



based on data from Gary Morgan's Avalon Hill game *Flight Leader*

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Figure 1: This picture shows the climactic end of turn 18 in my first ever playtest of Jet Duel. I used the counters from J.D.Webster's Speed of Heat instead of the Flight Leader counters. (You may make your own counters if desired, as shown in Figure 5.) The fight spanned levels 1-6 over the Korean hills, so the larger white dice coincide with the actual levels. The experienced F-80 wingman was bracketed by the green MiG pilots, and by terrible luck he lost situational awareness (SA) for 2 successive turns due to his veteran leader being behind him, so he flew straight ahead at airspeed 3 and altitude 2.4 as shown on his dice. On turn 17, the MiG wingman dove out of the sun and achieved a near miss in a close range deflection attack, before making a steep climbing left turn to altitude 3.2. His dice also show his left bank and his narrow retention of airspeed 4. The MiG leader meanwhile weaved left for a medium range tail attack from altitude 3.1 with wings level and airspeed 3, and even better fire rolls allowed his heavy cannon to down the F-80, which should actually have been removed at once. On turn 19, the orphaned F-80 leader broke off the fight, giving the very lucky MiGs a major victory by 5.5 points to 0 including their reduced handicap of 0.5. The game was a fascinating contest of US pilot quality against the MiG 15s' much superior performance.



Figure 2: This picture shows the track sheet for my pair of experienced F-4E pilots after turn 25 of a 1972 duel over Vietnam with two MiG 19Bs. The small dice show which level from 3 to 8 the larger white dice represent. Both jets are at airspeed 3, and my leader has an odd 0.5 speed points (shown by the rotated counter) so is within an ace of airspeed 4. If you use other jet counters on the map, the Flight Leader counters may be used to track speed points while also showing that jet's ratings. The F-4s still have several turns of afterburner fuel, and have fired one HSM and a burst of cannon. I use markers from Speed of Heat to show haze, contrails and the jets' maximum speed (20 for the F-4s) and to track VPs from handicaps and near misses. The pilot-specific markers are from the Alpha 1A and Alpha 3A sets in Flight Leader itself. The green AI MiG pilot lost SA and was downed by my AI wingman's AIM-9E on turn 26.

INTRODUCTION

Jet Duel is a spin-off of my tactical WW2 air game Fighter Duel Deluxe, which uses components from Lee Brimmicombe-Wood's Wing Leader games from GMT. Jet Duel uses the data from Gary Morgan's classic 1986 Avalon Hill game *Flight Leader* (available in the game's Vassal module and BGG page or in the cheap digital download at https://gamers-garage.com). Jet Duel is dedicated to the memory of Gary and of developer Craig Taylor. It lets 2 or 4 jets per side from 1950 to 1991 engage in high-G manoeuvring daylight combat, using formation tactics which are not as restrictive as some historical systems like the USAF's 'fighting wing' doctrine. I have developed further my unique AI system from Fighter Duel, allowing any or all jets on either side to be placed under AI control. Google 'Philip Sabin YouTube' for my gameplay video of a complete Vietnam scenario illustrating rules mechanisms and tactics, with all jets but mine under AI control. The game uses a 6 and a 10 sided die (D6 and D10), with rolls of '0' counted as '10'.

THE PLAYING BOARD

Jet Duel is designed to be played on an expanded copy of Charles Kibler's beautiful map from *Flight Leader*, blown up to twice the height and width of the original to accommodate the large *Wing Leader* counters in *Fighter Duel* and the tracking dice used in *Jet Duel* to display the jets' altitude, airspeed and bank angle. Each scenario has 6 playable altitude levels, shown by a 7mm white die. Each level contains 4 altitude steps (1-4), shown by a 5mm white die. Use other 5mm dice on the track sheet to show the actual 6 levels (from 0 to 11) represented by each 7mm die. Step 4 at level 8 is termed altitude 8.4, and is 1 step below altitude 9.1. Each hex and altitude step represent 250 metres, so the board represents a volume of airspace around 13 km long, 9 km wide and 6 km high. You may use a blank hexgrid of roughly the same size, and this works well for combats over the sea or a low cloud deck as illustrated on the cover.

COUNTERS & MARKERS

Each side has 2 or 4 jets of a single type, shown by the appropriate Flight Leader counters or by alternative numbered counters as shown in the Figures. Leader XX1 has wingman XX3, and leader XX2 (if present) has wingman XX4. (The leader's wingman should actually be XX2, but the change allows better modelling of seniority and flight tactics.) Each jet occupies a specific hex and faces one of the 6 corners, with 2 front hexes. A coloured 7mm die shows airspeeds of 2, 3 or 4 hexes per turn, representing 530 kph (330 mph), 795 kph (495 mph) and 1,060 kph (660 mph) respectively. As shown in Figure 1, the tracking dice are placed behind or to the left or right of the counter to show wings level or a right or left bank. Each flight needs a track sheet as provided on p.16 below. Markers from Flight Leader show if pilots are veteran, experienced or green and track pitch attitude, remaining gun, HSM and RHM ammo and remaining turns of afterburner. The speed markers (or the Flight Leader jet counters if available) show detailed speed points, and rotating them shows an extra 0.5 speed points, equivalent in energy to 50 metres of height. You may also use markers from other games or make your own markers if desired.

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JET & MISSILE DATA

Jet Duel uses the ratings on the *Flight Leader* counters, supplemented by the maximum speed and altitude figures, variant information and missile data on pp.20-26 of the *Flight Leader* Pilot's Manual. Issue 23/1 of *The General* has ratings for a few extra jets. *Jet Duel* uses only guns, HN, HW or HA HSMs, RR or RA RHMs and countermeasures. Jets with no internal guns may or may not be designated as having external cannon. All of each side's jets must be of the same sub-type and equipped identically. F-15s and Su 27s change their turn type to 'A', and Javelins to 'D'. A-5s, A-6s, Meteors, Scimitars, Buccaneers, Tu 28s and Yak 25s and 28s suffer the slow roll rate penalty. Only AA-8, Matra Magic 1, Red Top, Sidewinder D, G or J and Shafrir 2 HSMs count as HW rather than HN missiles.

INITIAL SET-UP

You must first decide the number, type and equipment of each side's jets and the skill of each pilot. 2 jets may fight 4. No jet may have a better pilot than a friendly jet with a lower ID. Asymmetries may be balanced by handicap awards in increments of 0.5. The default handicap is half the difference in flight value, counting veteran pilots as 3, experienced pilots as 2 and green pilots as 1. You may adjust the handicap to take account of situational or technical asymmetries (perhaps by bidding for sides), but it should end at least 1 below the number of that flight's jets. You may create a bespoke scenario for any tactical situation, or generate a random set-up in which the opposing jets spot the enemy 4 km away or approach to this range to identify contacts spotted earlier due to radar or contrails.

Choose first between low, medium or high altitude – levels 0-5, 3-8 or 6-11. Low altitude over hills uses levels 1-6 instead. Combats may be over the open sea, and those at medium or high altitude may be over mountains and/or a low cloud deck. Radar is handicapped at low altitude if its rating plus the target's height in *playable* steps totals 7 or less, counting each step as 2 if over hills or the sea. Put the XX1 leaders 16 hexes apart along the board's long axis, approaching head-on at the lowest playable level. Raise them 1 level each if they lack afterburners or high acceleration. Give them 1 step, and raise them as many steps as the lowest playable level, plus 1 for every full 2 points by which their maximum speed falls below 20, plus 1 for every level by which their maximum altitude exceeds that of the enemy. On a D6 roll of 3-6 in damp climates or 5-6 in dry climates, levels 0 and 1 contain haze or patchy cloud and jets at levels 8-10 leave tell-tale contrails.

Now roll a D6 for each XX1 jet. If the enemy is contrailing or the jet has unhandicapped radar or a countermeasures rating above 0 if the enemy has radar, put XX3 (or XX2 if present) 1 hex for every full 2 points of maximum speed to XX1's left on 1, its left and left rear alternately on 2, its left rear on 3, its right rear on 4, its right and right rear alternately on 5 or its right on 6. Otherwise, rotate XX1 60 degrees left on 1-2 or right on 5-6, and then put XX3 (or XX2 if present) 1 hex each to its left and left rear on an odd roll or its right and right rear on an even roll. Put any other jets 2 hexes outside their leaders as in Figure 4. All of each side's jets start with wings level, the same heading and altitude, and their speed point markers in the box matching the jets' maximum speed. They have 6 MG or 3 cannon bursts, and as many turns of afterburner fuel as their maximum speed. Roll a D6 to see in which of the 6 jet headings the sun is shining. If directly ahead of either flight, it is behind high cloud or too high to affect play.



Figure 3: Flight Leader squeezes a mass of data onto the counters themselves, as shown by this comparison between the small subsonic Vampire F.1 from 1946 and the large Mach 2 Tornado F.3 from 1985 whose afterburners and high acceleration give it many times the rate of climb. Page 23 of the Pilot's Manual shows the jets' respective maximum speeds as 7 and 20, while their maximum altitudes are 14 and 17. The Vampire's cannon have poorer sights, while the Tornado also carries 4 RA and 2 HA missiles as well as a potent radar and countermeasures suite. It can turn as well as the earlier jet thanks to its swing wing, albeit with much higher drag due to its heavier wing loading. Even the Vampire's bubble canopy is matched by the ability of the Tornado's second crewman to spot enemies in the rear quarter.

You may make your own tweaks to the *Flight Leader* aircraft and missile ratings if desired, in line with sources such as Marshall Michel's *Clashes*. Sparrows before the E-2 should probably count as RR missiles due to their protracted launch procedure.



Figure 4: In this random set-up, 4 MiG 17Cs meet 4 F-4Cs at levels 3-8 over the mountains of 'Thud Ridge', with contrailing at level 8 on a roll of 4. Jets 821 and 141 begin facing each other in hexes V18 and LL18, with wings level and at airspeeds 3 and 4 in line with each jet's maximum speed. The MiG is raised 2 levels and 8 steps (3+5+0) to altitude 7.1 (shown by 5 on the larger white die) while the F-4 is raised 1 level and 5 steps (3+0+2) to altitude 5.2. On a D6 roll of 5, the lead MiG rotates right and MiG 822 is placed on its left in hex W17. MiG wingmen 823 and 824 are placed in hexes T18 and X15 as shown. The F-4s have radar, so on a D6 roll of 3, F-4 142 is placed in a trail position 10 hexes to the left rear of 141 in hex VV23. F-4 wingmen 143 and 144 are placed 2 hexes outside their leaders in hexes MM17 and WW25. The sun is found to be shining from behind the F-4s (so from the MiGs' front left).



Figure 5: The Sea Vixen is one of the extra jets provided in *The General* 23/1. I added ID numbers to the scanned *Flight Leader* counter, and printed it along with the new counters which I have created for several jets using paint schemes found online. My alternative board showing the sea or a low cloud deck uses two maps from Mario Jugel's *Admirals Order: All Hands!*, for which I have designed another total conversion called *Battle Sail*.

The game shown takes place at levels 0-5, so the larger white dice show one more than the actual level. Both Sea Vixens are at airspeed 3. The veteran leader starts at altitude 4.1 and opts to make a shallow dive 1 step to altitude 3.4. He chooses to fly left in his first hex but right in his second and third. This prevents him continuing to attempt a left turn as he did last turn (as shown by his left bank), but the pilot now wishes to reverse his bank and turn right. Now that he is at level 3, the D10 score needed for jets with airspeed 3 and turn type B is only 1 or more. His veteran status adds 1 to his roll, but this is offset by the -1 penalty for not flying entirely to the right, and there is also a severe -3 penalty for rolling all the way from the opposite bank. Despite this, the leader decides to risk turning gently to reduce drag, and the associated -2 penalty takes his net modifier to -5. He rolls a 4, so his gamble fails as his modified score falls to -1 and he remains in his original heading. However, he ends in a right bank regardless, so turning right next turn will be much easier.

The experienced wingman starts at altitude 3.3, and he opts to make a steep climb 2 steps to altitude 4.1. He moves his manoeuvre marker to show the steep climb, which will prevent him diving steeply next turn. The climb also cuts his forward flight to 2 hexes, and he opts to move 1 hex left and 1 hex right. This would normally rule out a turn attempt in either direction, but steep climbs are the exception and he may try to turn either left or right if desired. He opts to attempt a right turn like his leader. This time the altitude change works against him since the roll needed at level 4 rises to 2, and the -1 penalties for starting with wings level and not flying entirely to the right mean his actual D10 roll needs to be 4 or more. He decides not to make things even harder by turning gently, and he is vindicated when his roll of 5 narrowly allows him to turn through 60 degrees. Like his leader he ends in a right bank, as shown by the position of his tracking dice.

SEQUENCE OF PLAY

In each turn (representing 3.4 seconds), jets activate sequentially in ID order (so Red jets go last). Each activated pilot checks his situational awareness and missile parameters, then adjusts his pitch and altitude, then flies forward, then adjusts his bank attitude and dices to change heading, then adjusts his throttle and speed points, and finally fires his guns or launches a missile if eligible. Missiles fly at the end of the launch jet's next activation, allowing their targets to react first.

FLIGHT

A pilot may maintain altitude or make a shallow or steep dive or climb. Shallow climbs gain 1 step. Steep climbs gain 2 steps and are banned at airspeed 2. Shallow dives lose 1 or 2 steps at airspeed 4, otherwise 1 step. Steep dives lose 3 steps at airspeed 4, otherwise 2 steps. Adjust the white dice to show the new step, as well as the new level if steps rise above 4 or fall below 1. Use the new altitude from now on, and shift the jet's manoeuvre marker to record steep dives or climbs. The opposite steep manoeuvre is prohibited next turn. After changing altitude, the jet flies 2-4 hexes forward as per its airspeed die, unless in a steep climb or dive at airspeed 3 or 4 in which case it flies 1 hex less. In each hex, the jet may fly left or right. Jets which leave the board edge or dive or climb beyond the playable altitude levels (prohibited at level 0) fly off the board and may not return.

After flying forward, a pilot may roll a D10 to turn 60 degrees right or left as long as he entered more hexes to that side, or the same number if climbing steeply. He needs an unmodified 10 or a modified score at least equal to that shown before the slash on the table below. Veteran pilots add 1 to their roll, as do jets climbing steeply at airspeed 4. Jets which entered any hexes to the other side deduct 1. Before dicing, pilots may opt to deduct 2 by turning gently. They *must* do so before firing guns, or at level 11 due to high stall speeds. Jets also deduct 1 if they start with wings level, or 3 if in the opposite bank. These penalties rise to 2 and 6 for slow rolling jets. Jets end their move banked in the direction in which they try to turn, even if they fail. Jets which do not try to turn will stay in or return to a wings level attitude.

Air	Turn		Altitude Level 0-1 2-3 4-5 6-7 8-9 10-1 /-3.0 2/-3.0 3/-2.5 4/-2.5 5/-2.0 6/-2 /-3.0 3/-3.0 4/-2.5 5/-2.5 6/-2.0 7/-2 /-3.5 4/-3.5 5/-3.0 6/-3.0 7/-2.5 8/-2 /-3.5 5/-3.5 6/-3.0 7/-3.0 8/-2.5 9/-2 /-3.5 5/-3.5 6/-3.0 7/-3.0 8/-2.5 9/-2 /-3.5 5/-3.5 6/-3.0 7/-3.0 8/-2.5 9/-2 /-3.5 5/-3.5 1/-3.5 2/-3.5 3/-3.0 4/-3											
Speed	Туре	0-1	2-3	4-5	6-7	8-9	10-11							
	Α	1/-3.0	2/-3.0	3/-2.5	4/-2.5	5/-2.0	6/-2.0							
2	В	2/-3.0	3/-3.0	4/-2.5	5/-2.5	6/-2.0	7/-2.0							
	D	3/-3.5	4/-3.5	5/-3.0	6/-3.0	7/-2.5	8/-2.5							
	E	4/-3.5	5/-3.5	6/-3.0	7/-3.0	8/-2.5	9/-2.5							
	F	5/-3.5	6/-3.5	7/-3.0	8/-3.0	9/-2.5	9/-2.5							
	Α	1/-3.5	1/-3.5	1/-3.5	2/-3.5	3/-3.0	4/-3.0							
	В	1/-4.0	1/-4.0	2/-3.5	3/-3.5	4/-3.0	5/-3.0							
3	D	1/-4.5	2/-4.5	3/-4.0	4/-4.0	5/-3.5	6/-3.5							
	E	2/-4.5	3/-4.5	4/-4.0	5/-4.0	6/-3.5	7/-3.5							
	F	3/-4.5	4/-4.5	5/-4.0	6/-4.0	7/-3.5	8/-3.5							
	Α	3/-3.0	3/-3.0	3/-3.0	3/-3.5	3/-3.5	3/-3.5							
	В	3/-3.5	3/-3.5	3/-3.5	3/-4.0	3/-4.0	3/-4.0							
4	D	3/-4.0	3/-4.0	3/-4.0	3/-4.5	3/-4.5	4/-4.5							
	E	3/-4.5	3/-4.5	3/-4.5	3/-5.0	4/-4.5	5/-4.5							
	F	3/-5.0	3/-5.0	3/-5.0	4/-5.0	5/-4.5	6/-4.5							

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ENERGY AND AIRSPEED

After changing bank angle and heading, the active pilot records net speed point changes on the track, and rotates his airspeed die if the marker enters a different airspeed zone. Each speed point represents kinetic energy equivalent to 100 metres of altitude, allowing smooth trading of speed for height. Net losses or gains of 0.5 speed points are shown by rotating the marker or turning it back upright, while shifting it to an adjacent box if need be. Net gains beyond the top end of the track are lost, and jets may not attempt moves which would drive net speed points below the bottom of the track.

Jets gain 2.5 speed points for each step dived, and lose 2.5 speed points for each step climbed. Jets which turn successfully lose the speed points shown after the slash in the table on p.4. Increase this loss by 1 or 2 or double it if the jet's maximum speed is 10-12, 13-16 or 17-20 respectively. Turning gently reduces the loss, but climbing or diving steeply has its own speed point cost unless the jet turned successfully this turn or climbed or dived steeply last turn. Speed point changes in either case are 1, 1.5 or 2 for jets with maximum speeds of 7-9, 10-16 and 17-20 respectively. Turning negates the pitch change cost so as to encourage vertical turns (especially climbing turns where the jet need not roll inverted).

Jets gain or lose speed points due to thrust and drag as shown on the table below. By using 1 turn of fuel, a pilot may use afterburner to gain extra speed points equal to those gained at airspeed 2 at his altitude, or he may opt instead to lose up to 6 speed points by throttling back and deploying airbrakes. These choices come last, so as to smooth airspeed swings caused by turn success or failure.

Max	Air		Altitude Level 0-1 2-3 4-5 6-7 8-9 10-1 +1.0 +1.0 +0.5 +0.5 +0.5 +0.5 +0.5 0 0 0 0 0													
Spd	Spd	0-1	2-3	4-5	6-7	8-9	10-11									
	2	+1.0	+1.0	+0.5	+0.5	+0.5	+0.5									
7	3	+0.5	0	0	0	0	0									
	4	0	-0.5	-0.5	-0.5	-0.5	-0.5									
	2	+1.0	+1.0	+1.0	+0.5	+0.5	+0.5									
8	3	+1.0	+0.5	+0.5	+0.5	0	0									
	4	0	0	0	0	-0.5	-0.5									
	2	+1.5	+1.5	+1.0	+1.0	+0.5	+0.5									
9	3	+1.0	+1.0	+1.0	+0.5	+0.5	+0.5									
	4	0	0	0	0	0	0									
	2	+2.0	+1.5	+1.5	+1.0	+1.0	+1.0									
10-12	3	+2.0	+1.5	+1.0	+1.0	+1.0	+0.5									
	4	0	0	0	0	0	+0.5									
	2	+2.5	+2.0	+1.5	+1.5	+1.0	+1.0									
13-16	3	+2.5	+2.0	+1.5	+1.0	+1.0	+1.0									
	4	0	0	0	0	+0.5	+0.5									
17-20	2	+3.0	+2.5	+2.0	+1.5	+1.5	+1.0									
Nrml	3	+3.0	+2.5	+2.0	+1.5	+1.0	+1.0									
Accel	4	0	0	0	+0.5	+0.5	+0.5									
17-20	2	+3.5	+3.0	+2.5	+2.0	+1.5	+1.5									
High	3	+3.5	+3.0	+2.5	+2.0	+1.5	+1.5									
Accel	4	+0.5	+0.5	+0.5	+1.0	+1.0	+1.0									



Figure 6: In this game at levels 1-6, the F-5A leader with airspeed 4 at altitude 3.4 climbs 1 step and completes a gentle left turn. The listed drag cost for the turn falls to 3.5 now the jet is at level 4. This cost is increased by 2 since the F-5A's maximum speed is 13, but it falls by 1.5 because the turn was gentle. The jet also loses 2.5 speed points for the climb, while gaining none for engine thrust since it is already at its maximum speed in military power. The pilot opts to use one of his 13 turns of afterburner, but this adds just 1.5 speed points at level 4, so there is still a net loss of 5 speed points. This drops the marker into the airspeed 3 zone, so the jet ends at airspeed 3.

The F-5A wingman with airspeed 3 at altitude 4.2 enters a steep dive but fails to turn left. He gains 5 speed points for the dive plus 2 for engine thrust at level 3 and airspeed 3. Failing to turn means he loses 1.5 speed points for the pitch change, and he opts to lose a further 1.5 points by throttling back so as to limit his net gain to 4 and avoid accelerating into the airspeed 4 zone.



Figure 7: In this game at levels 0-5, the Israeli Mirage IIIC at altitude 0.1 is flying just above the desert. Its airspeed is 3, so it could normally fly 2 hexes only by climbing steeply, and even if it turned left in hex VV26 it could not then fire down on the MiG 21 ahead. The veteran pilot instead uses the special provision on p.6 to stop one hex short if stacking with an enemy jet. His left turn succeeds, allowing him to make a close range deflection shot on the MiG. However, there is a heavy price in energy, since even by turning gently to allow cannon fire he loses 6 points (4x2 -2) for the turn due to his maximum speed of 19, in addition to the 2.5 points for the 1 step climb. The 3 point gain from engine thrust is entirely offset by the mandatory 3 point loss by throttling back when stopping short, so the net loss of 8.5 speed points drops him squarely to airspeed 2. The extra counters are from J.D.Webster's *Air Superiority*.

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Figure 8: Each jet has 6 quadrants as shown, in addition to its own hex. The frontal arc and front quarters together form the forward hemisphere, while everything else is the rear hemisphere. Pilots have a visual arc covering their frontal arc and front quarters, as well as their rear quarters if they have a bubble canopy or (except for the Sea Vixen) a second crewman. The airframe blocks the view from banked jets into the front and rear quarters on the side away from the bank, and the view from wings level jets to certain lower jets depending on range, angle and pitch attitude. The six starred hexes form the jet's gun fire zone.



Figure 9: In this game at levels 1-6 over Vietnam, the experienced A-7E wingman with wings level at altitude 2.3 and airspeed 4 begins by rolling 2 for his SA. This falls to 1 because his leader is outside his forward hemisphere, so everything depends on whether he also suffers the penalty for having no enemies in sight. The MiG 21 leader is just outside the pilot's visual arc, since he lacks a bubble canopy or second crewman. The MiG wingman at altitude 1.4 is in cloud, but he is still within the reduced visual range of 6, since the 3 steps count as just 3 hexes rather than 6. However, since the A-7 did not bank or dive steeply, the MiG is 1 step too low to be seen above the pilot's instrument panel or on his radar (still effective at this height over hills).

The pilot would retain SA if his radar warning receiver (RWR) displayed the MiG wingman's radar spike (regardless of the radar's effectiveness). However, since the MiG did not climb steeply, it is 1 step too low for its radar arc to connect. The A-7 pilot therefore loses SA with a modified D10 roll of 0, and flies straight and level as shown as he tries to get his bearings, with no speed point gain since he is already at his maximum speed. He is a sitting duck for a close range zero deflection cannon attack by the lead MiG, with a fearsome modifier of +3.

STACKING

Jets may not end their flight in the same hex and at the same altitude (level and step) as a friendly jet with a lower ID, or an enemy jet which has been fired on by guns or had a friendly missile tally or lockon marker this turn. As shown in Figure 7, a pilot may end his flight 1 hex early if he ends in the same hex and at the same altitude as an enemy jet, as long as he still flies 2 or 3 hexes, does not use afterburner, and loses at least 3 speed points by throttling back. Altitude changes or turn attempts proceed as normal.

SITUATIONAL AWARENESS

Each pilot has a visual arc as in Figure 8, depending on his bank attitude and whether he has a bubble canopy or second crewman. Pilots with wings level cannot see lower jets in their rear quarter or if the pilot climbed steeply, or if the step difference exceeds half the range in hexes (rounding halves up) and the pilot did not dive steeply. Jets with radar have a radar arc covering their frontal arc at step differences up to half the range in hexes (rounding halves up). This step limit increases to the full range in hexes for steeply climbing or diving jets, but their radars cannot see lower or higher jets respectively.

Each activated pilot rolls a D10 for situational awareness (SA). Veterans add 1, while green pilots deduct 1. Wingmen deduct 1 if their pair leader is not within 12 hexes (18 if a large jet) and in both their visual arc and forward hemisphere. All pilots deduct 1 if no enemy jets are within 12 hexes (18 if large) in their visual arc, unless they were just fired on by guns or attacked by a missile or have a countermeasures rating above 0 if in the radar arc of an enemy jet (except MiG 29s or Su 27s with IRST unless they have green pilots or launched or guided an RHM). Halve the range limits if one or both jets are in cloud or haze, but ignore them against *enemy* jets which launched a missile or are contrailing or are in the pilot's unhandicapped radar arc. Ignore 1 step difference per full 2 hexes of range, unless the other jet is higher in the 60 degree up-sun arc or lower and not silhouetted against a low cloud deck. Each other step counts as 2 hexes (or 1 hex if either jet is in cloud or haze).

If the modified SA roll is 0 or less, the pilot levels his wings and flies left and right alternately for as many hexes as his airspeed. He maintains altitude unless this leads him to stack with another jet, in which case he dives 1 step (or enters the other final hex if need be). Speed changes work as normal, without throttling back or using afterburner. The pilot may not fire guns or launch or guide missiles during his activation, and treats his countermeasures rating as 0 against a launched HSM due to not being warned by a radar lock.

GUNFIRE

As shown in Figure 8, each gun-armed jet has a fire zone covering its own hex and 5 hexes in its frontal arc at the same altitude, plus the 5 frontal arc hexes 1 step higher unless the jet dived and 1 step lower unless the jet climbed. If a pilot ends his activation with an enemy jet in his fire zone, he may choose to fire unless the enemy's heading differs by 120 or 180 degrees. (Head-on or front quarter gun attacks are too fleeting to be worth modelling at jet speeds.) Pilots may not fire if they launched a missile this *or last* turn, or if they attempted a non-gentle turn, or if the enemy jet has been fired on by guns or had a friendly tally or lockon marker this turn, or if a friendly jet with a lower ID is in the target's hex at the same altitude. If there are 2 or more eligible targets, the one closer in hexes will be engaged, or the firer's choice if equidistant. The firing jet expends 1 burst of gun ammo, and may not fire again once out of ammo. Roll a D10 and apply the following modifiers.

+1 if the target is in the same hex
+1 if the target is in the same heading
+1 if the firer has a veteran pilot
+1 if the target just fired guns or launched or guided a missile
+1 if the firer dived and is facing directly down-sun
+1 if one or both of the target's 2 front hexes are in the firer's fire zone
-1 if the firer has a green pilot
-1 if the firing jet has a gunnery penalty or external cannon
-1 if the target has a veteran pilot
-1 if the target has a better turn type and/or a higher airspeed in hexes
-1 if the firer made a successful gentle turn
-1 if the firer was just fired on by guns or attacked by a missile
-1 if the firer climbed and is facing directly up-sun
On a modified 8 or 9, a near miss stops the target firing gups or launching

On a modified 8 or 9, a near miss stops the target firing guns or launching or guiding missiles when next activated. If the unmodified roll was 10, it is damaged and removed instead on a D6 roll of 5-6 or 3-6 respectively. If the modified roll is 10 or more, the target is removed and considered downed on a D6 roll of 3-6 (5-6 with machine guns) or damaged if less.

MISSILES

To launch a missile, a pilot must level his wings this turn and start and end with the target within 12 hexes in his radar or equivalent arc, to confirm its identity and achieve a missile lock. Cut the limit by 2 if one or both jets are in cloud or haze, and also if the jet lacks radar or its radar is handicapped or is rated 1-3 with no second crewman. The initial arc uses the previous turn's pitch attitude. The pilot must end in the target's rear hemisphere to launch an RR missile, or in its rear arc to launch an HN or HW missile. If either jet is in cloud or haze, the pilot must end within 6 hexes for HA or 4 hexes for HN or HW missiles. If not, he must end no more than 4 hexes further away than his altitude level to launch HN or HW missiles due to their limited range. Step differences do not reduce these ranges. Pilots may choose whether and what type of missile to launch at which target, except that launches are banned if the jet ends its activation with a friendly jet within 14 hexes in its radar/HSM arc, and that HSMs must select the eligible target which ends closer in hexes. A target fired on by guns or with a missile launched against it this turn may not be engaged, but still blocks HSM launches on more distant targets.

When a missile is launched, put a missile counter under the jet, put that pilot's tally (HSM) or lockon (RHM) marker next to the target, and move the ammo marker down 1 (or 2 if opting for a paired RHM launch). Any launch by the jet next turn must use the same missile type, and have the same target if RHMs. After any follow-on launch, the original attack is resolved based on the new position and altitude of the target jet relative to the missile counter. This counter has no heading, and stays in the hex and at the altitude where the launch jet ended its previous activation (even if the jet has since been removed). It is removed (or shifted to show a follow-on launch) once its attack is resolved. The attack fails if the target jet is no longer on the board or is closer than the missile's minimum range (4 hexes for HW or HA missiles, 5 hexes for others). RHMs also miss if the launching pilot has lost SA or opts not to guide the missile, or if the target is outside his radar arc at the end of his activation (he may manoeuvre freely). Otherwise, roll a D10 and apply the modifiers on p.8.



Figure 10: In this high altitude contest over Korea, a green MiG 15 wingman at altitude 10.3 faces a veteran F-86A leader 2 steps above, with both jets at airspeed 4 to maximise their turn rate in the thin air. The F-86 is just above the contrail belt and the sun makes the range from the MiG 13 hexes (9+4), but the green pilot retains SA regardless. He dives to increase the altitude separation to 4 steps and tries to turn into the threat, but on a roll of 2 he fails. Next turn, the Sabre pilot seizes his chance and dives steeply down 3 hexes and steps while trying to reduce the deflection angle enough to attack. Although now below level 11, he still needs to turn gently if he is to fire, but his D10 roll of 6 is just enough to offset the adverse modifiers.

The F-86 receives penalties for having turned and for the MiG having a better turn type, but bonuses for its veteran pilot and for having one of the MiG's front hexes in its fire zone. (Although the Sabre is still in the MiG's up-sun arc, there is no sun bonus since it is no longer facing directly down-sun.) A roll of 10 will win the game by damaging or downing the MiG, but the actual roll of 8 yields only a near miss worth 0.5 VPs.



Figure 11: My third playtest of Jet Duel turned into an epic contest which showed the continuing utility of cannon even alongside the improved missiles of the 1980s. I pitted two F-16Cs against two MiG 29s at medium altitude, and the prolonged dogfight saw no fewer than 9 missile launches, with countermeasures, rapid defensive manoeuvres by the agile jets and poor die rolls by the F-16s limiting the results to 3 near misses. Repeated hard turns depleted fuel reserves and dragged the jets down to level 3. Finally on turn 33, the veteran F-16 leader gambled on breaking away from the MiG lead with whom he had been scissoring, so as to launch an all aspect Sidewinder at the MiG wingman circling in pursuit of his own wingman. The lead MiG seized the fleeting chance of a cannon shot with a net +1 modifier on his distracted opponent, and a lucky roll of 10 followed by 4 on the D6 downed the veteran pilot. His Sidewinder flew on regardless and downed the MiG wingman, but the MiGs still won by 10 points to 5 including their handicap of 1. (Using the mock combat rules on p.13, they would have lost on turn 9 by 5.6 points to 1.4.)



Figure 12: In this 1972 game at levels 1-6 over Vietnam, 2 experienced F-4E pilots are flying at altitude 3.1 and airspeed 3, with the wingman 15 hexes behind his leader. An experienced MiG 19B pilot at airspeed 3 has the lead F-4 in his radar arc and makes a shallow climb in lag pursuit to a position 2 steps below and 3 hexes behind the F-4 in its rear arc, thereby fulfilling the conditions to launch an Atoll HN missile. His green wingman flies a parallel course and starts and ends within the range limits of 10 (12-2) and 6 (4+2) hexes, but he cannot launch since his leader is in his radar arc and has just launched against this target anyway.

Next turn, the F-4 leader cannot quite stay within the Atoll's minimum range by climbing or diving steeply. He dives 1 step to avoid using afterburner, but his attempted right turn fails on a roll of 2. The F-4 wingman has both MiGs within 12 hexes in his radar arc, and he dives steeply forward 2 hexes to their altitude of 2.3 before launching two Sparrow E-2 RA missiles at the lead MiG. (The lead F-4 is 16 hexes away and also above his new radar arc.)



Figure 13: The lead MiG pilot breaks off his pursuit and makes a steep diving left turn to evade the Sparrows. His Atoll has -1 for unreliability but +1 for being in the lead F-4's rear arc and +1 for its relative height total of 4 (2+2). On a lucky roll of 9 followed by a D6 roll of 2, the F-4 is damaged and removed from play. The green MiG pilot loses SA since the other F-4 is not in view.

Next turn, the F-4 wingman cannot switch RHM targets, so he continues his steep dive to the MiG lead's altitude of 2.1 and launches his last two Sparrows while guiding his first pair. These have penalties for unreliability and the front quarter aspect, but bonuses for the second crewman and the MiG's lack of countermeasures. The steep dive negates the bonus for the relative height total of 2, but a shallow dive would have cut the total to 0 (2-2). With a net modifier of 0 a roll of 3 misses, but the game continues despite the remaining F-4's loss of combat effectiveness, since its other missiles are still in flight.

ALL MISSILES
+1 if in the target's rear arc
+1 if the launch jet has a veteran pilot
+1 if the target is at airspeed 2
+1 if the target just fired guns or launched or guided a missile
+1 if the target has a countermeasures rating of 0 and/or a green pilot
-1 before 1975 due to immature missile technology
-1 if the target has a veteran pilot
-1 if the launch jet has a green pilot
-1 if the target has a countermeasures rating of 6 or more
-1 if in the target's front quarter
RADAR HOMING MISSILES ONLY
+2 if the launch jet's radar rating is 7 or more
+1 if the launch jet's radar rating is 6
+1 if the launch jet has 2 crew and a radar rating of 5 or less
+1 if the launch jet is not diving steeply and the target's level +2 for
each step it is above the jet and -2 for each step it is below comes to at
least 1 over the sea, 3 over mountains or 2 otherwise
-1 if only 1 missile was launched, unless it is a Sparrow F or M
-1 if the launch jet's radar rating is 4
-2 if the launch jet's radar rating is 3 or less
HEAT SEEKING MISSILES ONLY
+1 if the target just used afterburner
+1 for a Sidewinder G, L or M or Shafrir (Python) 2 or 3, due to their
proven lethality

+1 If the target's level +2/-2 for each step it is above/below the missile comes to at least 1 over the sea with no low cloud deck or 2 otherwise, unless the missile is in cloud or haze or the target is in its up-sun arc

Missiles have the same effects as cannon, based on the modified D10 roll. Even attacks which fail without rolling affect the target's gunfire and SA.

VICTORY

Near misses give points due to pilot shock and minor damage. To balance variations of fortune, all near miss points accumulated so far by a flight are lost as soon as the flight damages or downs an enemy jet. A flight loses combat effectiveness if any of its jets are downed or if its XX1 leader or half of its other jets are damaged and/or fly off the board. Play ends after 40 turns or when a flight has lost combat effectiveness at the start of its activations and ends them with no jets of either side still on the board and targeted by a missile. Each flight gains the victory points below - the bigger the difference in scores, the clearer the game victory.

1 for each near miss on an enemy jet (falling to 0.5 if firing machine guns and/or engaging a green pilot)

1 for each undamaged enemy jet which has lost combat effectiveness or flown off the board

1 for each damaged enemy jet with a green pilot

2 for each damaged enemy jet with an experienced pilot

2 for each downed enemy jet with a green pilot

4 for each damaged enemy jet with a veteran pilot

4 for each downed enemy jet with an experienced pilot

8 for each downed enemy jet with a veteran pilot

Any handicap bonus awarded to that side

SOLITAIRE VARIANT

Jet Duel already plays well solo, but the following AI system (developed from that in *Fighter Duel*) automates the choices of any or all pilots on one or both sides. You may now control a flight against AI adversaries, or pilot just one jet in a dogfight (my own favourite form of solo play). Two players may fly co-operatively instead of head to head. AI tactics are far less subtle and coordinated than those of human players, but still present a stiff challenge. All normal rules apply unless modified below, with contests ending and victory being determined as in the standard game.

INITIAL SET-UP

Set up 2 or 4 jets per side as in the main game, and decide board altitude, pilot skill and which pilots will be AI (all green pilots should be AI). Jet deployment, sun direction, cloud and the default handicap are determined as normal, but with non-AI pilots worth 3 if experienced and 5 if veteran to balance their greater tactical acumen. You may vary the two sides' initial deployment as usual to set up any bespoke combat situation. If one side has only AI pilots, it should have a handicap of between half the number of opposing non-AI pilots and the full number of its own pilots.

SEQUENCE OF PLAY

Jets activate in the usual order. To offset their natural advantage in tactical decisions, non-AI pilots suffer an extra -1 SA penalty, while AI wingmen of an AI leader ignore the SA penalty for the leader not being in front. AI pilots who retain SA decide their moves in a 4 stage sequence based on nested lists of priorities. Higher priorities take precedence if there is a clash, but lower priorities should also be satisfied if possible. Some priorities apply only if the opponent is a missile or a jet. If there is still a choice once all priorities have been considered, dice randomly for which option to use. Unlike for SA, distances ignore step differences unless stated. AI pilots ignore enemy ammo depletion but not their own.

OPPONENT SELECTION

An AI pilot who retains SA first selects which enemy will shape his choices, using the following Opponent Priorities (OPs). He bases further choices just on the selected opponent, though he may stack with, fire at or launch or guide missiles at another jet if his move happens to permit this.

1	A launched missile targeted on the AI pilot
2	An opposing jet at which the AI pilot just launched an RHM
3	A gun-armed opponent within 3 hexes and 3 steps of a front hex of the AI jet, in a heading differing by 0 or 60 degrees (in which case the front hex must be in its forward hemisphere) or 120 degrees (in which case the front hex must be in its frontal arc)
4	An opposing jet in the AI pilot's frontal arc which he will engage with guns (assuming any turn attempt succeeds) or launch a missile at if selected
5	A missile-armed opponent with the AI jet in its frontal arc, if it is within 10 hexes and in the AI pilot's rear hemisphere
6	An opposing jet whose total separation in hexes and steps is smaller by at least half the AI pilot's unmodified SA die roll

7 An opposing jet whose heading differs least from the AI jet



Figure 14: In this 1965 game at levels 1-6, 2 Pakistani F-86Fs carrying AIM-9B HN missiles confront 2 Indian Hunters armed only with cannon. All the jets are AI-controlled except the lead Sabre, with which I make a successful diving turn towards the lead Hunter, without firing since the closing speed at this angle is too great.

My wingman retains SA on a roll of 4 and selects the lead Hunter as his opponent since its heading differs by 60 degrees and it has his right front hex 3 hexes and 3 steps away in its forward hemisphere as per OP3. As per AP6 and AP7, he dives 1 step due to his airspeed of 2, and as per OP2 he flies 2 hexes right to stay as close as possible to his opponent. He makes a successful right turn as per HP4, but still regains airspeed 3.

The lead Hunter retains SA on a roll of 5. Despite my proximity, he does not focus on my own jet under OP3 since my heading differs by 120 degrees and his front hexes are not in my frontal arc. My missiles do earn me priority under OP5, but this is trumped by OP4 since my wingman is in the Indian leader's frontal arc and vulnerable to a gun attack if the Hunter turns successfully. AP4 is negated since the range is only 3 hexes, so the Hunter makes a steep climb 2 steps to match my wingman's altitude as per AP5, and uses his reduced 2 hex move to fly adjacent as per FP2. He tries to turn for a deflection shot as per HP3 and HP4, but to my relief the penalties for banking and turning gently mean he fails to do so.

The Indian wingman retains SA on a roll of 7. OP3 does not apply since our headings differ by 180 degrees. I am only 4 hexes and 1 step away while my wingman is 5 hexes and 3 steps away, but the total difference is still less than half the SA roll, so OP6 is also negated, as is OP7 since our headings both differ by the same amount. The pilot therefore chooses his opponent randomly, selecting me after all (which is a shame since I might have been able to attack him had he chosen my wingman instead). He climbs to my altitude as per AP5, and since my position in his frontal arc negates FP6, he flies 2 hexes left as per FP7 and FP5 before closing 1 hex right as per FP2. He does not try to turn left, to avoid breaking HP2.



Figure 15: In this 1982 Falklands game at levels 3-8 over a low cloud deck, I control 2 Sea Harrier FRS.1s with veteran and experienced pilots, while the Argentinians have 1 experienced and 3 green Dagger pilots, all run by the AI. The Daggers are ex-IAF Neshers, each with two Shafrir 2 HW missiles. However, their countermeasures have been removed and they have no spare fuel so far from the mainland, so I raise their handicap from 1.5 (8-5 halved) to 3. My leader has just launched an AIM-9L against Dagger 622, and all 3 other enemy pilots select my veteran's jet as their opponent this turn.

Dagger 621 is at airspeed 4, so since my leader is behind him he climbs steeply as per AP3. He flies right since it takes him further from my lead's frontal arc as per FP4. He makes a successful right turn as per HP4 (helped by the +1 bonus), but he cannot use burner and the speed loss drops him to airspeed 3.

Dagger 622 focuses on my missile as per OP1, and makes a shallow dive as per AP2. He flies right at first, since this puts him 11 rather than 10 hexes from his flight leader's new position as per FP7. He continues right as per FP5, but he would normally weave left in his final hex to close with his opponent as per FP2. However, now that he is in the same hexrow as the missile, FP1 takes precedence so he leaves the hexrow by continuing right. This puts the missile in his ideal front quarter arc, so he maintains heading as per HP1 as he braces for the attack.

Dagger 623 makes a steep climb 2 steps to my leader's altitude as per AP5, with AP4 negated by starting within 4 hexes. Since he met the initial conditions to launch a missile, he weaves 2 hexes right into my leader's rear arc as per FP3, with wings level as per HP2. If his colleagues in front had not dropped below his radar arc due to his steep climb, he would make a long range gun attack. As it is, he launches a Shafrir 2 instead at its minimum AI rear arc range of 2 hexes, so my leader will have to evade this as the price of his own attack.

Dagger 624 maintains height as per AP7. He ignores FP4 since he is in my leader's rear arc, but his right bank means that he flies right in his first hex anyway as per FP6. He must now weave left and override normal flight rules by stopping early and by banking and turning left so as to stay on the board.

ALTITUDE CHANGE

The AI pilot next chooses whether and how to climb or dive, subject to the standard limits and based on the following Altitude Priorities (APs).

- 1 Do not climb above or dive below the board altitude
- 2 Dive if targeted by a missile, steeply if it is in the rear hemisphere
- **3** Climb steeply if at airspeed 4 with the opposing jet in the rear hemisphere; dive or climb steeply if at airspeeds 3 or 4 with the opposing jet in the forward hemisphere within 2 or 3 hexes respectively; (shallow climbs or dives have no backup priority)
- 4 Do not dive or climb steeply if the opponent is over twice as many hexes as steps away, and do not climb at all if at airspeed 2
- 5 Minimise the altitude difference if the opposing jet is within 12 hexes in the forward hemisphere
- 6 Dive if at airspeed 2 or airspeed 3; climb if at airspeed 4
- 7 Avoid or minimise altitude changes

Climbs in red apply only at altitude levels 0-9 if the jet has turn type A, levels 0-7 if type B, levels 0-5 if type D, levels 0-3 if type E and levels 0-1 if type F; dives in red apply only above these altitudes

FLIGHT

The AI pilot decides whether to fly left or right in each successive hex based on the following Flight Priorities (FPs).

- A hex not along the same hexrow if the AI jet is currently in the same hexrow as the missile (in any of the 3 possible angles)
 The hex closer to the opponent
 The hex closer to the opposing jet's rear arc if its heading differs by 60 degrees and the AI jet met the initial conditions of range and arc to launch a missile at it
 The hex further from the opposing jet's frontal arc unless the AI
- jet is in its rear arc
- **5** The same direction as the previous hex the pilot entered this turn
- 6 The direction in which the AI pilot is already banked unless the opponent is a jet in his frontal arc
- 7 The hex which puts the furthest friendly jet closer to 8 hexes away if initially in a pair or 12 hexes away if initially in 2 pairs

HEADING CHANGE

After flying forward, an AI pilot who is eligible to turn decides whether to attempt this, based on the Heading Priorities (HPs) below. AI pilots turn gently only at level 11 or if they will fire guns if they succeed, but the overall drag cost for normal turns by AI jets is cut by 0.5 speed points (1 if maximum speed is 17-20) as a further balancing measure.

- 1 Place or keep the missile in the AI jet's front quarter, or if need be its frontal arc, or if both are impossible its rear quarter
- 2 Place or keep the opposing jet in the AI pilot's frontal arc
- **3** If the opposing jet will be in the AI pilot's own hex or frontal arc regardless, maintain heading if this allows a missile launch (on any enemy jet) or if a successful turn will not reduce the heading difference from 120 to 60 or from 60 to 0 degrees
- 4 Attempt a turn, towards the opponent's heading if there is a choice

SPEED CHANGE

AI pilots use afterburner if they turn successfully, or if their airspeed is 2 or would fall to 2 this turn without (or even with) afterburner. They never use afterburner if they have lost SA or have exhausted their fuel or are throttling back or are currently targeted by an HSM. AI pilots throttle back by 3 speed points only if stopping short to stack with the opposing jet as discussed below.

BOARD EDGE EFFECTS

Corner hexes next to only 2 others count as off the board. If one of their front hexes is off the board, AI pilots enter the other. If both front hexes are off the board, the AI jet stops its flight in its current hex. AI pilots never turn if this would leave both front hexes off the board. Those already in this position make an automatically successful bank and turn to regain an on-board front hex, even if normally ineligible. If either turn direction would serve, AI pilots choose the side to which they moved more hexes, or decide randomly if this is equal. All of these special rules apply equally to AI pilots who lose SA, so AI jets will never fly off the board. Non-AI pilots may leave the board normally, and they are also counted as doing so if they ever enter a board edge hex.

STACKING

AI pilots with SA whose flight would end in a prohibited stack with another jet adjust their final hex (or if need be hexes) of movement to avoid this, or end their move early if blocked by the board edge. An AI pilot will ignore AP3 if this allows him to stop short and stack with the opposing jet (only), as long as he will fire his guns at it if any gentle turn attempt succeeds. AI pilots with no guns or gun ammo may never end their flight stacked with an enemy jet.

COMBAT

If an AI pilot meets the conditions to launch an initial or follow-on missile, he will do so as long as the range at launch is at least 3 hexes if in the target's rear arc, 5 hexes if in the target's rear quarter, and 8 hexes if in the target's forward hemisphere. HW or HA missiles reduce these minima by 1 hex. If the closest eligible HSM target is below these ranges or has already been engaged, it prevents HSM launches at more distant targets. (Ineligible gun targets do not block fire in this way.) AI pilots with a choice launch an RHM if in cloud or haze or if the HSM target is in their up-sun arc, otherwise an HSM. RHMs except Sparrow F or M are launched in pairs if possible. AI pilots eligible to fire guns will do so unless they would otherwise launch a missile at a target no further away in hexes. A potential missile launch still stops heading changes as per HP3, and only green pilots fire guns if the net modifier is -3 or less. With a given weapon, targets closer in heading are prioritised if there is a choice. If an AI jet ends its activation in a position to guide an RHM which it launched last turn, it will do so. However, an AI pilot targeted by a missile will not fire his guns or launch or guide his own missile unless he ends below the enemy missile's minimum range.



Figure 16: This game at levels 0-5 over the Pacific uses AI opponents and the mock combat rules on p.13 to model the training of two experienced USN F-14A crews in the early 1980s by my two veteran Top Gun instructors in A-4M Skyhawks with simulated AA-8 HW missiles. The scattered cloud markers are from *Wing Leader*. The lead F-14 has just launched a Sparrow F at my leader (whose position in cloud puts him just beyond the Sidewinder range limit). My leader dives to altitude 1.3 and turns hard towards the missile. My wingman risks a climbing left bank and turn out of the sheltering clouds and away from the approaching F-14s, in the hope of bouncing the trainee leader out of the sun as he guides his simulated Sparrow.

As I had hoped, the lead F-14 prioritises his AIM-7 target as per OP2, even though my wingman poses an imminent guns threat as per OP3. The F-14 starts 7 hexes from my leader, so he makes only a shallow dive to altitude 1.4 as per AP4 and AP5. He flies right as per FP2 and successfully banks and turns right in full burner as per HP2 to bring my jet back into his radar arc and complete the guidance process. His Sparrow now makes its attack, with the bonus for his powerful radar giving a net modifier of 0 despite the penalties for the front quarter aspect and my veteran pilot. He therefore gains 8 hit points (2x4) worth 0.8 VPs to add to the maximum handicap of 2.

The trainee wingman selects my own wingman as his opponent, since he is 3 hexes and steps closer and in a closer heading as per OP6 and OP7. The AI pilot maintains altitude as per AP5, and flies 3 hexes left with wings level as per FP2 and HP3. He would be perfectly placed to launch an AIM-9L with its shorter minimum range at my wingman, were his own leader not still on the fringe of his radar arc (as I had anticipated).

Next turn, my wingman can dive down for a medium range gun attack on the distracted trainee leader with a terrific modifier of +5, and so gain 21 hit points (7x3). The trouble is that his wingman may well manage to turn in behind mine and return the compliment by gaining 16 hit points (4x4) in a gun attack of his own. I need to split the F-14s up and sandwich just one of the trainees' jets if my tactics are to yield secure net benefits. Mock combats are less luck-dependent than the sudden death environment of real dogfights, and let you pit your wits and experience against headstrong young hotshots like 'Maverick'.

DESIGN NOTES

Jet Duel was conceived when I realised that Gary's jet data in *Flight Leader* gave similar generic information to Lee's Aircraft Data Cards in *Wing Leader*, allowing me to create a jet age version of my WW2 tactical air game *Fighter Duel Deluxe*. My *Fighter Duel* design notes already discuss the thinking behind key systemic aspects such as the Igo-Ugo sequence, energy modelling, SA, the heavy use of die rolls and the inclusion of unique AI provisions, so rather than duplicating these discussions here, I will take them as read and focus on what has changed in *Jet Duel* to model the distinctive features of jet combat from 1950 to 1991.

One unchanged aspect is that the turn timescale is only slightly longer than in *Fighter Duel*. Only Dave Isby's jet game *Air War* had shorter turns, while the turn scale in other grid-based jet sims ranges from 5 seconds in Lou Zocchi's *MiG Killer* and 7.5 seconds in Charles Moylan's PC game *Flight Commander 2* to 12 seconds in J.D.Webster's jet games and 30 seconds in James Dunnigan's *Foxbat & Phantom* and in *Flight Leader* itself. Gary recognised the problems with such long turns, and added an option to divide each turn into no fewer than 20 interleaved impulses! *Jet Duel* offers a more playable response to the rapidity of action-reaction cycles in air combat, and it capitalises on the limited options available in each short turn by simplifying flight rules and implementing practical AI provisions.

Each hex and altitude step in *Jet Duel* represent only 250 metres instead of the 1 km in *Flight Leader* itself, but this is still almost 3 times more than the 300 feet hexes and steps in *Fighter Duel* with its similar turn timescale. The increase stems partly from the much greater combat speeds and climb rates of jets, but also from my decision to limit jet movement to just a few hexes per turn so that there is space to recover from loss of SA and failed turn attempts without flying off the board. Whereas other jet games including *Flight Leader* itself make provision for extreme speeds, altitudes and weapon ranges like those attained by the MiG 25 and AIM-54 Phoenix, I have chosen to focus *Jet Duel* on the far more common experience of visual range combat at high subsonic speeds and at heights below 40,000 feet.

Supersonic flight costs so much fuel and brings such severe G-forces that it is compatible only with brief hit and run engagements instead of the turning dogfights which I seek to model. I hence limit jets to around 660 mph (Mach 1 at high altitude), while making theoretical maximum speeds matter instead for acceleration and climb rates. Giving jets as many turns of afterburner as their maximum speed is rather 'gamey', but it neatly models the spectrum from subsonic craft like the F-94 to Mach 2 powerhouses like the F-104. Real afterburners have intermediate settings and are not flicked on and off so frequently or responsively, but my abstraction works well with my turn die rolls and AI rules.

Flight Leader does not model the gradual decrease of turn and climb rates with height, but studying F-16 performance charts at different altitudes soon convinced me that I needed to go beyond the simple modifiers in Fighter Duel and to include altitude as a key variable on the expanded turn and thrust-drag charts in Jet Duel. Jets turn more tightly at lower altitude, but at the cost of increased drag in the thicker air. I have streamlined the climb and dive rules to capitalise on the smaller range of move distances, while continuing to omit truly vertical flight to keep things simple without the overly simplistic distortions of linear trading of hexes for steps.

Mike Spick's *Jet Fighter Performance* describes how afterburning Mach 2 jets soon achieved sustained climb rates up to 10 times those of jets from the Korean war. My thrust-drag chart reflects this huge disparity, but since even an F-16 in full burner loses speed in tight turns, it was apparent that the underpowered earlier jets would be crippled if they suffered the same turn drag. I hence realised that I needed to reflect the higher wing loading of the Mach 2 jets by doubling their turn drag, thereby creating a dynamic balance which lets agile subsonic jets hold their own against supersonic craft. Roll penalties are mostly lower than before, due to jets' rapid roll rates.

Fighter Duel shows how even the slower piston-engined craft of WW2 ran into common G limits at higher speeds, making decreased turn drag as important a benefit of aircraft agility as increased turn rate. Although jets were much more exposed to such G limits due to their greater speed, this was offset by stronger airframes and better G preparation for aircrew including routine use of G suits. Whereas *Fighter Duel* limits turns to around 4G, *Jet Duel* allows pilots to sustain up to 7G, as shown by the common turn rate which takes effect at airspeed 4 regardless of altitude and aircraft turn type. However, I have stricter G limits in the stratosphere or when firing guns, and I prohibit turns while launching a missile.

The rules for gunfire and visual SA differ little from their successful counterparts in Fighter Duel. Although a few forward hemisphere gun engagements still occurred despite the massive closing speeds, prohibiting these removes a lot of rules complication. I have added some nuances to spotting now that the playable height range has expanded from 5,000 to 20,000 feet. Visibility upward is no longer unlimited, blind arcs with wings level now vary with pitch attitude, and there are simple rules for contrails, patchy cloud at its usual low altitude, and fuller cloud layers just below or above the 6 playable levels, silhouetting jets or masking the sun. Large jets may be seen further off, both by the enemy and by wingmen trying to keep in touch with their leaders. Second crewmen give the same rear quarter spotting benefits as bubble canopies now tail gunners are obsolete.

The big change in spotting is the advent of radar. Real radar arcs were highly variable, with a constant trade-off between the horizontal and vertical extent of the scan and the update frequency. I cut through the complexity (not least the problem of banking) by giving jets a standard 60 degree search arc in both dimensions, building on the frontal arcs and hex corner facing which give planes in my rules more freedom of manoeuvre than do the artificial 'tramlines in the sky' created by traditional hexside facing. Poor radars are handicapped by ground clutter and clumsy displays, but still betray their presence on the RWRs which I assume that all jets with countermeasures possess.

RHM launches beyond visual range became more common in the 1980s, as in Israel's ambush of Syrian jets in 1982 and Iran's use of AIM-54s against Iraqi jets. However, it remained hard to be sure that radar blips were not errant friendly jets, and even in the 1991 Gulf war F-14s and Tornado F3s were held back because their IFF capability was judged insufficient for safe BVR combat. *Jet Duel* models confused clashes between a few jets as part of more tangled air battles in which the identity of the multiple radar echoes is unclear without visual confirmation. My 12 hex recognition threshold makes it realistically hard to achieve head-on missile shots before the merge, forcing jets into classic manoeuvre combat as happened in Vietnam.

Excluding BVR engagements saves me from having to model missile flight over several turns as in *Air War*. I instead create a standard simple 2 turn sequence – a launch turn which reflects the time taken to achieve a lock and release the missile, and a flight turn in which the missile engages its target. This lets target jets make last ditch evasive manoeuvres and forces jets launching RHMs to maintain their lock on the second turn, exposing them more than jets launching 'fire and forget' HSMs. I try to capture other relative merits of the 2 missile types in my launch requirements and multiple die roll modifiers, such as the bonus for having a separate radar operator before HUD and HOTAS systems allowed pilots to fire RHMs just as well.

Missile hit ratios varied greatly, from the poor results in Vietnam (as analysed in Marshall Michel's *Clashes*) to the stellar performance of the AIM-9L in the Falklands. The IAF relied mainly on cannon in 1967, but its missiles became dominant in 1973 and 1982. I have reflected these variations by allowing paired launches to offset the chronic unreliability of most RHMs, and by giving the best HSMs a hit bonus and increasing missile effectiveness across the board as technology matured. I make HN and HW launch requirements as permissive as possible, since HSMs were often released out of the envelope and missed as a result. In a fascinating inversion of the usual contest for superior height, at lower altitudes missiles work best when launched from below against targets not masked by ground clutter.

Combat with jet age weaponry was more a matter of single lucky hits, so *Jet Duel* no longer tracks cumulative damage and any clean hit removes the target and usually prompts other enemy pilots to break off into the bargain. To mitigate the high luck element which this creates, I have introduced 'near misses' which give small VP bonuses like the minor hits in *Fighter Duel*. This makes it possible for dogfights to swing in either side's favour even if no jets are damaged or downed, and it also offers losing flights some VP compensation.

My AI system has benefited from the abolition of forward hemisphere gunfire, but the priority lists have inevitably grown so that AI pilots may react to missile threats and set up their own missile launches. As in *Fighter Duel*, the AI system suits angles fighters better than energy fighters, and human players are much better at the subtle judgements needed to balance multiple opponents, achieve the best airspeed, make vertical turns or launch missiles from just far enough below. It still takes proper formation tactics to beat the AI.

Since the jet age coincided with the Cold War rather than the World Wars, many jet types saw little or no real air combat during their entire service lives. However, theorising about optimum dogfight tactics reached new heights, as illustrated in Robert Shaw's Fighter Combat (posted free online). There were many mock combats during training exercises, culminating in the famous creation of Top Gun, Red Flag and Maple Flag. To simulate these, replace combat dice with hit points for each side -2, 3 or 4 vs. green, experienced or veteran enemies. Multiply points by 0.5 if the combat modifier is -2, or by 2 more than the net modifier if it is -1 or better. Round halves up, and deduct 1 for every full 3 points if firing MGs. Record hit points on the turn tracks. If they exceed 40, they fall by 15 (or 30 with 4 enemy jets) and the enemy flight loses combat effectiveness. There are no near misses, and jets are removed only if they fly off the board. Calculate victory normally, scoring 0.1 VPs for each remaining hit point.

As in *Fighter Duel*, there is a certain gladiatorial artificiality to *Jet Duel*, with the pilots forced to stay within the confines of the board for 2 scale minutes to avoid forfeiting the contest. Real life jet combat had a larger context in terms of assailing or protecting strike flights, and was more likely to involve surprise attacks, hit and run passes or desperate evasion attempts than dogfighting. That said, it is the dogfight which holds most fascination for jet enthusiasts, and *Jet Duel* with just 7 pages of rules plus a 3 page AI add-on allows these classic craft to fly and fight again in any virtual match-ups desired. Google 'Sabin wargames' for links to *Fighter Duel* and to my many other game designs.



Situational Awareness Altitude Change

Flight Bank & Heading Change

Speed Change Combat

SITUATIONAL AWARENESS

HEADING CHANGE Roll a D10, turning on an unmodified 10 or a score \geq that shown below

Move straight ahead on 0 or less (D10)

- +1 for a veteran pilot
- -1 for a green pilot -1 for a wingman whose leader is not in
- sight ahead, unless both are AI
- -1 if no enemies are in sight or on
- radar/RWR, and no attack occurred -1 for a non-AI pilot if using AI pilots

SPEED POINT CHANGE

± 2.5 for each step dived or climbed
\pm the figure in the thrust & drag table
+ the speed point gain at airspeed 2 if
using afterburner
- up to 6 if throttling back and extending
speedbrakes
- the red loss from the turn table (+1 if
MS 10-12, +2 if MS 13-16 or doubled if
MS 17-20) if successful in turning
+0.5 (1 if MS 17-20) for an AI pilot if
successful in turning normally
+1 (1.5 if MS 10-16, 2 if MS 17-20) if
successful in turning gently
-1 (1.5 if MS 10-16, 2 if MS 17-20) if
changing pitch without a successful turn

GUNFIRE

+1 if the target is in the same hex
+1 if the target is in the same heading
+1 if the firer has a veteran pilot
+1 if the target just fired guns or
launched or guided a missile
+1 if the firer dived and is facing
directly down-sun
+1 if one or both of the target's 2 front
hexes are in the firer's fire zone
-1 if the firer has a green pilot
-1 if the firing jet has a gunnery penalty
or external cannon
-1 if the target has a veteran pilot
-1 if the target has a better turn type
and/or a higher airspeed in hexes
-1 if the firer made a successful gentle
turn
-1 if the firer was just fired on by guns
or attacked by a missile
-1 if the firer climbed and is facing
directly up-sun

+1 for a	+1 for a veteran pilot													
+1 if climbing steeply at airspeed 4														
-1 if any hexes entered to the other side														
-1 (or -2 for slow rolling jets) if starting with wings level														
-2 if turning gently (required at level 11 or before firing guns)														
-3 (or -6 for slow rolling jets) if starting in the opposite bank														
Air Turn Altitude Level														
Speed	Туре	0-1	2-3	4-5	6-7	8-9	10-11							
2	Α	1/-3.0	2/-3.0	3/-2.5	4/-2.5	5/-2.0	6/-2.0							
	В	2/-3.0	3/-3.0	4/-2.5	5/-2.5	6/-2.0	7/-2.0							
	D	3/-3.5	4/-3.5	5/-3.0	6/-3.0	7/-2.5	8/-2.5							
	E	4/-3.5	5/-3.5	6/-3.0	7/-3.0	8/-2.5	9/-2.5							
	F	5/-3.5	6/-3.5	7/-3.0	8/-3.0	9/-2.5	9/-2.5							
	Α	1/-3.5	1/-3.5	1/-3.5	2/-3.5	3/-3.0	4/-3.0							
	В	1/-4.0	1/-4.0	2/-3.5	3/-3.5	4/-3.0	5/-3.0							
3	D	1/-4.5	2/-4.5	3/-4.0	4/-4.0	5/-3.5	6/-3.5							
	E	2/-4.5	3/-4.5	4/-4.0	5/-4.0	6/-3.5	7/-3.5							
	F	3/-4.5	4/-4.5	5/-4.0	6/-4.0	7/-3.5	8/-3.5							
	Α	3/-3.0	3/-3.0	3/-3.0	3/-3.5	3/-3.5	3/-3.5							
	В	3/-3.5	3/-3.5	3/-3.5	3/-4.0	3/-4.0	3/-4.0							
4	D	3/-4.0	3/-4.0	3/-4.0	3/-4.5	3/-4.5	4/-4.5							
	E	3/-4.5	3/-4.5	3/-4.5	3/-5.0	4/-4.5	5/-4.5							
	F	3/-5.0	3/-5.0	3/-5.0	4/-5.0	5/-4.5	6/-4.5							

THRUST AND DRAG

Max	Air		Altitude Level 0-1 2-3 4-5 6-7 8-9 10-11 1-0 1-0 1-0 5 1-0 1-0 1-0 1-0 1-0 1-0 1-0 1-0 1-0 1-0 1-0 1-0 1-0 1-0 1-0 1-0													
Speed	Speed	0-1	2-3	4-5	6-7	<mark>8-9</mark>	10-11									
	2	+1.0	+1.0	+0.5	+0.5	+0.5	+0.5									
7	3	+0.5	0	0	0	0	0									
	4	0	-0.5	-0.5	-0.5	-0.5	-0.5									
	2	+1.0	+1.0	+1.0	+0.5	+0.5	+0.5									
8	3	+1.0	+0.5	+0.5	+0.5	0	0									
	4	0	0	0	0	-0.5	-0.5									
	2	+1.5	+1.5	+1.0	+1.0	+0.5	+0.5									
9	3	+1.0	+1.0	+1.0	+0.5	+0.5	+0.5									
	4	0	0	0	0	0	0									
	2	+2.0	+1.5	+1.5	+1.0	+1.0	+1.0									
10-12	3	+2.0	+1.5	+1.0	+1.0	+1.0	+0.5									
	4	0	0	0	0	0	+0.5									
	2	+2.5	+2.0	+1.5	+1.5	+1.0	+1.0									
13-16	3	+2.5	+2.0	+1.5	+1.0	+1.0	+1.0									
	4	0	0	0	0	+0.5	+0.5									
17-20	2	+3.0	+2.5	+2.0	+1.5	+1.5	+1.0									
Nrml	3	+3.0	+2.5	+2.0	+1.5	+1.0	+1.0									
Accel	4	0	0	0	+0.5	+0.5	+0.5									
17-20	2	+3.5	+3.0	+2.5	+2.0	+1.5	+1.5									
High	3	+3.5	+3.0	+2.5	+2.0	+1.5	+1.5									
Accel	4	+0.5	+0.5	+0.5	+1.0	+1.0	+1.0									



Situational Awareness	onal Awareness Altitude Change Flight Bank & Heading Change Speed Change C										
MISSII	FS		-	OPPONEN	T PRIC	ORITIES					
		1	A launc	hed missile targeted o	on the Al	I pilot					
ALL MISS	ILES	2	An opp	osing jet at which the	AI pilot	just launched an R	HM				
+1 if in the target's rear	arc	3	A gun-a	A gun-armed opponent within 3 hexes and 3 steps of a front							
+1 if the launch jet has a $+1$ if the tanget is at single	i veteran pilot		of the A	of the AI jet, in a heading differing by 0 or 60 degrees (in v							
+1 if the target is at airs			case the	case the front hex must be in its forward hemisphere) o							
+1 if the target just fired	guns or	4	degrees	tegrees (in which case the front hex must be in its frontal arc)							
1 1 if the target has a cou	Intermeasures	4	An opp	osing jet in the AI pil	ot s from	ital arc which he w	111 engage				
+1 in the target has a contract of 0 and/or a gree	internieasures		with gi	ins (assuming any t	urn alle	empt succeeds) or	launch a				
-1 before 1975 due to ut	reliability	5	A missi	le-armed opponent w	ith the A	AI jet in its frontal	arc if it is				
-1 if the target has a vet	eran pilot	5	within 1	0 hexes and in the AI	[nilot's]	rear hemisphere	are, 11 ft 15				
-1 if the launch iet has a	green pilot	6	An opp	osing jet whose tot	al senar	ation in hexes and	d steps is				
-1 if the target has a cou	ntermeasures	Ŭ	smaller	by at least half the AI	pilot's	unmodified SA die	roll				
rating of 6 or more		7	An opp	osing jet whose heading	ng differ	rs least from the AI	iet				
-1 if in the target's front	quarter			ALTITUDE	E PRIO	RITIES	<u>,</u>				
RADAR HOMING M	ISSILES ONLY	1	Do not	climb above or dive b	elow the	e board altitude					
+2 if the launch jet's rac	lar rating is ≥ 7	2	Dive if	targeted by a missile,	steeply	if it is in the rear he	misphere				
+1 if the launch jet's rac	lar rating is 6	3	Climb s	steeply if at airspeed	4 with	the opposing jet i	n the rear				
+1 if the launch jet has 2	2 crew and a		hemisph	nere; dive or climb st	teeply if	at airspeeds 3 or 4	4 with the				
radar rating of 5 or less			opposin	g jet in the forward	d hemis	phere within 2 or	r 3 hexes				
+1 if the launch jet is no	ot diving steeply		respecti	vely; (shallow climbs	or dives	s have no backup pi	riority)				
and the target's level $+2$	/-2 for each step	4	Do not	dive or climb steeply	if the op	ponent is over twic	e as many				
it is above/below the jet	is ≥ 1 over the		hexes as	s steps away, and do n	not climb	o at all if at airspeed	12				
sea, ≥ 3 over mountains	or ≥ 2 otherwise	5	Minimis	se the altitude differe	ence if t	he opposing jet is	within 12				
-1 if only 1 missile was	launched, unless	-	hexes in the forward hemisphere								
1 if the lounsh jet's red	or rating is 1	6	Dive if	at airspeed 2 or airspe	ed 3; cli	imb if at airspeed 4					
-1 if the launch jet's rad	ar rating is <3		Avoia c	r minimise altitude cr	nanges	1. 0. 0. 'f (h '. (h	4				
HEAT SEEKING MI	SSILFS ONLY		limbs in red apply only at altitude levels 0-9 if the jet has turn type								
± 1 if the target just used	afterburner	A,	1000000000000000000000000000000000000	type F: dives in red a	only on	ly above these altitu	ype E allu				
+1 for a Sidewinder G	or M or Shafrir			FLICHT							
(Python) 2 or 3, due to r	proven lethality	1	A hey r	ot along the same he	exrow if	the AI jet is current	ntly in the				
+1 if the target's level +	2/-2 per step it is	1	same he	exrow as the missile (i	in any of	the 3 possible and	les)				
above/ below the missile	e is ≥ 1 over the	2	The hex	closer to the opponer	nt	the 5 possible dig	(03)				
sea with no low cloud d	eck or ≥ 2	3	The hex	closer to the opposit	ng jet's	rear arc if its head	ing differs				
otherwise, unless the mi	ssile is in cloud	-	by 60 d	legrees and the AI ie	t met th	ne initial conditions	s of range				
or haze or the target is in	n its up-sun arc		and arc	to launch a missile at	it		0				
		4	The hex	further from the opp	posing j	et's frontal arc unle	ess the AI				
COMBA	4T		jet is in	its rear arc							
Roll a D10 and add appli	cable modifiers	5	The san	ne direction as the pre	vious he	ex the pilot entered	this turn				
8 or 9 means a near miss	s, stopping the	6	The dire	ection in which the A	AI pilot	is already banked	unless the				
target firing or launchin	g or guiding		opponer	nt is a jet in his frontal	l arc						
missiles for a turn; if the	unmodified roll	7	The hex	which puts the furthe	est friend	dly jet closer to 8 h	exes away				
was 10, the target is dan	naged instead on		if initial	ly in a pair or 12 hexe	es away	if initially in 2 pairs	S				
a D6 roll of 5-6 or 3-6 r	espectively	1	DI	HEADING	PRIO	RITIES	·C 11				
10 or more means the ta	rget is removed	1	Place of	keep the missile in the	ne Al jet	s front quarter, or	If need be				
from play, being downed	d on a D6 roll of	2	Diago cr	ar arc, or if both are if	t in the	Al pilot's frontel or	0				
3-6 (5-6 with MGs) or d	amaged if less	2	If the er	nosing jet will be in	the AL	nilot's own how on	trontal are				
Flights lose combat effe	ctiveness if any	3	regardle	oposing jet will be in	if this	allows a missile 1	aunch (on				
jet is downed or if their	AXI leader or		any ene	my jet) or if a succes	sful turr	a will not reduce the	ne heading				
have flown off the been	damaged or		differen	ce from 120 to 60 or 1	from 60	to 0 degrees	ie nouunig				
nave nown on the board	*	4	Attempt	a turn, towards the o	pponent	's heading if there i	s a choice				



HANDICAP & NEAR MISS VICTORY POINTS 0 0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0





MISSILES REMAINING

0	1	2	3	4	5	6
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SPEED POINTS

2	2	2	2	2	2	2	2	3	3	3	3 (7)	3	3 (8)	3	3 (9)	3	3 (10)	3 (11)	3 (12)
4 (13)	4 (14)	4 (15)	4 (16)	4 (17)	4 (18)	4 (19)	4 (20)	4	4	4	4	4	4	4	4	4	4	4	4

PITCH ATTITUDE

Steep	Shallow	Steep
Climb	or Level	Dive

BOARD ALTITUDE

0	1	2	3	4	5	6	7	8	9	10	11
---	---	---	---	---	---	---	---	---	---	----	----

GAME TURN, AFTERBURNER FUEL & MOCK COMBAT HIT POINTS

