LUFTWAFFE DESIGN ANALYSIS
BEHIND THE LUFTWAFFE AERIAL COMBAT TABLE

Lou Zocchi is probably the father of modern air warfare games as we know them today. The groundwork he laid in designing three earlier, now out of print, air games was the major factor in our publication of LUFTWAFFE. Lou takes over the Design Analysis chores this month to give you an in-depth view of *what goes into a Combat Results Table; a study made more interesting by the application of tactical doctrine to a strategic level game.*

GAME DESIGN CREDITS: ALIEN SPACE, BATTLE OF BRITAIN, FLYING TIGERS, HARDTACK, LUFTWAFFE, MINUTEMAN, TWELVE O'CLOCK HIGH.

Although aerial combat results table in the Luftwaffe game appears to be a collection of randomly selected numbers, it is the essence of a number of related studies. On page 3 of the designer's notes, I explained that the table shows what happens when an aircraft fires one burst. When fighting superior opponents, players subtract points from the die roll to simulate the difficulty an inferior plane has trying to achieve a good shooting position. When fighting an inferior aircraft, the shooting position is more easily attained but this does not increase the number of bullets fired during a single burst. So you get the full value of each die roll, but add nothing to the rolled numbers, even though you had to deduct from their when shooting from an inferior plane.

To understand where those CRT numbers come from, let's look at where and how damage is inflicted and how much damage a plane suffers before destruction.

According to "RIFLES & MACHINE GUNS", "A MODERN HANDBOOK ON INFANTRY AND AIRCRAFT ARMS", "GERMAN MILITARY AIRCRAFT OF THE SECOND WORLD WAR", and other sources, the machineguns mounted in aircraft wings average one round in six on target when firing at a relatively stationary, 25 square meters target at 200 meters.

At least 5 rounds out of 6 miss their mark during a typical burst. Since the parameter above assumes that the target is relatively stationary, (a situation rarely encountered during air to air combat) you can see that allowing 1/6th of all bullets fired to hit on the combat results table would be overly generous. But even the single bullet which hits is not always effective. The following information shows that much depends upon where those bullets go.

Generally speaking, bullets strike the body of an aircraft in direct proportion to the amount of surface exposed during the attack. From head on, the engine presents the largest and easiest target area while the wings are the smallest. Attacking from behind puts few rounds into the engine but many into the body. Attacking from above is almost the same as attacking from below because most of the rounds hit the wings and a smaller number go through the body. A side attack causes more body hits than wing hits. The size of the target affects the number of hits taken and the design of the plane determines in large measure the number of hits it can survive.

A number of private and military studies indicate that damage can be classified into three categories:

CATEGORY I includes pilot and gunner cabins, controls and vital equipment in wings and fuselage. This is generally estimated to be 2/3rds of the wing fuselage area of the plane. When struck by a 50 caliber bullet, every twelfth penetration (8 1/2) generally causes damage. One instance of damage in this area has a 16% chance of killing or injuring nearby crew members and a 2% chance of starting a fire.

CATEGORY II includes the oil and gas tanks. They average 1/3rd of the wing fuselage area of the plane and are generally damaged by every third (33%) 50 caliber bullet which penetrates. Each instance of damage causes fuel loss and 50% of the time will start fires.

CATEGORY III is the engine or engines of the plane. One out of 3 penetrations (33%) causes critical damage. Such damage could stop engines and 16% of the time will start fires.

Explosions are most likely when category II or III areas are damaged. One case in six causes an explosion in category II while only one case in fifty (2%) causes an explosion in category III.

To provide a better understanding of the information expressed in the former statements, I've restated the facts in a graphic format which follows.

There are many recorded instances when a damaged aircraft has been able to continue combat effectively. There are even a few recorded instances where a burning aircraft has been able to continue combat. I can find no instances where an aircraft has continued combat after exploding. It therefore seemed logical to assume that the situation which required the least number of bullets to achieve an explosion would be the safest example upon which a fire power chart could be calculated. Since the smallest number of 50 caliber bullets which can cause an explosion is 108 in category II, the number 108 became very significant because it also caused fires in category III.

Because the formulas given in standard cases assumed that the damaging bullets were all 50 caliber, the firepower of every aircraft in the game had to be translated into something which would equate their true destructive abilities, as expressed in 50 caliber bullets. Since a 30 caliber bullet is only 3/5ths the size of a 50 caliber bullet, it is only 3/5ths as effective when only its outside diameter is considered. 100 thirty caliber bullets cause about the same amount of damage as 60 fifty caliber bullets. A 20mm shell is the equivalent of 1 & 1/2 fifty caliber rounds if only the outside diameter is considered. However, the greater mass, penetrating power and explosiveness of the 20mm shell entities it to a higher rating than its outside diameter indicates.

In addition to caliber sizes, the differing rates of fire for each weapon had to consider if a true firepower picture was to be obtained. Another complication to be surmounted was the change in weaponry as the war progressed.

Rapid fire weapons are best for fighter to fighter combat because the shooter can put more bullets into more spaces and increase his chances for hits. While a bomber may be held in the gunsights for one or two seconds, the smaller, more

maneuverable fighter moving at twice bomber speeds is rarely held for more than a second. During that second the 20mm cannon would give you only 5 chances to hit the target while a 30 caliber machinegun would give you 13! The RAF defeated Luftwaffe fighters during the Battle of Britain because their armament was suited for fighter to fighter combat. The RAF fighters were spitting out 104 thirty caliber rounds per second while their German opponents fired only 31 projectiles in the same time period. While the impact of a full German burst was more effective than that of an RAF fighter, a target rarely received the full burst.

In the later stages of the Battle of Britain, when few fighters were being encountered, the RAF switched over from eight 30 caliber guns per fighter to 4 twenty millimeter cannons per plane. A few big hits on bombers are more effective than many small hits.

As the menace of the American bombardment effort mounted, the Germans switched from small caliber fast firing anti-fighter weapons to heavier caliber anti-bomber cannons.

While allied armament remained fairly consistent throughout the war, the Germans continued to upgrade and increase their weapon calibers and rates of fire. Rapid advances in German weapon technology during the last stages of the war complicated the firepower picture. I resolved the situation by freezing the game at "TYPICAL" points. In other words, the P51 began the war with only 4 fifty caliber machine guns but later carried 6. In our game, it is assumed to be carried 6 since this is the most common configuration. Page 20 of the Campaign Briefing Manual describes the armament which I felt was most often used by each aircraft in the game.

German Mg15: The MG15 was used by the Luftwaffe from 1932 to 1943. It was the standard German aircraft machinegun until 1939 when the MG81 was introduced. It was used in aircraft as both a fixed mount and free traverse gun. The MG15 was gas assisted, air cooled. As an aircraft gun it was belt fed, firing 1000 to 1100 rounds per minute. For small arms use it was equipped with a saddle type magazine (75 round capacity).

German MG81: The MG81 was introduced in 1939 and replaced the MG15 in the following aircraft: Bola 81Z, Ju88, Me110, Fw190. The MG81 was used by the Luftwaffe as a free traverse and fixed mount gun. The MG81 was equipped with a muzzle booster, and was the first German twin mounted machinegun. The MG81 was capable of firing a pattern when used as a twin mount.

FIREPOWER OUTPUT EXPRESSED IN 50 CALIBER SHELLS

AMERICAN		GERMAN	
A20	1066	**He162**	4330
A26	2133	**Me163**	4300
B25	2133	**De520**	3612
B26	2133	**Ta152**	5237
B17	4266	**Ju88**	6144
B24	4266	**Me109**	7088
P39	4893	**Me110**	7402
P38	5653	**Me262**	8660
P40	6400	**Fw190**	8624
P51	6400	**Do217**	9984
Spitfire	7180	**He219**	10002
P47	8533	**Me410**	11696

Each American counter represents 75 planes when at 1/2 strength and 150 planes when at full strength. Because 108 fifty caliber bullets are required to destroy one aircraft, 8100 fifty caliber bullets are needed to destroy the 75 American planes we refer to as one factor.

German Counters were figured to average 160 planes each although many had only 120. The reason for the overage is that a number of Geschwaders had a fourth gruppen of 40 more fighters. This gruppen was usually a training outfit which further polished the pilots before committing them to combat. However, when unescorted bombers were within range, these training gruppens and anything else which could fly were used.

This brings about a situation wherein the Americans have to score 8640 bullets on target to destroy 80 Germans while the Germans have to score only 8160 to shoot down 75 Americans.

To provide you with a working example of how this was built into the aerial combat table, I'll try to explain why the light American bombers shoot as they do.

I analyzed each bomber design to determine the minimum number of guns an attacker would face when fighting such a formation. Since the A-20 could bring only one gun to bear in its weakest area, its firepower was too insignificant to register on the results table. We would have needed at least 8 of them to shoot down one factor. Since there are only 4 factors of A-20's in the game, they were omitted from the results table.

Each A-26, B-25 and B-26 was able to bring at least four 50 caliber guns into play against attackers so their firepower is the equivalent of four guns per plane times 75 planes per factor … which works Out as 2133 fifty caliber shells per factor. Four factors shooting yield a combined output of 8532 which is less than 8640 and 8640 you'll remember is the minimum number of 50 caliber rounds needed to destroy one factor of German fighters. The American needs at least 5 factors shooting before his firepower exceeds 8640 and has a chance of causing the Germans a loss.

Since there are less than 5 B-25 and A-26 factors in the game, these bombers are not permitted to return fire. There is no way they can generate the volume of fire needed to register on the results table.

Since one bullet out of 6 reaching the target is considered to be optimum accuracy, I had to figure out the consequences of shooting at less than maximum accuracy.

The 6 column of the aerial combat table shows how many factors are destroyed if 1/6th of all bullets fired, hit the target. The 5 column on the combat table shows only 5/6ths of the hits registered in the six column. A die roll of 4 means you'd have to use the 4th column which is only 4/6ths as effective as the 6 column and so on.

The B-26 results table looked something like this before I boiled it down.

Roll 1	Roll 2	Roll 3	Roll 4	Roll5	Roll 6
355	711	1066	1422	1777	2133

A die roll of I meant only 355 bullets hit the target. A die roll of two meant 711 bullets found their mark and so on. If two factors were shooting and rolled a 5, they would each score 1777 hits for a combined total of 3554. Since 3554 hits is less than 8640, the Germans Suffered no measurable losses.

You can see how 5 factors of B-26's shooting 2133 bullets into the target will give you the number of hits needed to reach or exceed 8640. But if you had rolled a 5 on the die instead of a 6, your firepower would be 1777 per factor. 5XI777=8885 hits on target which is greater than the minimum 8640 and thereby causing the Germans one combat factor lost.

If you could put 17,280 hits into a German Counter, You'd inflict a two factor loss. Each multiple of 8640 causes the Germans to loose another factor.

Since the German has to score only 8100 hits, to destroy an American factor, you may be enhanced play balance by considering the following rationales:

1. Not every German Geschwader mustered 160 fighters.
2. Even when 160 fighters were mustered, they were not all equally effective due to training in progress.
3. It takes more hits to down a two engine plane than it does to destroy a single engine plane. A four engine plane can survive more damage than a two engine plane.
4. While some of the German planes had two engines, most were single engine. Many of the American planes were multi-engine.
5. Most American planes were a bit more sturdy than their German counterparts and able to survive more punishment.

In light of these considerations, I decided that the Germans would have to score 8640 hits to destroy one American combat factor. The Fw190 shoots 8624 per factor which is just short of the required 8640 needed. But the Me262, Do217, He219 and Me410 fire more than 8640 which is why each of these fighter factors has a chance to destroy an equal number of enemy factors.

In rare circumstances, the Me410 is allowed to kill more factors than lie commits to battle. These circumstances do not occur unless the German saves all his Me410's from their Rail Road duties and combines them with his regular Air to Air 410's.

I have yet to see a game where this happened, but there is a remote possibility of it happening. If it does happen, the Me410 is allowed to kill more than it has in combat because of the strength in its rearward shooting l3mm machine guns.

The forward firepower of the Me410 is so formidable that rolling 5 causes just as many losses to the enemy as rolling a 6 until you have 5 or more factors involved. At this point, the two stingers in the tail become measurably effective and are allowed to add their firepower to that already inflicted oil the attacking inbound pass. In other words, as the Me410 retires from its inbound attack, his tail gunner gets in a few choice licks.

I've had many irate letters from fans who claim that the LUFTWAFFE results table is a piece of *SCIENCE FICTION* because it allows too much variation between the results of a one and a six on the die. They claim that their games are better balanced and more accurate because they call a roll of one on the die a two. When they roll a six on the die they call it a five. By eliminating the two extreme outcomes called for oil the one and six column, they find a more convenient game. This is not what I had in mind when I designed the game, but if doing so gives you pleasure, go ahead. I designed the LUFTWAFFE game to give you a minimum of bookkeeping and a maximum of action. I was quite surprised to learn that some of you find the game too lively. While I like to think I can keep an open mind to the suggestions made by fellow enthusiasts, I must admit that I was unable to go along with an earlier suggestion which recommended *"BOMBERS SHOULD BE ENTITLED TO TRIPLE THEIR DEFENSIVE FIRES WHEN ENTRENCHED UPON FORTIFIED CLOUDS.*