B] > 0 \wedge \\
&\exists m, 1 \leq m \leq \text{NCmsgs}[B], Mimp(B,g,m,\text{Mainloop}) \wedge \\
&\neg Mimp(B,g,m,\text{Mainloop}-1)) \vee \\
&(Active(B,f) \wedge Active(\neg B,e) \wedge \text{Army}[B,f].\text{Report} = g \wedge \\
&\exists t, 0 < t = \text{Mainloop} - RepT(B,f,g) - \text{Army}[B,g].\text{ProcDelay} - \\
&\qquad \frac{\text{Army}[B,g].\text{RecRate}}{NumRec(B,g,\text{Mainloop}-\text{Army}[B,g].\text{ProcDelay})}, \\
&EObserve(B,f,e,t-1) \wedge NumSend(B,f,t) > 0))
\end{aligned}
$$

Condition II:

$$
\begin{aligned}
&CmdSum(B,g,-1,\text{Mainloop}) + ReptSum(B,g,-1,\text{Mainloop}) \\
&> NumProcess(B,g,\text{Mainloop})
\end{aligned}
$$

Condition III: True

7.5: Bad check in Observation

Condition I:$Active(B,g) \wedge Active(\neg B,e) \wedge EObserve(B,g,e,\text{Mainloop})$
Condition II:$Active(B,f) \wedge f > g \wedge EObserve(B,f,e,\text{Mainloop})$
Condition III:

$$
\begin{aligned}
&\nexists t, 1 \leq t \leq \text{Duration}, EObserve(B,f,e,t) \wedge \\
&\forall f', 1 \leq f' < f, \neg EObserve(B,f',e,t)
\end{aligned}
$$

7.6: Bad condition on NArmy check

Condition I:$\text{Duration} > 0$
Condition II:$\exists B, B \in \{\text{True}, \text{False}\}, \text{NArmy}[B] = 0$
Condition III: True

7.7: Improperly rejected ObsXpire=0

Condition I:$\text{Duration} > 0 \wedge \exists B, B \in \{\text{True}, \text{False}\}, \text{NArmy}[B] > 0$
Condition II:$\exists g, 1 \leq g \leq \text{NArmy}[B], \text{Army}[B,g].\text{ObsXpire} = 0$
Condition III: True

7.8: Improperly rejected ProcDelay=0

Condition I:$\text{Duration} > 0 \wedge \exists B, B \in \{\text{True}, \text{False}\}, \text{NArmy}[B] > 0$
Condition II:$\exists g, 1 \leq g \leq \text{NArmy}[B], \text{Army}[B,g].\text{ProcDelay} = 0$
Condition III: True

7.9: No report communication

Condition I:

$$Active(B,g) \wedge Active(\neg B,e) \wedge Active(B,f) \wedge \text{Army}[B,f].\text{Report} = g \wedge$$
$$\exists t, 0 < t = \text{Mainloop} - RepT(B,f,g) - \text{Army}[B,g].\text{ProcDelay} - \frac{\text{Army}[B,g].\text{RecRate}}{NumReceive(B,g,\text{Mainloop}-\text{Army}[B,g].\text{ProcDelay}}$$
$$EObserve(B,f,e,t-1) \wedge NumSend(B,f,t) > 0 \wedge \text{Army}[B,f].\text{ObsXpire} > 0$$

Condition II: True

Condition III: $\nexists t', 0 \leq t' \leq \text{Duration}, EObserve(B,g,e,t')$

7.10: Misplaced reinitialization of variable in Observation

Condition I: $Active(B,g) \wedge Active(\neg B,e)$

Condition II:

$$\exists k, 1 \leq k \leq \text{Army}[\neg B,e].\text{Squadrons}, Endurance(\neg B,e,k,\text{Mainloop}) > 0 \wedge$$
$$(\exists j, 1 \leq j \leq \text{Army}[B,g].\text{Squadrons}, Endurance(B,g,j,\text{Mainloop}) > 0 \wedge$$
$$Observe(B,g,j,e,k,\text{Mainloop})) \wedge$$
$$\exists k', k < k' \leq \text{Army}[\neg B,e].\text{Squadrons}, Endurance(\neg B,e,k'\text{Mainloop}) > 0 \wedge$$
$$(\exists j', 1 \leq j' \leq \text{Army}[B,g].\text{Squadrons}, Endurance(B,g,j',\text{Mainloop}) > 0 \wedge$$
$$Observe(B,g,j',e,k',\text{Mainloop}))$$

Condition III:

$$\text{Params.NumWTypes} > 0 \wedge \text{Mainloop} + 1 < \text{Duration} \wedge$$
$$\exists w, 1 \leq w \leq \text{Params.NumWTypes}, NumWeapon(B,g,w,\text{Mainloop}+1) > 1 \wedge$$
$$\text{Army}[B,g].\text{Weapon}[w].\text{FireRate} > 0 \wedge \text{Army}[B,g].\text{Weapon}[w].\text{UseLimit} > 0 \wedge$$
$$\text{Army}[B,g].\text{WeapPriority}[e,w] > 1 \wedge$$
$$\frac{Endurance(\neg B,e,k,\text{Mainloop}+1)}{2} \leq \text{Army}[B,g].\text{Weapon}[w].\text{Damage} + \text{Army}[\neg B,e].\text{Wear}$$
$$< Endurance(\neg B,e,k,\text{Mainloop}+1)$$

7.11: Segmentation Violation if battalion leaves terrain grid

Condition I:(Duration > 0)

Condition II:

$$\exists B,g, Active(B,g) \wedge$$
$$(X_{B,g} < 0 \vee Y_{B,g} < 0)$$

Condition III: True

7.12: Restoration>0 after FixSuppl=0

Condition I: $Active(B, g) \wedge NumCas(B, g, \text{Mainloop} - 1) > 0$
Condition II: $Suppl(B, g, \text{Mainloop} - 2) < 0$
Condition III:

$\exists j, 1 \leq j \leq \text{Army}[B, g].\text{Squadrons},$
$\frac{\text{Army}[B,g].\text{Endurance}[j]}{2} < Endurance(B, g, j, \text{Mainloop} - 1) - \frac{Suppl(B,g,\text{Mainloop}-2)}{NumCas(B,g,\text{Mainloop}-1)}$

7.13: Wrong variable on loop in Observation

Condition I: $Active(B, g)$
Condition II: $\text{NArmy}[B] \neq \text{NArmy}[\neg B]$
Condition III:

$(\text{NArmy}[B] > \text{NArmy}[\neg B]) \vee$
$(\text{NArmy}[B] < \text{NArmy}[\neg B] \wedge$
$\exists e, \text{NArmy}[B] < e \leq \text{NArmy}[\neg B], Active(\neg B, e) \wedge$
$EObserve(B, g, e, \text{Mainloop}))$

7.14: Command with 0 squadrons doesn't destroy battalion

Condition I:

$Active(B, g) \wedge \text{NCmsgs}[B] > 0 \wedge$
$\exists m, 1 \leq m \leq \text{NCmsgs}[B], Mimp(B, g, m, \text{Mainloop}) \wedge \neg Mimp(B, g, m, \text{Mainloop} - 1)$

Condition II: $\text{Cmsgs}[B, m].\text{msg.Squadrons} = 0$
Condition III: True

7.15: NumWeaponToUse not initialized

Condition I: $Active(B, g) \wedge Active(\neg B, e) \wedge EObserve(B, g, e, \text{Mainloop})$
Condition II: True
Condition III: $\text{Mainloop} < \text{Duration} - 1$

7.16: Does not reject Army.NumFixers > Army.Squadrons

Condition I: $(\text{Duration} \geq 0)$
Condition II:

$(\exists B, B \in \{1...\text{NArmy}[\text{true}]\},$
$\quad \text{Army}[\text{true}, B].\text{NumFixers} > \text{Army}[\text{true}, B].\text{Squadrons}) \vee$
$(\exists B, B \in \{1...\text{NArmy}[\text{false}]\},$
$\quad \text{Army}[\text{false}, B].\text{NumFixers} > \text{Army}[\text{false}, B].\text{Squadrons})$

Condition III: True

7.17: Does not reject Army.NumJammers > Army.Squadrons

Condition I:(Duration ≥ 0)
Condition II:

$(\exists B, B \in \{1...\text{NArmy[true]}\},$
$\quad \text{Army[true}, B\text{].NumJammers} > \text{Army[true}, B\text{].Squadrons)} \vee$
$(\exists B, B \in \{1...\text{NArmy[false]}\},$
$\quad \text{Army[false}, B\text{].NumJammers} > \text{Army[false}, B\text{].Squadrons)}$

Condition III: True

7.18: Does not reject Army.NumProcess > Army.Squadrons

Condition I:(Duration ≥ 0)
Condition II:

$(\exists B, B \in \{1...\text{NArmy[true]}\},$
$\quad \text{Army[true}, B\text{].NumProcess} > \text{Army[true}, B\text{].Squadrons)} \vee$
$(\exists B, B \in \{1...\text{NArmy[false]}\},$
$\quad \text{Army[false}, B\text{].NumProcess} > \text{Army[false}, B\text{].Squadrons)}$

Condition III: True

7.19: Does not reject Army.NumReceive > Army.Squadrons

Condition I:(Duration ≥ 0)
Condition II:

$(\exists B, B \in \{1...\text{NArmy[true]}\},$
$\quad \text{Army[true}, B\text{].NumReceive} > \text{Army[true}, B\text{].Squadrons)} \vee$
$(\exists B, B \in \{1...\text{NArmy[false]}\},$
$\quad \text{Army[false}, B\text{].NumReceive} > \text{Army[false}, B\text{].Squadrons)}$

Condition III: True

7.20: Does not reject Army.NumSend > Army.Squadrons

Condition I:(Duration ≥ 0)
Condition II:

$(\exists B, B \in \{1...\text{NArmy[true]}\},$
$\quad \text{Army[true}, B\text{].NumSend} > \text{Army[true}, B\text{].Squadrons)} \vee$
$(\exists B, B \in \{1...\text{NArmy[false]}\},$
$\quad \text{Army[false}, B\text{].NumSend} > \text{Army[false}, B\text{].Squadrons)}$

Condition III: True

7.21: Does not reject Cmsgs.msg.NumFixers > Cmsgs.msg.Squadrons

Condition I:

$\exists B, \quad B \in \{\text{true}, \text{false}\},$
$(\exists f, 1 \leq f \leq \text{NArmy}[B],$
$(\exists m, m \in \{1...\text{NCmsgs}[B]\}, Mimp(B, f, m, \text{Duration})))$

Condition II:

$\text{Cmsgs}[B, m].\text{msg.NumFixers} > \text{Cmsgs}[B, m].\text{msg.Squadrons}$

Condition III: True

7.22:Does not reject Cmsgs.msg.NumJammers > Cmsgs.msg.Squadrons

Condition I:

$\exists B, \quad B \in \{\text{true}, \text{false}\},$
$(\exists f, 1 \leq f \leq \text{NArmy}[B],$
$(\exists m, m \in \{1...\text{NCmsgs}[B]\}, Mimp(B, f, m, \text{Duration})))$

Condition II:

$\text{Cmsgs}[B, m].\text{msg.NumJammers} > \text{Cmsgs}[B, m].\text{msg.Squadrons}$

Condition III: True

7.23: Does not reject Cmsgs.msg.NumProcess > Cmsgs.msg.Squadrons

Condition I:

$\exists B, \quad B \in \{\text{true}, \text{false}\},$
$(\exists f, 1 \leq f \leq \text{NArmy}[B],$
$(\exists m, m \in \{1...\text{NCmsgs}[B]\}, Mimp(B, f, m, \text{Duration})))$

Condition II:

$\text{Cmsgs}[B, m].\text{msg.NumProcess} > \text{Cmsgs}[B, m].\text{msg.Squadrons}$

Condition III: True

7.24: Does not reject Cmsgs.msg.NumReceive > Cmsgs.msg.Squadrons

Condition I:

$\exists B, \quad B \in \{\text{true}, \text{false}\},$
$(\exists f, 1 \leq f \leq \text{NArmy}[B],$
$(\exists m, m \in \{1...\text{NCmsgs}[B]\}, Mimp(B, f, m, \text{Duration})))$

Condition II:

$\text{Cmsgs}[B, m].\text{msg.NumReceive} > \text{Cmsgs}[B, m].\text{msg.Squadrons}$

Condition III: True

7.25:Does not reject Cmsgs.msg.NumSend > Cmsgs.msg.Squadrons

Condition I:

$\exists B, \quad B \in \{\text{true}, \text{false}\},$
$(\exists f, 1 \leq f \leq \text{NArmy}[B],$
$(\exists m, m \in \{1...\text{NCmsgs}[B]\}, Mimp(B, f, m, \text{Duration})))$

Condition II:

$\text{Cmsgs}[B, m].\text{msg.NumSend} > \text{Cmsgs}[B, m].\text{msg.Squadrons}$

Condition III: True

7.27: Divide by zero KF in CalcNumWeapToUse

Condition I:

$Active(B, g) \wedge Active(\neg B, e) \wedge \text{Params.NumWTypes} > 0 \wedge$
$\exists w, 1 \leq w \leq \text{Params.NumWtypes}, NumWeapon(B, g, w, \text{Mainloop}) > 0 \wedge$
$\exists j, 1 \leq j \leq \text{Army}[B, g].\text{Squadrons}, Endurance(B, g, j, \text{Mainloop}) > 0 \wedge$
$\exists k, 1 \leq k \leq \text{Army}[\neg B, e].\text{Squadrons}, Endurance(\neg B, e, k, \text{Mainloop}) > 0 \wedge$
$Observe(B, g, j, e, k, \text{Mainloop} - 1) \wedge InRange(B, g, w, e, k, \text{Mainloop} - 1)$

Condition II:$\text{Army}[B, g].\text{Weapon}[w].\text{FireRate} = 0$
Condition III: True

7.28: Number Variables exceed initial values

Condition I: $Active(B, g) \wedge NumCas(B, g, \text{Mainloop} - 1) > 0$

Condition II: $s(B, g, \text{Mainloop}) < NumCas(B, g, \text{Mainloop}-1) - NumCas(B, g, \text{Mainloop})$

Condition III: True

7.29: Double increments of Weapon and Target index

Condition I:

$Active(B, g) \wedge Active(\neg B, e) \wedge \text{Params.NumWTypes} > 0 \wedge \text{Mainloop} > 2 \wedge$
$\exists j, 1 \leq j \leq \text{Army}[B, g].\text{Squadrons}, Endurance(B, g, j, \text{Mainloop}) > 0 \wedge$
$\exists k, 1 < k \leq \text{Army}[\neg B, e].\text{Squadrons}, Endurance(\neg B, e, k, \text{Mainloop}) > 0 \wedge$
$\exists w, 1 \leq w \leq \text{Params.NumWTypes}, NumWeapon(B, g, w, \text{Mainloop}) > 1 \wedge$
$Observe(B, g, j, e, k, \text{Mainloop} - 2) \wedge InRange(B, g, w, e, k, \text{Mainloop} - 1) \wedge$
$\text{Army}[B, g].\text{WeapPriority}[e, w] > 1 \wedge \text{Army}[B, g].\text{Weapon}[w].\text{UseLimit} > 0 \wedge$
$\text{Army}[B, g].\text{Weapon}[w].\text{FireRate} > 0$

Condition II:

$\exists j', 1 \leq j' \leq \text{Army}[B, g].\text{Squadrons}, Endurance(B, g, j', \text{Mainloop} - 2) > 0 \wedge$
$Observe(B, g, j', e, k - 1, \text{Mainloop} - 2)$

Condition III: $\text{Army}[B, g].\text{Weapon}[w].\text{Damage} > 0$

7.32: Numeric Precision fault in Series

Condition I:

$$Active(B,g) \wedge Active(\neg B,e) \wedge \text{Params.SampleRate} > 2 \wedge$$
$$\exists j, 1 \leq j \leq \text{Army}[B,g].\text{Squadrons}, Endurance(B,g,j,\text{Mainloop}) > 0 \wedge$$
$$\exists k, 1 \leq k \leq \text{Army}[\neg B,e].\text{Squadrons}, Endurance(\neg B,e,k,\text{Mainloop}) > 0 \wedge$$
$$BigEnough(B,g,j,e,k,\text{Mainloop})$$

Condition II:

$$\log_2(\text{Params.SampleRate}) \neq \lfloor \log_2(\text{Params.SampleRate}) \rfloor$$

Condition III:

$$xgj = x_{B,g,j}(\text{Mainloop}-1) \wedge ygj = y_{B,g,j}(\text{Mainloop}-1) \wedge$$
$$xek = x_{\neg B,e,k}(\text{Mainloop}-1) \wedge yek = y_{\neg B,e,k}(\text{Mainloop}-1) \wedge$$
$$(\forall a,a',c,c',z,z', a = \left\lfloor \frac{xgj}{\text{Params.XDelta}} \right\rfloor \wedge a' = \left\lfloor \frac{xek}{\text{Params.XDelta}} \right\rfloor \wedge$$

$$c = \left\lfloor \frac{ygj}{\text{Params.YDelta}} \right\rfloor \wedge c' = \left\lfloor \frac{yek}{\text{Params.YDelta}} \right\rfloor \wedge$$

$$z = Alt(a,c,xgj,ygj) \wedge z' = Alt(a',c',xek,yek) \wedge$$
$$(\forall n, 1 \leq n < 2^{\lfloor \log_2(\text{Params.SampleRate}) \rfloor} - 1,$$
$$(\exists r,p,q,x',y', r = \frac{n}{2^{\lfloor \log_2(\text{Params.SampleRate}) \rfloor - 1}},$$
$$x' = xgj + r \times (xek - xgj), y' = ygj + r \times (yek - ygj),$$
$$p = \left\lfloor \frac{x'}{\text{Params.XDelta}} \right\rfloor, q = \left\lfloor \frac{y'}{\text{Params.YDelta}} \right\rfloor,$$

$$(z + r \times (z' - z)) > Alt(p,q,x',y')$$
$$)\ ) \quad \wedge$$
$$\left(\left(\frac{BI(a',c',xek,yek) - \text{Army}[\neg B,e].\text{SquadIntensity}[k]}{BI(a',c',xek,yek)} \right) \right.$$

$$\sum_{n=1}^{2^{\lfloor \log_2(\text{Params.SampleRate}) \rfloor}} \left(\left(WO\left(xgj \times \frac{n \times (xek - xgj)}{2^{\lfloor \log_2(\text{Params.SampleRate}) \rfloor}}, ygj \times \frac{n \times (yek - ygj)}{2^{\lfloor \log_2(\text{Params.SampleRate}) \rfloor}}, \text{Mainloop} \right) \times \text{Army}[B,g].\text{VWEffect} \right) + \right.$$

$$\sum_{e'=1}^{\text{NArmy}[\neg B]} \begin{cases} 0 \quad \text{if } \sqrt{\left(x_{\neg B,e'}(\text{Mainloop}-1) - xgj \times \frac{n \times (xek - xgj)}{2^{\lfloor \log_2(\text{Params.SampleRate}) \rfloor - 1}} \right)^2 + \left(y_{\neg B,e'}(\text{Mainloop}-1) - ygj \times \frac{n \times (yek - ygj)}{2^{\lfloor \log_2(\text{Params.SampleRate}) \rfloor - 1}} \right)^2} \\ \qquad > \text{Army}[\neg B,e'].\text{ObsJamRadius} \\ \dfrac{\sqrt{\left(x_{\neg B,e'}(\text{Mainloop}-1) - xgj \times \frac{n \times (xek - xgj)}{2^{\lfloor \log_2(\text{Params.SampleRate}) \rfloor}} \right)^2 + \left(y_{\neg B,e'}(\text{Mainloop}-1) - ygj \times \frac{n \times (yek - ygj)}{2^{\lfloor \log_2(\text{Params.SampleRate}) \rfloor}} \right)^2}}{\text{Army}[\neg B,e'].\text{ObsJamRadius}} \\ \times \text{Army}[\neg B,e'].\text{ObsJamEff otherwise} \end{cases}$$
$$)\ ) < \text{Army}[B,g].\text{ObsMinContrast}[j]))$$

7.33: Undefined value when battalion leaves terrain grid

Condition I:(Duration > 0)
Condition II:

$\exists B, g, Active(B, g) \wedge$
$(X_{B,g}(\text{Mainloop}) \geq \text{Params.XDelta} \times \text{MaxTerrain} \vee$
$Y_{B,g}(\text{Mainloop}) \geq \text{Params.YDelta} \times \text{MaxTerrain})$

Condition III: True

7.35: Invalid expiration of observations

Condition I:$Active(B, g) \wedge Active(\neg B, e) \wedge EObserve(B, g, e, \text{Mainloop})$
Condition II:$\text{Army}[B, g].\text{ObsXpire} < 2$
Condition III:

$\text{Mainloop} < \text{Duration} - 1 \wedge \text{Params.NumWTypes} > 0 \wedge$
$\exists w, 1 \leq w \leq \text{Params.NumWTypes}, NumWeapon(B, g, w, \text{Mainloop} + 1) > 0 \wedge$
$\text{Army}[B, g].\text{WeapPriority}[e, w] > 0 \wedge \text{Army}[B, g].\text{Weapon}[w].\text{UseLimit} > 0 \wedge$
$\text{Army}[B, g].\text{Weapon}[w].\text{Range} > 0 \wedge \text{Army}[B, g].\text{Weapon}[w].\text{Damage} > 0 \wedge$
$\text{Army}[B, g].\text{Weapon}[w].\text{FireRate} > 0$

Failure Regions in Version 8

8.1: Divide by zero in UpdateKA

Condition I:

$$Active(B,g) \wedge Active(\neg B,e) \wedge \text{Params.NumWTypes} > 0 \wedge$$
$$\exists j, 1 \leq j \leq \text{Army}[B,g].\text{Squadrons}, Endurance(B,g,j,\text{Mainloop}) > 0 \wedge$$
$$\exists k, 1 \leq k \leq \text{Army}[\neg B,e].\text{Squadrons}, Endurance(\neg B,e,k,\text{Mainloop}) > 0 \wedge$$
$$Observe(B,g,j,e,k,\text{Mainloop}) \wedge$$
$$\exists w, 1 \leq w \leq \text{Params.NumWTypes}, NumWeapon(B,g,w,\text{Mainloop}) > 0 \wedge$$
$$InRange(B,g,w,e,k,\text{Mainloop}) \wedge \text{Army}[B,g].\text{Weapon}[w].\text{FireRate} > 0 \wedge$$
$$\text{Army}[B,g].\text{WeapPriority}[e,w] > 0$$

Condition II: $\text{Army}[B,g].\text{Weapon}[w].\text{UseLimit} = 0$
Condition III: True

8.2: Divide by zero in SquadPos

Condition I: $Active(B,g)$
Condition II: $\text{Army}[B,g].\text{Grow} = 0$
Condition III: True

8.3: No check on send time for equal-priority messages at start of queue

Condition I: $Active(B,g) \wedge \text{NCmsgs}[B] > 1$
Condition II:

$$\exists m, 1 \leq m \leq \text{NCmsgs}[B], Mimp(B,g,m,\text{Mainloop}) \wedge \neg Mimp(B,g,m,\text{Mainloop}-1) \wedge$$
$$\exists n, 1 \leq n \leq \text{NCmsgs}[B], Mimp(B,g,n,\text{Mainloop}) \wedge \neg Mimp(B,g,n,\text{Mainloop}-1) \wedge$$
$$\text{Cmsgs}[B,m].\text{Priority} = \text{Cmsgs}[B,n].\text{Priority} \wedge \text{Cmsgs}[B,m].\text{Time} < \text{Cmsgs}[B,n].\text{Time} \wedge$$
$$\text{Cmsgs}[B,m].\text{msg} \neq \text{Cmsgs}[B,n].\text{msg}$$

Condition III:

$$\nexists m', 1 \leq m' \leq \text{NCmsgs}[B], Mimp(B,g,m',\text{Duration}) \wedge \neg Mimp(B,g,m',\text{Mainloop})$$

8.4: Pointer past end of list in PutQue

Condition I:

$Active(B, g) \wedge \text{NCmsgs}[B] > 1 \wedge$
$\exists m, 1 \leq m \leq \text{NCmsgs}[B], \text{Cmsgs}[B, m].\text{Dest} = g \wedge$
$RecT(B, g, m) < \text{Mainloop} \wedge \neg Mimp(B, g, m, \text{Mainloop}) \wedge$
$\exists n, 1 \leq n \leq \text{NCmsgs}[B], \text{Cmsgs}[B, n].\text{Dest} = g \wedge$
$RecT(B, g, n) = \text{Mainloop} \wedge \text{Cmsgs}[B, m].\text{Priority} = \text{Cmsgs}[B, n].\text{Priority}$

Condition II:

$\nexists m', 1 \leq m' \leq \text{NCmsgs}[B], \text{Cmsgs}[B, m'].\text{Dest} = g \wedge$
$m' \neq m \wedge m' \neq n \wedge RecT(B, g, m') \leq \text{Mainloop}) \wedge$
$\neg Mimp(B, g, m', \text{Mainloop})$

Condition III: True

8.5: Infinite loop in InsertMsg

Condition I:

$Active(B, g) \wedge \text{NCmsgs}[B] > 1 \wedge$
$\exists m, 1 \leq m \leq \text{NCmsgs}[B], \text{Cmsgs}[B, m].\text{Dest} = g \wedge$
$RecT(B, g, m) < \text{Mainloop} \wedge \neg Mimp(B, g, m, \text{Mainloop}) \wedge$
$\exists n, 1 \leq n \leq \text{NCmsgs}[B], \text{Cmsgs}[B, n].\text{Dest} = g \wedge$
$RecT(B, g, n) = \text{Mainloop}$

Condition II:$\text{Cmsgs}[B, m].\text{Priority} \leq \text{Cmsgs}[B, n].\text{Priority}$
Condition III: True

8.6: No check on send time for equal-priority messages in middle of queue

Condition I:$Active(B, g) \wedge \text{NCmsgs}[B] > 2$
Condition II:

$\exists m, 1 \leq m \leq \text{NCmsgs}[B], Mimp(B, g, m, \text{Mainloop}) \wedge$
$\neg Mimp(B, g, m, \text{Mainloop} - 1) \wedge$
$\exists n, 1 \leq n \leq \text{NCmsgs}[B], Mimp(B, g, n, \text{Mainloop}) \wedge$
$\neg Mimp(B, g, n, \text{Mainloop} - 1) \wedge$
$\exists m', 1 \leq m' \leq \text{NCmsgs}[B], Mimp(B, g, m', \text{Mainloop}) \wedge$
$\neg Mimp(B, g, m', \text{Mainloop} - 1) \wedge$
$\text{Cmsgs}[B, m'].\text{Priority} > \text{Cmsgs}[B, m].\text{Priority} \wedge \text{Cmsgs}[B, m].\text{Priority} = \text{Cmsgs}[B, n].\text{Priority} \wedge$
$\text{Cmsgs}[B, m].\text{Time} < \text{Cmsgs}[B, n].\text{Time} \wedge \text{Cmsgs}[B, m].\text{msg} \neq \text{Cmsgs}[B, n].\text{msg}$

Condition III:

$\nexists m', 1 \leq m' \leq \text{NCmsgs}[B], Mimp(B, g, m', \text{Duration}) \wedge \neg Mimp(B, g, m', \text{Mainloop})$

8.7: NC not zeroed on reciept of command message

Condition I:

$$Active(B,g) \wedge \text{NCmsgs}[B] > 0 \wedge$$
$$\exists m, 1 \leq m \leq \text{NCmsgs}[B], Mimp(B,g,m,\text{Mainloop}) \wedge \neg Mimp(B,g,m,\text{Mainloop}-1)$$

Condition II: $NumCas(B,g,\text{Mainloop}) > 0$

Condition III:

$$\nexists n, 1 \leq n \leq \text{NCmsgs}[B], Mimp(B,g,n,\text{Duration}) \wedge \neg Mimp(B,g,m,\text{Mainloop})$$

8.8: Segmentation violation when squadron is off terrain grid

and

8.10: Infinite loop in CalcBI

Condition I: $Active(B,g) \wedge Active(\neg B,e)$

Condition II:

$$\exists j, 1 \leq j \leq \text{Army}[B,g].\text{Squadrons}, Endurance(B,g,j,\text{Mainloop}) > 0 \wedge$$
$$(X_{B,g,j}(\text{Mainloop}) < 0 \vee Y_{B,g,j}(\text{Mainloop}) < 0)$$

Condition III: True

8.9: Observation blocked if first squadron destroyed

Condition I: $Active(B,g) \wedge Active(\neg B,e)$

Condition II: $Endurance(B,g,1,\text{Mainloop}) \leq 0$

Condition III:

$$\exists j, 1 \leq j \leq \text{Army}[B,g].\text{Squadrons}, Endurance(B,g,j,\text{Mainloop}) > 0 \wedge$$
$$\exists k, 1 \leq k \leq \text{Army}[\neg B,e].\text{Squadrons}, Endurance(\neg B,e,k,\text{Mainloop}) > 0 \wedge$$
$$Observe(B,g,j,e,k,\text{Mainloop}) \wedge$$
$$(\nexists t, 0 \leq t \leq \text{Mainloop}, EObserve(B,g,e,t)) \wedge$$
$$(\nexists f, Active(B,f), \text{Army}[B,f].\text{Report} = g \wedge$$
$$\exists t, 0 \leq t = \text{Mainloop} - RepT(B,f,g) - \text{Army}[B,g].\text{ProcDelay} - \frac{\text{Army}[B,g].\text{RecRate}}{NumRec(B,g,\text{Mainloop}-\text{Army}[B,g].\text{ProcDelay})},$$
$$EObserve(B,f,e,t)$$

8.11: Excessive length loop in CalcBI

Condition I: $Active(B, g) \wedge Active(\neg B, e)$

Condition II:

$\exists j, 1 \leq j \leq \text{Army}[B, g].\text{Squadrons}, Endurance(B, g, j, \text{Mainloop}) > 0 \wedge$
$(X_{B,g,j}(\text{Mainloop}) > \text{MaxTerrain} \times \text{Params.XDelta} \vee$
$Y_{B,g,j}(\text{Mainloop}) > \text{MaxTerrain} \times \text{Params.YDelta})$

Condition III: True

8.12: No check if RA ≤ 0

Condition I:

$Active(B, g) \wedge ((\text{NCmsgs}[B] > 0 \wedge$
$\exists m, 1 \leq m \leq \text{NCmsgs}[B], \text{Cmsgs}[B, m].\text{Dest} = g \wedge RecT(B, g, m) = \text{Mainloop}) \vee$
$(Active(B, f) \wedge Active(\neg B, e) \wedge \text{Army}[B, f].\text{Report} = g \wedge$
$EObserve(B, f, e, \text{Mainloop} - RepT(B, f, g))))$

Condition II: $NumRec(B, g, \text{Mainloop}) \leq ComJam(B, g, \text{Mainloop})$

Condition III: True

8.13: Always engaged if observation is within range

Condition I:

$Active(B, g) \wedge Active(\neg B, e) \wedge \text{Params.NumWTypes} > 0 \wedge$
$\exists j, 1 \leq j \leq \text{Army}[B, g].\text{Squadrons}, Endurance(B, g, j, \text{Mainloop}) > 0 \wedge$
$\exists k, 1 \leq k \leq \text{Army}[\neg B, e].\text{Squadrons}, Endurance(\neg B, e, k, \text{Mainloop}) > 0 \wedge$
$Observe(B, g, j, e, k, \text{Mainloop})$

Condition II:

$\forall w, 1 \leq w \leq \text{Params.NumWTypes}, InRange(B, g, w, e, k, \text{Mainloop}) \rightarrow$
$(NumWeapon(B, g, w, \text{Mainloop}) \leq 0 \vee \text{Army}[B, g].\text{WeapPriority}[e, w] \leq 0 \vee$
$\text{Army}[B, g].\text{Weapon}[w].\text{FireRate} \leq 0 \vee \text{Army}[B, g].\text{Weapon}[w].\text{UseLimit} \leq 0)$

Condition III: True

8.14: Divide by zero in OJ calculation

Condition I:

$Active(B, g) \wedge Active(\neg B, e) \wedge \text{Params.SampleRate} > 2 \wedge$
$\exists j, 1 \leq j \leq \text{Army}[B, g].\text{Squadrons}, Endurance(B, g, j, \text{Mainloop}) > 0 \wedge$
$\exists k, 1 \leq k \leq \text{Army}[\neg B, e].\text{Squadrons}, Endurance(\neg B, e, k, \text{Mainloop}) > 0 \wedge$
$BigEnough(B, g, j, e, k, \text{Mainloop}) \wedge Clear(B, g, j, e, k, \text{Mainloop})$

Condition II: $\exists e', Active(\neg B, e'), \text{Army}[\neg B, e'].\text{ObJamRadius} = 0$

Condition III: True

8.15: Version does not observe when Params.SampleRate = 2

Condition I:

$Active(B, g) \wedge Active(\neg B, e)$
$\exists j, 1 \leq j \leq \text{Army}[B, g].\text{Squadrons}, Endurance(B, g, j, \text{Mainloop}) > 0 \wedge$
$\exists k, 1 \leq k \leq \text{Army}[\neg B, e].\text{Squadrons}, Endurance(\neg B, e, k, \text{Mainloop}) > 0 \wedge$
$BigEnough(B, g, j, e, k, \text{Mainloop})$

Condition II: Params.SampleRate = 2
Condition III: True

8.18: Destroyed battalions still move

and

8.35: Velocity undefined if battalion destroyed

Condition I:$\text{Duration} > 2 \wedge \exists B, B \in \{\text{True}, \text{False}\}, \text{NArmy}[B] > 0$
Condition II:

$\exists g, 1 \leq g \leq \text{NArmy}[B], \exists t, 0 \leq t < \text{Duration} - 1, s(B, g, t) = 0$

Condition III: True

8.19: Version observes when Params.SampleRate < 2

and

8.39: Divide by zero in FindPoints

Condition I:

$Active(B, g) \wedge Active(\neg B, e)$
$\exists j, 1 \leq j \leq \text{Army}[B, g].\text{Squadrons}, Endurance(B, g, j, \text{Mainloop}) > 0 \wedge$
$\exists k, 1 \leq k \leq \text{Army}[\neg B, e].\text{Squadrons}, Endurance(\neg B, e, k, \text{Mainloop}) > 0 \wedge$
$BigEnough(B, g, j, e, k, \text{Mainloop})$

Condition II: Params.SampleRate < 2
Condition III: True

8.23: Use of 0 as flag conflicts with position in width

Condition I:$Active(B, g)$
Condition II:

$\exists j, 1 \leq j \leq \text{Army}[B, g].\text{Squadrons}, Endurance(B, g, j, \text{Mainloop}) > 0 \wedge$
$X_{B,g,j}(\text{Mainloop}) < 0$

Condition III: Mainloop = Duration − 1

8.25: Does not reject Army.NumFixers > Army.Squadrons

Condition I:(Duration ≥ 0)
Condition II:

$(\exists B, B \in \{1...\text{NArmy[true]}\},$
$\quad \text{Army[true, } B\text{].NumFixers} > \text{Army[true, } B\text{].Squadrons}) \vee$
$(\exists B, B \in \{1...\text{NArmy[false]}\},$
$\quad \text{Army[false, } B\text{].NumFixers} > \text{Army[false, } B\text{].Squadrons})$

Condition III: True

8.26: Does not reject Army.NumJammers > Army.Squadrons

Condition I:(Duration ≥ 0)
Condition II:

$(\exists B, B \in \{1...\text{NArmy[true]}\},$
$\quad \text{Army[true, } B\text{].NumJammers} > \text{Army[true, } B\text{].Squadrons}) \vee$
$(\exists B, B \in \{1...\text{NArmy[false]}\},$
$\quad \text{Army[false, } B\text{].NumJammers} > \text{Army[false, } B\text{].Squadrons})$

Condition III: True

8.27:Does not reject Army.NumProcess > Army.Squadrons

Condition I:(Duration ≥ 0)
Condition II:

$(\exists B, B \in \{1...\text{NArmy[true]}\},$
$\quad \text{Army[true, } B\text{].NumProcess} > \text{Army[true, } B\text{].Squadrons}) \vee$
$(\exists B, B \in \{1...\text{NArmy[false]}\},$
$\quad \text{Army[false, } B\text{].NumProcess} > \text{Army[false, } B\text{].Squadrons})$

Condition III: True

8.28: Does not reject Army.NumReceive > Army.Squadrons

Condition I:(Duration ≥ 0)
Condition II:

$(\exists B, B \in \{1...\text{NArmy[true]}\},$
$\quad \text{Army[true, } B\text{].NumReceive} > \text{Army[true, } B\text{].Squadrons}) \vee$
$(\exists B, B \in \{1...\text{NArmy[false]}\},$
$\quad \text{Army[false, } B\text{].NumReceive} > \text{Army[false, } B\text{].Squadrons})$

Condition III: True

8.29: Does not reject Army.NumSend > Army.Squadrons

Condition I:(Duration ≥ 0)

Condition II:

$(\exists B, B \in \{1...\text{NArmy[true]}\},$
$\quad \text{Army[true}, B].\text{NumSend} > \text{Army[true}, B].\text{Squadrons}) \vee$
$(\exists B, B \in \{1...\text{NArmy[false]}\},$
$\quad \text{Army[false}, B].\text{NumSend} > \text{Army[false}, B].\text{Squadrons})$

Condition III: True

8.30: Does not reject Cmsgs.msg.NumFixers > Cmsgs.msg.Squadrons

Condition I:

$\exists B, \quad B \in \{\text{true}, \text{false}\},$
$(\exists f, 1 \leq f \leq \text{NArmy}[B],$
$(\exists m, m \in \{1...\text{NCmsgs}[B]\}, Mimp(B, f, m, \text{Duration})))$

Condition II:

$\text{Cmsgs}[B, m].\text{msg.NumFixers} > \text{Cmsgs}[B, m].\text{msg.Squadrons}$

Condition III: True

8.31: Does not reject Cmsgs.msg.NumJammers > Cmsgs.msg.Squadrons

Condition I:

$\exists B, \quad B \in \{\text{true}, \text{false}\},$
$(\exists f, 1 \leq f \leq \text{NArmy}[B],$
$(\exists m, m \in \{1...\text{NCmsgs}[B]\}, Mimp(B, f, m, \text{Duration})))$

Condition II:

$\text{Cmsgs}[B, m].\text{msg.NumJammers} > \text{Cmsgs}[B, m].\text{msg.Squadrons}$

Condition III: True

8.32: Does not reject Cmsgs.msg.NumProcess > Cmsgs.msg.Squadrons

Condition I:

$\exists B, \quad B \in \{\text{true}, \text{false}\},$
$(\exists f, 1 \leq f \leq \text{NArmy}[B],$
$(\exists m, m \in \{1...\text{NCmsgs}[B]\}, Mimp(B, f, m, \text{Duration})))$

Condition II:

$\text{Cmsgs}[B, m].\text{msg.NumProcess} > \text{Cmsgs}[B, m].\text{msg.Squadrons}$

Condition III: True

8.33: Does not reject Cmsgs.msg.NumReceive > Cmsgs.msg.Squadrons

Condition I:

$\exists B, \quad B \in \{\text{true}, \text{false}\},$
$(\exists f, 1 \leq f \leq \text{NArmy}[B],$
$(\exists m, m \in \{1...\text{NCmsgs}[B]\}, Mimp(B, f, m, \text{Duration})))$

Condition II:

$\text{Cmsgs}[B, m].\text{msg.NumReceive} > \text{Cmsgs}[B, m].\text{msg.Squadrons}$

Condition III: True

8.34: Does not reject Cmsgs.msg.NumSend > Cmsgs.msg.Squadrons

Condition I:

$\exists B, \quad B \in \{\text{true}, \text{false}\},$
$(\exists f, 1 \leq f \leq \text{NArmy}[B],$
$(\exists m, m \in \{1...\text{NCmsgs}[B]\}, Mimp(B, f, m, \text{Duration})))$

Condition II:

$\text{Cmsgs}[B, m].\text{msg.NumSend} > \text{Cmsgs}[B, m].\text{msg.Squadrons}$

Condition III: True

8.36: Divide by zero in CalcContrast

Condition I:

$$
\begin{aligned}
&Active(B, g) \wedge Active(\neg B, e) \wedge \\
&\exists j, 1 \leq j \leq \text{Army}[B, g].\text{Squadrons}, Endurance(B, g, j, \text{Mainloop}) > 0 \wedge \\
&\exists k, 1 \leq k \leq \text{Army}[\neg B, e].\text{Squadrons}, Endurance(\neg B, e, k, \text{Mainloop}) > 0 \wedge \\
&BigEnough(B, g, j, e, k, \text{Mainloop}) \wedge Clear(B, g, j, e, k, \text{Mainloop})
\end{aligned}
$$

Condition II:

$$
\begin{aligned}
&(X_{\neg B,e,k}(\text{Mainloop}) = 0 \vee \text{Params.IX} = 0) \wedge \text{Params.IC} = 0 \wedge \\
&(Y_{\neg B,e,k}(\text{Mainloop}) = 0 \vee \text{Params.IY} = 0) \wedge \\
&(\text{Params.IAltFactor} = 0 \vee \\
&Alt(X_{\neg B,e,k}(\text{Mainloop}), Y_{\neg B,e,k}(\text{Mainloop})) = \text{Params.IMeanAlt}) \wedge \\
&\text{Params.ISlopeFactor} = 0
\end{aligned}
$$

Condition III: True

8.37: Divide by zero in CalcAngle

Condition I:$Active(B, g) \wedge Active(\neg B, e)$

Condition II:

$$
\begin{aligned}
&\exists j, 1 \leq j \leq \text{Army}[B, g].\text{Squadrons}, Endurance(B, g, j, \text{Mainloop}) > 0 \wedge \\
&\exists k, 1 \leq k \leq \text{Army}[\neg B, e].\text{Squadrons}, Endurance(\neg B, e, k, \text{Mainloop}) > 0 \wedge \\
&(X_{B,g,j}(\text{Mainloop}) = X_{\neg B,e,k}(\text{Mainloop}) - \frac{\text{Army}[\neg B,e].\text{SquadWidth}}{2} \vee \\
&X_{B,g,j}(\text{Mainloop}) = X_{\neg B,e,k}(\text{Mainloop}) + \frac{\text{Army}[\neg B,e].\text{SquadWidth}}{2})
\end{aligned}
$$

Condition III: True

8.38: Missing equal-y case in FindAngle

Condition I:$Active(B, g) \wedge Active(\neg B, e)$

Condition II:

$$
\begin{aligned}
&\exists j, 1 \leq j \leq \text{Army}[B, g].\text{Squadrons}, Endurance(B, g, j, \text{Mainloop}) > 0 \wedge \\
&\exists k, 1 \leq k \leq \text{Army}[\neg B, e].\text{Squadrons}, Endurance(\neg B, e, k, \text{Mainloop}) > 0 \wedge \\
&(Y_{B,g,j}(\text{Mainloop}) = Y_{\neg B,e,k}(\text{Mainloop}) - \frac{\text{Army}[\neg B,e].\text{SquadLength}}{2} \vee \\
&Y_{B,g,j}(\text{Mainloop}) = Y_{\neg B,e,k}(\text{Mainloop}) + \frac{\text{Army}[\neg B,e].\text{SquadLength}}{2})
\end{aligned}
$$

Condition III: True

8.40: Out-of-Bounds array reference in FindPoints

Condition I:

$$Active(B, g) \wedge Active(\neg B, e) \wedge$$
$$\exists j, 1 \leq j \leq \text{Army}[B, g].\text{Squadrons}, Endurance(B, g, j, \text{Mainloop}) > 0 \wedge$$
$$\exists k, 1 \leq k \leq \text{Army}[\neg B, e].\text{Squadrons}, Endurance(\neg B, e, k, \text{Mainloop}) > 0 \wedge$$
$$BigEnough(B, g, j, e, k, \text{Mainloop})$$

Condition II: Params.SampleRate > 51
Condition III: True

8.41: Divide by zero in Height

Condition I:

$$Active(B, g) \wedge Active(\neg B, e) \wedge \text{Params.SampleRate} > 1 \wedge$$
$$\exists j, 1 \leq j \leq \text{Army}[B, g].\text{Squadrons}, Endurance(B, g, j, \text{Mainloop}) > 0 \wedge$$
$$\exists k, 1 \leq k \leq \text{Army}[\neg B, e].\text{Squadrons}, Endurance(\neg B, e, k, \text{Mainloop}) > 0 \wedge$$
$$BigEnough(B, g, j, e, k, \text{Mainloop})$$

Condition II:

$$X_{B,g,j}(\text{Mainloop}) = X_{\neg B,e,k}(\text{Mainloop}) \wedge Y_{B,g,j}(\text{Mainloop}) = Y_{\neg B,e,k}(\text{Mainloop})$$

Condition III: True

8.42: Divide by zero in Altitude

Condition I:$Active(B, g)$
Condition II: Params.XDelta = 0 $\vee$ Params.YDelta = 0
Condition III: True

8.44: Divide by zero in CalcBI

Condition I:

$$Active(B, g) \wedge Active(\neg B, \epsilon) \wedge$$
$$\exists j, 1 \leq j \leq \text{Army}[B, g].\text{Squadrons}, Endurance(B, g, j, \text{Mainloop}) > 0 \wedge$$
$$\exists k, 1 \leq k \leq \text{Army}[\neg B, \epsilon].\text{Squadrons}, Endurance(\neg B, e, k, \text{Mainloop}) > 0 \wedge$$
$$BigEnough(B, g, j, e, k, \text{Mainloop})$$

Condition II: Params.IMeanAlt = 0
Condition III: True

8.45: Divide by zero in WeatherMoveEffect

Condition I: $Active(B, g)$
Condition II: Params.WMaxSeverity $= 0 \vee$ Params.NumWEvents $= 0$
Condition III: True

8.46: Divide by zero in WObsEffect

Condition I:

$Active(B, g) \wedge Active(\neg B, e) \wedge$ Params.SampleRate $> 2 \wedge$
$\exists j, 1 \leq j \leq$ Army$[B, g]$.Squadrons, $Endurance(B, g, j,$ Mainloop$) > 0 \wedge$
$\exists k, 1 \leq k \leq$ Army$[\neg B, e]$.Squadrons, $Endurance(\neg B, e, k,$ Mainloop$) > 0 \wedge$
$BigEnough(B, g, j, e, k,$ Mainloop$)$

Condition II: Params.WMaxSeverity $= 0 \vee$ Params.NumWEvents $= 0$
Condition III: True

8.48: Divide by zero in UpdateK

Condition I:

$Active(B, g) \wedge$ Params.NumWTypes $> 0 \wedge$
$\exists w, 1 \leq w \leq$ Params.NumWTypes, $NumWeapon(B, g, w,$ Mainloop$) > 0 \wedge$
$\exists i, 1 \leq i \leq NumWeapon(B, g, w,$ Mainloop$)$,
$ax_{B,g,w,i}($Mainloop$) \neq \infty \wedge ay_{B,g,w,i}($Mainloop$) \neq \infty$

Condition II: Army$[B, g]$.Weapon$[w]$.Radius $= 0$
Condition III: True

8.50: Divide by zero in CalcRDelay

Condition I:

$Active(B, g) \wedge Active(\neg B, e) \wedge$
(NCmsgs$[B] > 0 \wedge$
$\exists m, 1 \leq m \leq$ NCmsgs$[B]$, $Mimp(B, g, m,$ Duration$)) \vee$
$(Active(B, f) \wedge$ Army$[B, f]$.Report $= g \wedge$
$\exists t, 0 \leq t \leq$ Duration $- RepT(B, f, g), SomeObserve(B, f, t))$

Condition II: Army$[\neg B, e]$.ComJamRadius $= 0$
Condition III: True

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