



Ministry  
of Defence

Air Command Secretariat  
Spitfire Block  
Headquarters Air Command  
Royal Air Force  
High Wycombe  
Buckinghamshire  
HP14 4UE

Ref. 2020/05938

[REDACTED]

20 July 2020

Dear [REDACTED],

Thank you for your e-mail of 21 May 2020 asking for Tornado GR4 documentation. Specifically, you requested:

*".....a copy of the paragraph regarding the procedure used by Tornado GR4 pilot during Formation flight, formation landing, formation departure, normal formation, tactical formation and tactical turn and the concerning OCU material about the procedures mentioned above of Tornado."*

I am treating your correspondence as a request for information under the Freedom of Information Act 2000. A search for the information has now been completed within the Ministry of Defence and I can confirm that information within the scope of your request is held and I attach a copy of the relevant paragraphs. However, a small amount of information has been withheld.

Notwithstanding the withdrawal of the Tornado from RAF service, the aircraft remains in service with NATO allies and other countries. Section 27(1)(a) (International Relations) of the Act provides that we should withhold information that would, or would be likely to, prejudice relations between the United Kingdom and any other. Additionally, Section 26(1)(b) of the Act provides we should withhold information which would be likely to prejudice the capability, effectiveness or security of relevant forces.

The Act requires that we have to carry out a Public Interest Test (PIT) in these respects to show that the reasons for withholding the information outweigh the reasons for releasing information.

Section 27(1)(a) is engaged because although it would provide further public understanding of how the UK operated the Tornado aircraft and the necessary skills required of RAF aircrew, releasing defence systems and operations information could have a detrimental

effect on other nations operating capabilities and breach their security regulations. It would also jeopardise our relations with our allies.

The effective conduct of international relations depends upon maintaining trust and confidence between Governments. This relationship of trust allows for the free and frank exchange of information on the understanding that it will be treated in confidence. If the UK does not respect such confidences, its ability to protect and promote UK interest through international relations will be hampered. The States concerned may be reluctant to share sensitive information with the UK Government in future and may be less likely to respect the confidentiality of information supplied by the UK Government to them, to the detriment of UK interests.

Section 26(1)(b) is engaged because the paragraphs requested contain sensitive current UK defence systems and operations information which could be used by a potential enemy wishing to attack the UK or its interests to identify defence weaknesses and therefore place service personnel in danger.

I conclude that the balance of the public interest for providing the information requested is firmly in favour of maintaining the exemptions under S.27(1)(a) and thus of withholding the document in full, with the level of prejudice set at the level of "would be likely to". I also conclude that information should be withheld under S.26(1)(b) with the level of prejudice also set at the level of "would be likely to".

If you have any queries regarding the content of this letter, please contact this office in the first instance.

If you wish to complain about the handling of your request, or the content of this response, you can request an independent internal review by contacting the Information Rights Compliance team, Ground Floor, MOD Main Building, Whitehall, SW1A 2HB (e-mail [CIO-FOI-IR@mod.uk](mailto:CIO-FOI-IR@mod.uk)). Please note that any request for an internal review should be made within 40 working days of the date of this response.


If you remain dissatisfied following an internal review, you may raise your complaint directly to the Information Commissioner under the provisions of Section 50 of the Freedom of Information Act. Please note that the Information Commissioner will not normally investigate your case until the MOD internal review process has been completed. The Information Commissioner can be contacted at: Information Commissioner's Office, Wycliffe House, Water Lane, Wilmslow, Cheshire, SK9 5AF. Further details of the role and powers of the Information Commissioner can be found on the Commissioner's website at <https://ico.org.uk/>.

Yours sincerely

  
Secretariat 3a1  
Air Command

## GENERAL CONDITIONS AND PROCEDURES

1. Pilots are to conform to the following general procedures:
  - a. Pilots are not to join or rejoin a formation if that formation is in, or is just about to enter, conditions of restricted visibility.
  - b. All configuration changes in close formation are to be called, or signalled, by the leader.
  - c. Ac in close formation should routinely adopt the same wing sweep.
2. **R/T Procedures.** All instructions for frequency or formation changes are to be given twice, followed by the executive word "Go" on the radio to which the change applies to. Allow sufficient time for all formation members to make the change before calling the check-in, which is to be as follows: "*Formation Callsign* check". The formation is to check-in in sequence, ie "2", "3", "4"; the formation leader is not required to acknowledge a complete and correct check-in. Formations may 'autochop' to a new frequency iaw IG 2390.100.
3. **Loss of R/T Contact on Frequency Change.** The following sequence of actions is to be adopted following loss of R/T contact on frequency change:
  - a. Return to the previous frequency and wait 30 sec.
  - b. Attempt contact on pre-briefed collector frequency.
  - c. Transmit on 243.0 MHz, making clear that this is a transmission on Guard, eg 'Cobra 2 on Guard'.
  - d. Attract attention (wing waggle) and indicate a channel change by holding up a number of fingers as follows:
    - i. **Collector Frequency.** One finger.
    - ii. **243.0 MHz.** 2 fingers.
    - iii. **121.5 MHz.** 3 fingers.



## GROUND OPS

4. Formation starts may be initiated by hand signals, R/T or may be commenced at a pre-briefed time. Aircraft should taxi with a minimum spacing of 150 m to reduce the FOD risk. During line-up, the formation leader must taxi sufficiently far forward such that all formation members can clear the areas of oil and rubber

contamination that are likely to exist near the runway threshold. The leader is normally to line-up on the downwind side of the runway. Ac must be lined-up so there is wing-tip to jet wash separation between all ac.

## **RUNWAY POSITIONING**

5. Ac are to line up as follows:
  - a. **Echelon.** Ac are to line up just aft of line abreast such that the leader's mainwheels appear to be in line.
  - b. **4-Ship.** Unless necessary, pairs at 2 mins are considered the SOP. If appropriate, 2 types of 4-ship line-up can be considered, namely echelon (ie 4 ac lined-up in echelon into wind) or pairs 500-1000ft displaced. Echelon should be the type routinely used. All ac power up to Max Dry at the same time. If the runway is insufficient for 4 ac, the formation should line-up and take off separately as 2 pairs.

## **STREAM TAKE-OFF**

6. Whilst lining-up on the runway, crews are to visually check all other ac in their formation, paying particular attention to the flaps and slats to ensure they have travelled. When the formation is lined-up and take-off clearance has been obtained, elements are to complete individual 'Line-up Checks' and placard checks. When complete, a thumbs-up signal is to be passed to the element leader whilst maintaining MAX DRY power. This not only signifies that the placard checks have been completed but also that the position of the leaders flaps and slats have been checked.
7. During a stream take-off following the abort of an ac ahead, crews should, at the pilots' discretion, comply with the following procedures:
  - a. If stationary - hold position.
  - b. If below 100 kt - discontinue take-off.
  - c. If above 100 kt - continue take-off.
8. **Take-Off Interval.** There is no SOP stream take-off interval. The lead crew should brief an interval that caters for rwy length, ac performance, FOD, weather, tactical scenario or any other airmanship considerations deemed appropriate. The minimum interval is 10 secs, except when departing in radar trail, when the minimum is 20 secs. A high-low-high initial climb is SOP.

## **IMC STREAM DEPARTURES**

9. A climb-out in poor weather immediately after take-off is potentially one of the most dangerous elements of a sortie and **should be fully covered in the brief**. The default IMC stream departure is 30 sec radar trail. The aim of a radar trail

departure is to maintain a consistent non-standard formation using the GMR to monitor the heading and height changes of the aircraft ahead, thereby maintaining the pre-briefed stream separation. However, due to the limitations of the GMR, snake climb procedures are to be briefed as the back up.

10. When both aircraft are equipped with TCAS a radar trail departure affords both aircraft RA protection. The advantages of trail formation when compared to close formation are, increased freedom of manoeuvre for the lead aircraft and considerably lower pilot workload for both pilots and therefore increased awareness. The disadvantages of trail formation are increased time to transition to visual formations and increased formation separation.

11. Owing to the limitations of the GMR, it cannot be relied upon for safety of flight and should be cross checked with a second system (TACAN/[REDACTED]/TCAS) to ensure the WSO is tracking the correct radar return. [REDACTED]

12. Radar trail departure. Once the WSO has finished monitoring the line up checks he should set the radar up ready for departure. Before selecting M+R and starting to transmit it is important to reduce the scan volume and ensure that the runway caravan will not be inside the 63m RF hazard. The WSO should select 30° Scan, LONG Pulse, PENCIL beam, FAST Scan, and ensure the Video Display Threshold is set mid-range. The WSO should also get the display ready for the subsequent monitoring, and reduce the scale to 10Nm.

13. Once the aircraft ahead in the formation clears the RADHAZ area the WSO should set the GMR to M+R and select AAS. As a rule of thumb, every 10s between elements equates to 1nm of radar trail separation at 300Kts, eg for 30s stream, place the radar marker ready at 3nm and set the GMR elevation to +4°. The radar will start transmitting and the WSO should start seeing radar returns. Once the trail aircraft begins the take-off roll, the WSO is to ignore the GMR and monitor the take-off, only returning to the GMR once the aircraft is airborne in a safe configuration. Once safely airborne, the WSO should see the aircraft radar return straight ahead with some ground returns around it. If departing as more than a pair, nos. 3 and 4 must be very careful which ac they track! Before attempting a LK ON the WSO should wait until the radar return in search is clear (solid return), persistent (painted every sweep) and discrete (small return separated from any ground or weather clutter). You may need to select 60° Scan Width if the ac ahead has already manoeuvred off the runway heading. The WSO should use the GAIN and TILT to ensure a steady return, about the size of a pin head before attempting to LK ON. Too large a return will spill over the tracking gates and prevent the GMR achieving a LK ON. Too small and too infrequent a return will mean the GMR doesn't achieve tracking at all. For closer contacts the WSO may need to select SHORT pulse and/or STC 1 to reduce the size of the radar return and assist with the LK ON. Once the return is clear, frequent and discrete the WSO should conduct a couple of NHC inserts to establish a GMR track before selecting LK ON. Once LK ON has been achieved there is no need to call '#2 TIED'; you are assumed to be so unless you say

otherwise. If you are unable to achieve a LK ON but can still see the ac ahead on radar, forget about the lock and continue your radar trail departure in search. Remember, radar SA alone, in lock or search, should not be used for the climb and if you do not have SA from a secondary source you must "request snake". Similarly, if you lose radar SA, or are code 5, you must call "CLEAN" so that the formation can revert back to a snake climb.

14. Once LK ON is achieved trail ac should follow the ac ahead through the departure procedure. It is important during any turns that the pilot does not keep the BOGEY marker central in the HUD; if you maintain pure pursuit throughout any manoeuvres then the pre-briefed range will reduce. As a rule of thumb you should lag any co-speed radar contact by  $7^\circ$  per Nm to maintain your trail separation; eg 30s stream is approx 3nm trail, therefore lag turns by  $21^\circ$  in azimuth to maintain the trail separation. When following turns by the aircraft ahead the Pilot should maintain their current heading until the WSO sees that the radar contact has reached the required azimuth before starting their turn to maintain trail. You can use these principles of lead and lag during trail departures to increase/decrease formation separation. With radar SA and the secondary back-up you can close up in the climb but you should not close within 1nm unless you can see the ac ahead and it safe to complete a visual join. The WSO should monitor the AAS ROL for changes in the height/speed (GS is displayed) of the ac ahead. The radar will also show when the ac ahead has rolled out on its new heading.

15. Snake climb. If the wingman's radar is U/S on line up or radar SA is lost during the climb a snake climb should be flown/reverted to. To enable all members of the formation to hear the turn calls, consideration should be given to requesting a change to the departure frequency on the RW once take-off clearance has been received. The leader may also wish to simulcast on both radios. The leader must call all turns using the executive word 'Now'; trailing ac are to follow at the interval used between ac during the take-off. The leader must also call level-off altitudes or flight levels, and at 5 000 ft intervals in the climb. The initial turn after take-off is to be at either a pre-briefed range, a pre-briefed height or as directed by ATC. With the exception of specific airfield departure procedures, turns are not to exceed  $90^\circ$  change of heading. After completing a turn, the leader is to maintain heading for at least one minute before commencing another turn. In addition if the required height is anticipated to be IMC the leader should negotiate an altitude block to enable successive elements to level-off at 500 ft intervals. After take-off, fly at 300 kts / 0.7M in the climb and when level, until snake-climb procedures have been cancelled. All turns must be flown at  $45^\circ$  AOB at 300 kts and at  $30^\circ$  AOB at 0.7M. Snake-climb procedures cease when VMC is achieved. If visual contact is subsequently lost, elements should carry out the standard lost-leader procedure. The formation leader is to call upon achieving VMC. Successive element leaders are to call their relative position when in visual contact with the ac ahead. Once visual, wingmen may move into the pre-briefed transit formation; element leaders may call for a jink to speed up the formation join-up if required.

## **JOIN UP**

16. **Join-Up.** Join-ups are to be flown using the leader's speed and height as a reference; leaders may transmit these details if necessary. Ac are to join initially in Arrow formation, and are then to proceed as briefed. Subordinate crews are to select GMR to M+S before joining in close formation.

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

18. **Cloud Penetration.** Wingmen are automatically to move into close formation prior to cloud penetration; element leaders are to visually check that their wingmen are in position before entering cloud. Should close formation not be achieved before cloud penetration, the formation leader is to call the datum heading and wingmen are to take the 'lost leader in IMC' action. When in IMC, the WSO is to make all R/T frequency changes. He is to monitor the instruments (particularly the AI) and is to warn the pilot if a hazardous situation is developing. To minimize spatial disorientation effects for the flying pilot, he should call the attitude, height, speed and heading during close formation flight in cloud, at night or when there is not a clear horizon. In cloud, the maximum bank angle should not ordinarily exceed 30°.

19. **Sanctuaries.** The leader should brief a sanctuary plan which should be used by any of the formation if IMC and/or unsure of the position of other ac within the formation. The SOP is the Lead taking odd flight levels (above safety altitude), No 2 taking even FLs, No 3 taking odd +500' FLs and No 4 taking even + 500' FLs. Should the formation be more than 4 ac, the lead should allocate a wider range of height blocks.

20. **Lost Leader.**

a. **IMC.** Should a wingman lose his leader in IMC, an immediate R/T call is to be made. At the same time, the pilot is to transfer to HDD instruments and:

i. If wings are level, turn away 20° AOB, 20° for 20 sec, then resume original heading.

ii. If on the outside of a turn, level the wings.

iii. If on the inside of a turn, over-bank away to max 45°. The leader is to roll wings level.

iv. Continued separation is to be requested from the controlling agency. If descending, the wingman should level-off; if climbing or level, he is to maintain the profile.

b. **VMC.** Should a wingman lose his leader in VMC, he is to fly the ac into a known safe area.

## **CLOSE FORMATION POSITIONS**

21. **Close Formation References.** In Echelon or Vic, the No 2 is normally to fly on the right hand side of the leader. The close formation references are as follows:

a. **Echelon - 25° Wingsweep.**

- i Wing tip obstruction light on centre of Krueger flap.
- ii Top surface of wing visible.
- iii Jet pipes squared off.

b. **Echelon - 45° Wingsweep.**

- i Wing tip obstruction light below heat exchanger inlet.
- ii Top surface of wing visible.
- iii Jet pipes squared off.

c. **Echelon - 63/67° Wingsweep.**

- i Wing tip obstruction light below heat exchanger outlet.
- ii Top surface of wing visible.
- iii Jet pipes squared off.

d. **Close Line Astern.**

- i Nose-tail separation.
- ii Below leader's jet wash.

## **TACTICAL FORMATION**

22. Standard tactical formations are shown below. All other formations, particularly those required in escort duties, are to be specifically briefed. The following procedures are to apply in VMC, when not using TFR:



a. **Navigational Turns.** Turns required on a pre-planned navigation route are normally executed silently. The leader is to use  $60^\circ$  AOB and is to maintain speed. Element leaders are to anticipate or delay their turns to maintain position.

b. **Collision Avoidance.**

i During turns, the crew on the outside of the turn is responsible for collision avoidance and is to fly high if this is necessary.

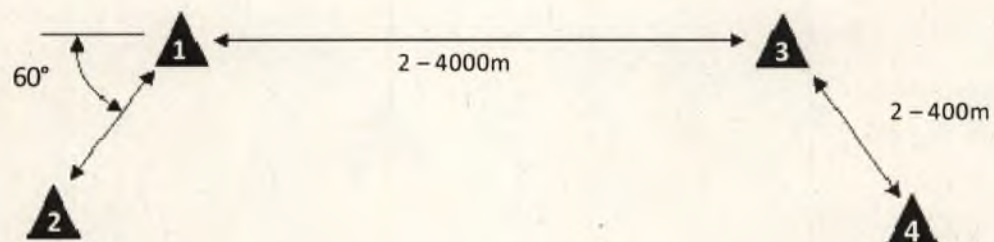
ii During 'shackle' or 'hook' manoeuvres, the wingman is responsible for collision avoidance.

iii The trailing element crews in a container formation are responsible for avoiding the ac ahead. The rear element crew on the inside of a turn must ensure that they remain clear of the front element ac on the outside of the turn. The dangerous situation of an over-square formation (battle width exceeds element trail distance) is to be avoided.

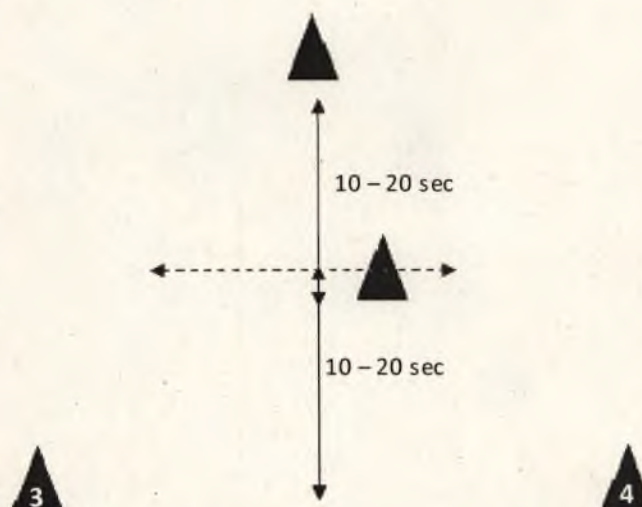
### TACTICAL FORMATION POSITIONS

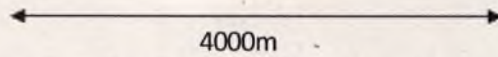
23. The following tactical formations may be employed; in all cases the ranges are a guide and may be changed to suit the tactical situation or the weather:

a. **Defensive Battle.**



b. **Goose.**





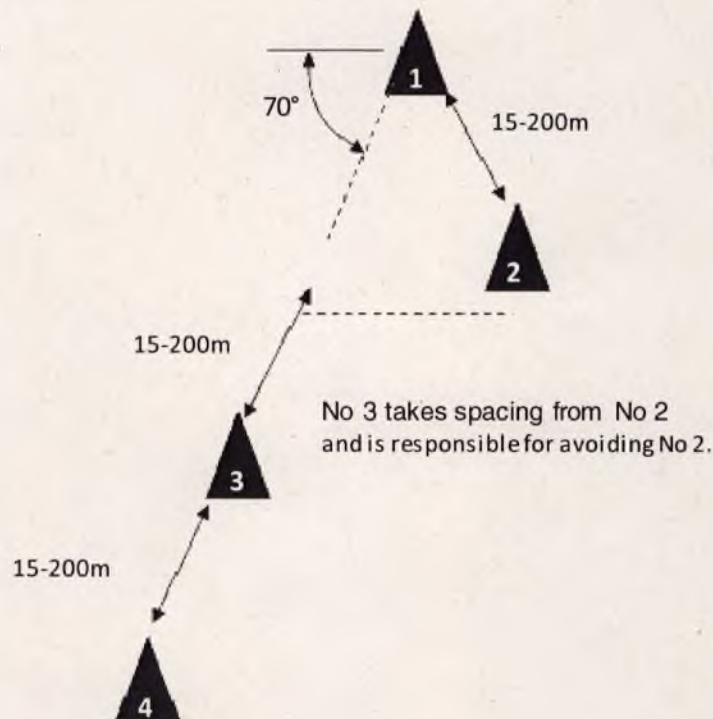
i. Goose formation is usually flown using a single-track plan and in VMC. For an IMC-compatible single-track plan with timings based on a 20 sec **war** trail at the split point, each ac flies on time except No 4, who flies 20 sec early.

ii. The leader's prime area for lookout is forward with the No 2 clearing the leader's '6'. Nos 3 and 4 clear No 2's '6' while covering each other as in a standard Battle-pair. Since the back pair flies assisted cross-over turns with a longer ground-track than Nos 1 and 2, it should turn at the same time as the No 2, to avoid being stretched. However, if the back pair become offset on the inside of a turn, there is a collision risk between the No 2 and the inside rear-man. In all cases, the back pair must avoid the front elements. For a single-track plan, Goose formation IMC/VMC transitions are carried out as follows:

iii. **VMC-IMC Transition.** On the call of "India Go", Nos 1, 2 and 3 regain their timelines if they are not already on them. No 4 S-turns towards No 3 and regains his timeline; the No 4 is responsible for safe separation from the rest of the formation.

iv. **IMC-VMC Transition.** When weather conditions permit, the leader calls 'Goose go', the No 4 accelerates or cuts corners to visually acquire No 3, calling him to jink to regain Battle, if reqd.

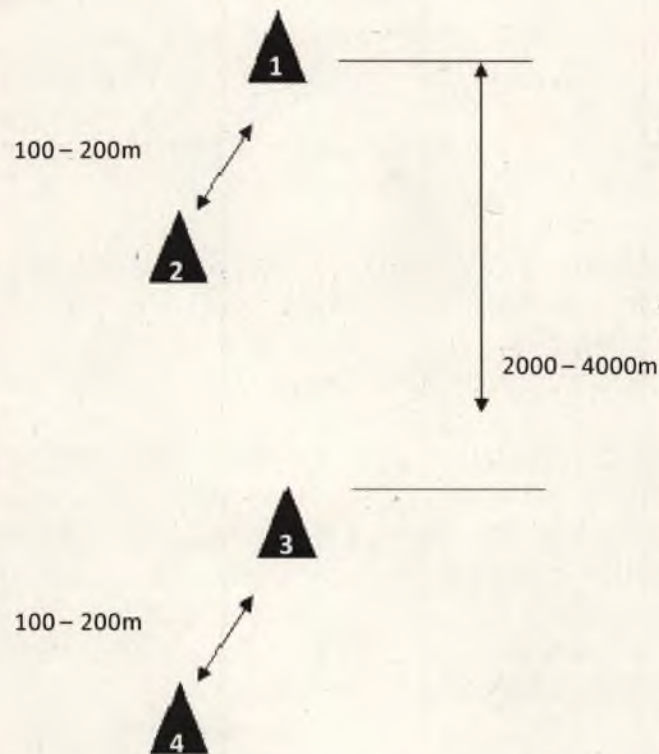
c. **Arrow.**



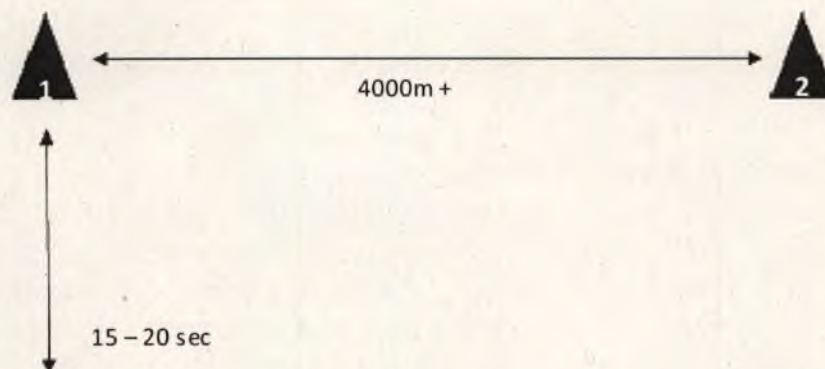
i. Fighting Wing tactical formation is a variation on Arrow to be used with a pair of ac only. No 2 is to take an appropriate spacing that allows the leader to manoeuvre fully. (See also EO Fighting Wing).

ii. At Low-Level, subordinate elements should fly a spacing commensurate with manoeuvrability; for recovery to an airfield and subsequent break into the circuit, subordinate elements may close up to the minimum spacing or slightly closer as long as there is nose to tail separation.

d. **Pairs Trail.**



e. **Container.**



i. If the distance between the first element (1 and 2) and the second element (3 and 4) is less than the separation within each element, the formation is 'over square' and a collision risk will exist in cross over turns.

ii. Trailing pairs are normally to offset iaw the threat direction.

iii. Container formation can be flown as below from either a single or // track plan. In VMC, it can be flown with the back pair compressed to a visual 20 sec and offset (away from turns), as required. This formation is the easiest to plan, but it is also the one the fighters expect to see and is easy for them to 'sort'. For an IMC-compatible single-track plan with timings based on a 20 sec **war** trail at the split point, both No 2 and 3 fly 20 sec early, and No 4 flies 40 sec early.

iv. **Lookout.** Within each pair, lookout is standard; however, the back pair can also check the '6' of the front pair. The arcs of primary lookout responsibility are: Pilot - 10 o'clock through 12 o'clock to 2 o'clock and WSO - 10 o'clock through 6 o'clock to 2 o'clock.

v. In Battle formation, WSO should concentrate their lookout across the formation. Both pairs fly standard battle-turns, turning at the same point. There is a collision risk between the outside front-man and the inside rear-man if the formation either becomes over-square or if the back pair offset to the inside of the turn. In all cases, the back pair are to avoid the front pair, by going high, if necessary. For a single-track plan Card formation, IMC/VMC transitions occur as follows:

vi. **VMC-IMC Transition.** To transition from VMC 40 sec Card to IMC trail, the leader calls 'India Go'. Nos 1 and 3 remain on or regain their time-lines, whilst Nos 2 and 4 turn towards their element leads. As they cross behind them, TF, FD, TRK and AP are engaged, which S-turns them to track in 20 sec trail. This also works for a pair flying in Battle. This is a difficult position to fly because of the lack of timeline flexibility.

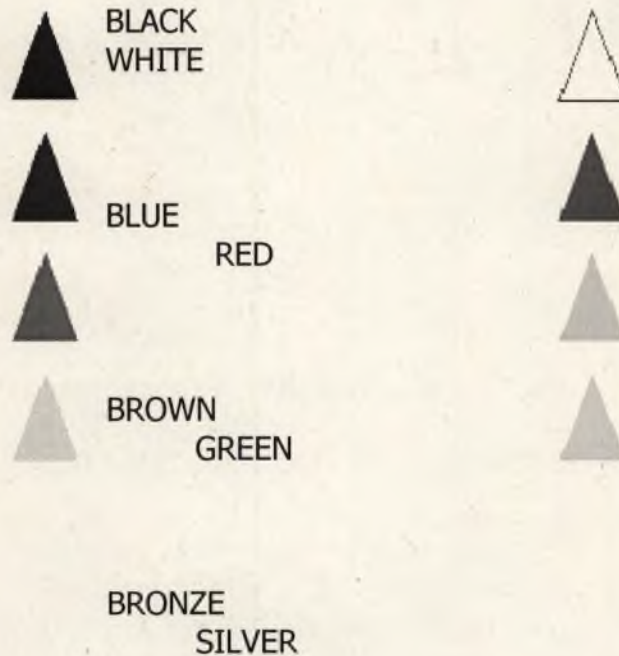
viii. The No 2 is to ensure safe separation from Nos 1 and 3 at all stages and must not rejoin track until on the time line. If this cannot be achieved, a turn away from the formation or a climb to MEA may be necessary. This situation may occur if close to a waypoint and in this case Nos 2 and 4 must stay outside the turn and away from track until back on the timeline. To increase safety and separation, all ac could fly left and right of track (using heading hold). **IMC-VMC Transition.** On the call of

"Container Go," Nos 2 and 4 accelerate and cut corners to regain Battle with element leaders, then compress or offset as required.

24. **Visual Reporting.** Sightings are always to be called in the order 'action' then 'information', as follows:

- Call-sign of reporting ac: -
- "*Individual Callsign*"
- Action to be taken: - "Lean 30 right"
- Left/Right, clock-code relative to reporting ac: - "Left 7 o'clock"
- High or Low: -
- "High"
- Range (in km): - "5 km"
- Type and number: - "2 Bandits"
- Activity: -
- "Closing"

Colour codes for ac position in larger formations can also be briefed to aid SA. Colour codes are as follows (eg if back left ac of a 4 ship gets Tally then the call would call 'Blue, Tally, left 8 o'clock High'):



25. **Radar Reporting.** Radar contacts should be reported as follows:

- Callsign of reporting ac:  
*Callsign*"

- "Individual

- Contact call:

- "2 contacts"

- Reference Bull:

- "330/24"

*Or*

- Azimuth:

- "30 left"

- Elevation:

- "2 up"

- Range (in nm):

- "Range 20"

- Activity:

- "Crossing

left to right"

Note: The formation can be given an action instruction if appropriate.

26. **RHWR Reporting.** RHWR contacts are to be reported iaw 3-1 / 80-6 terminology, as appropriate.

27. **Formation Terminology.** Differences exist in terminology between Refs A and B. Table One describes the differences between UK/NATO and USAF terminology.

UK / NATO	USAF
Battle	No direct equivalent
Arrow	No direct equivalent
Goose	No direct equivalent
Escort	No direct equivalent
Wall	Line Abreast

**Table One. Formation Terminology**

Table 2 conforms with Ref A and is to be used when flying formation:

BREAK LEFT/RIGHT	Directive call to perform an immediate maximum performance 180-degree turn (or as directed) in the indicated direction. Default is a 180-degree turn. Assumes a defensive situation requiring infrared missile defence and jettison.
HARD LEFT/RIGHT	Energy sustaining 180° turn (or as directed) in the indicated direction. The crew on the outside of the turn are responsible for collision avoidance and are to go high or achieve adequate nose/tail

	separation.
LEAN X° LEFT/RIGHT	Crews turn simultaneously through nominated number of degrees, maintaining speed and height.
HOOK LEFT/RIGHT	An in-place turn, through 180° using 60° AOB. The crew in trail during the manoeuvre adjusts to be in line astern at the 90° point; it also responsible for collision avoidance.
SHACKLE	Crews turn towards each other using 60° AOB and, after crossing over, reverse onto the required heading using 70-80° AOB. At co-altitude, collision avoidance is the responsibility of the element wingman, who is always to go high.
COME OFF X° LEFT/RIGHT	Manoeuvre as indicated to regain mutual support or to deconflict flight paths.

**Table 2. Basic Formation Directive Terminology**

28. **Formation Descent Through Cloud.** Close formation is to be used when a formation has to make a prolonged cloud penetration; radar trail should be used when there are more than 3 ac. The descent plan requires careful thought and should be briefed thoroughly before a sortie. If there is doubt regarding the accuracy of nav kit [REDACTED] consideration should be given to larger than normal spacing and/or time separation until a positional update can be guaranteed.

- a. **VMC.** Formations should descend in Battle or Arrow formation as appropriate.
- b. **IMC.** Formations should descend in close, using a radar service if possible. If VMC has not been achieved by the SALT, the leader should commence a singleton ATF descent on track to achieve VMC. Once VMC, the leader should fly at least 2 nm off track. Having informed the subordinate of the leader's location in relation to track, clearance will be given to the subordinate to commence an on-track ATF descent.

### **RADAR TRAIL - TRANSIT**

29. Radar Trail can be used to transit IMC or to maintain formation integrity at night without increasing pilot workload by flying in close formation. The principles are exactly the same as for departure; achieve radar SA backed up with another sensor and then use lead/lag to maintain position and monitor the radar azimuth/elevation changes to see turns, climbs, descents and using the AAS ROL to confirm the lead aircraft parameters once manoeuvring has ceased. The minimum radar trail separation is 1Nm.

30. If the aircraft is not armed with a Live Gun the easiest way of obtaining radar trail is to use the Pilot AAO mode and Pilots Hand Controller to slew the ranging

reticle, and command a lock using LOR/Phase Change. This will not generate an AAS ROL but the WSO still has lock information displayed on the FLIR repeater and in the NAV ROL which is sufficient for monitoring. Monitoring the azimuth and elevation information will indicate when the lead aircraft is manoeuvring but remember to use 7°/Nm to maintain the briefed trail separation. Once locked, the trail aircraft should call 'TIED' as an informative call to the flight lead that they are in radar trail.

31. [REDACTED]

this case the WSO should use similar procedures as for departure to achieve a radar lock to the ac ahead. The WSO will need to reduce the range scale to the minimum practicable and may need to switch between LONG and SHORT pulse to achieve a suitable return prior to attempting a LK ON. The Scale setting on the TARDIS and Pulse length on the MRCP determine the pulse repetition frequency (PRF) of the GMR which can affect your ability to achieve a LK ON. Generally speaking, the WSO should work in a range scale where the radar return is in the centre of the screen and use LONG pulse apart from close range (<1.5Nm) contacts. As for departure, the WSO should refine GAIN and TILT to ensure a discrete, pin head sized return prior to attempting LK ON.

## **APPROACH & LANDING**

### **RADAR TRAIL RECOVERY**

32. A radar trail recovery can be used in order to achieve VFR below and compress the formation for a subsequent visual recovery when close formation is not practicable. Trail aircraft should endeavour to initially fly the same headings and speeds to ensure they are following the same ground track and not compressing the formation/diverging from ATC vectors. Due to the limitations of the GR4 radar it is not practical to fly radar trail GCAs. Should instrument approaches be necessary the formation leader should arrange for ATC to split the formation into the required number of speaking units.

33. Before commencing a radar trail descent, elements are to achieve 2-3 nm separation. Element leaders are to call descending, the reference pressure is to be specified and elements are to fly the same speeds and headings. The formation leader is to call his height iaw TGRF descent procedures, call each level-off height and maintain speed.

34. When slowing on recovery, the lead pilot should call 'Decelerating XXX Kts' to give increased awareness to the trail pilot rather than relying on the WSO to detect the change from the AAS ROL. The trail aircraft should use lead/lag during any turns to maintain trail separation and can use the scanner elevation angle to fly the same descent angle as the lead aircraft. Once steady on heading, the trail aircraft should manoeuvre to be directly astern on the same heading.

35. During this phase the WSO should monitor the radar for changes by the lead aircraft and allow the pilot to concentrate on flying the aircraft and setting up for recovery. If required, WSOs should be directive to pilots in order to maintain trail separation.



36. As the ac ahead descends in close proximity to the ground the radar return can enter ground clutter. Keeping the depression angle relatively low (0 to  $-3^{\circ}$ ) may alleviate some of these problems. It is possible to follow the radar return lower in search than in LK ON, but trail ac should be on its own instrument recovery by then anyway.

37. **Formation Instrument Approach.** Formations are to split into pairs or singletons for instrument penetrations and approaches. The descent and recovery checks are to be completed before descending. The WSO is responsible for calculating the ac's threshold speed according to stores carried, fuel remaining and type of approach. The HUD height display is to be set to BARO. Manoeuvre flap may be used at any time without R/T or hand signals.

38. **Pairs Landing.** 'Echelon into wind' recoveries should be flown leading to pairs landings. The following procedures are to be adhered to:

a. **Pre-Landing Checks.** Pilots should select the SPILS off before moving into close formation if possible. Service selection is to be either called or signalled. After completion of his own pre-landing checks, the wingman is to inform his element leader of his indicated undercarriage position and full-flap threshold speed, (eg "Gear down, 156"). The leader is to compare this speed with his own, and is to use the higher value.

b. **Approach.** Prior to glidepath interception, ac are to be flown at 200 kt with mid-flap selected. At glidepath interception, or at the ATC call of 'begin descent now', pilots are to select full flap independently. The final approach is to be flown at 8 AOA until DH/MDH when the speed can be gradually tapered back to achieve threshold AOA. Within one mile of touchdown, the wingman is to fly slightly higher than normal, superimposing the lead ac's wingtip obstruction lights on the base of that ac's fuselage.

c. **Landing.** During the final stages of an approach, the wingman is to manoeuvre progressively to be able to carry out an independent landing using visual references. Lift dump is to be pre-selected, independently, in the flare. The element leader is not to use Pre-Armed Thrust Reverse (PATR). After landing, the leader is to select TR and maintain the throttles at IDLE until safe nose-tail separation from the wingman is achieved; the wingman is to use max dry TR. Power settings may then be adjusted as required. Crews must remain aware of the implications of lateral movement due to thrust reverse on a wet runway.

39. **Thrust Reverse/NWS Failure.** If a wingman suffers a TR or NWS failure, he is to call the problem immediately. The element leader is to continue with his TR braking and is to allow the wingman to overtake. The wingman is then clear to use the centre of the runway and to engage the cable if required.

40. **Pairs Low approach.** The leader is to call the decision to go around. He is to apply power as required and is to call or signal, gear and flap selections separately.

41. **Lead Low Approach/Wingman Landing.** When it is necessary for the leader to low approach and the wingman to land, the leader is to discontinue the approach at a minimum height of 150 ft and is to climb straight ahead. This is to ensure that the wingman avoids the wake turbulence produced by the lead ac. If the leader's ac is significantly heavier than that of the wingman, the wingman may need to make a large speed reduction prior to touchdown; in this case, the leader should discontinue his approach at an altitude greater than 150 ft. If the wingman is not able to continue with his approach and landing, he is to remain in formation throughout the go around.

34. **Recovery.** Ac are to run in on the dead side. Arrow formations are to be heavy side away from the direction of the break, with the No 2 sitting low relative to the leader. If for any reason the formation is heavy side towards the break, the formation is to break in numerical order with Lead, No 2 and No 3 breaking up and over the trailing ac. Echelon and tactical formations are to line up away from the direction of the break.

35. **Break and Landing.** The SOP break interval is 3 sec with airbrake being used for breaks flown above 360 kt. The leader is to call "*Formation Callsign Break*" with the intentions of each crew. Each pilot is to call "Final, gear down" in sequence. If the break is flown with 45° wingsweep selected, the wings should be moved forward as the speed decays below 350 kt (if within ac fit limits). Ac are to be landed on the centre line with a minimum touchdown separation of 3 000 ft. The briefed slow lane is only to be used when ac speed is safely under control.

Annex:









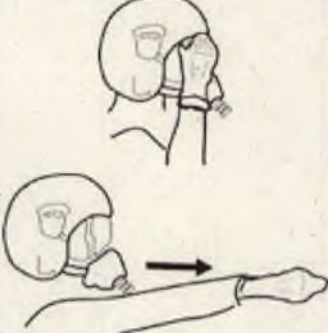
A. Silent Procedure Signals.

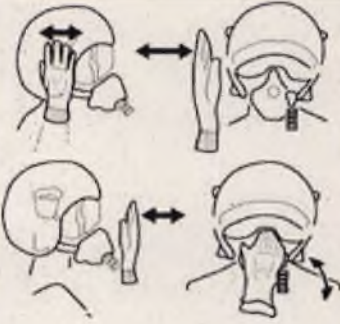

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# ANNEX A

# SILENT PROCEDURE SIGNALS

1. **Visual Signals.** The following visual signals are to be used during silent procedures or following R/T failure and are iaw STANAG 3379. The preparatory signal is to be given at least twice. A wing waggle may be required to attract the attention of another crew and instruct them to join-up in close formation.

Meaning (a)		Preparatory Signal (b)	Executive Signal (c)
Airbrakes - In or Out		Biting motion with hands, fingers and thumb meeting and opening alternately 	Nod of head 
Flaps and Slats (not manoeuvres)		Hand flat - fingers forward. Downward motion of hand from wrist to lower flaps, reverse motion to raise flaps. Each signal indicates one flap position change only (ie UP to/from MID, or MID to/from FULL) 	Nod of head 
Undercarriage		Hold a closed hand near the top of canopy and then move the hand vertically downward and upward three times 	Nod of head 
Wing sweep	Rearward	Rearward motion of horizontally held arm, bent at the elbow, with the forearm pointing forward. Each signal indicates one wingsweep position change only (ie 25° to 45°, or 45° to 63°/67°)	Nod of head 
	Forward	Forward motion of horizontally held arm bent at the elbow, with the forearm pointing forward. Each signal indicates one wingsweep position change only (ie 63°/67° to 45°, or 45° to 25°)	Nod of head 
Power on		Forearm vertical with fingers of a clenched fist forwards, rotating the fist at the wrist	Cessation of signal
Take over the lead		Point to new leader then hold an open hand vertically at eye level with fingers together and move it horizontally forward to finish with arm fully extended and hand pointing forward 	Cessation of signal
Join into close		Lateral rocking of wings	Cessation of signal

<b>Meaning</b>  <b>(a)</b>	<b>Preparatory Signal</b>  <b>(b)</b>	<b>Executive Signal</b>  <b>(c)</b>
formation		
Relax formation	Push palm outwards, fingers together, against the canopy	Cessation of signal
Move to echelon left or right	Point at ac concerned and indicate with forefinger to move across	Cessation of signal
Radio failure	<p>Rx only - tap earphone with an open hand and then move hand forward and backward over the ear position</p> <p>Tx only - tap mask with an open hand and then move hand up and down in front of the face</p>	
Systems failures (HEFOM Code)	<p>In the event of no R/T contact, the HEFOM code is to be used to indicate the nature of an emergency as follows:</p> <p>Hold clenched fist to the top of the canopy and then raise the appropriate number of fingers to indicate the emergency or malfunctioning system:</p> <p>H - Hydraulics 1 finger (forefinger)</p> <p>E - Electrics 2 fingers</p> <p>F - Fuel 3 fingers</p> <p>O - Oxygen 4 fingers</p> <p>M - Motor 5 fingers (open hand)</p>	

<b>Meaning</b> <b>(a)</b>	<b>Preparatory Signal</b> <b>(b)</b>		<b>Executive Signal</b> <b>(c)</b>
Abandon ac	Imitate pulling face blind		Cessation of signal
Wish to land at nearest airfield	Hold open hand horizontally above the shoulder and then move it forward and downward finishing with a movement to simulate rounding out for a landing		
Wish to land at base	Describe a circle with the forefinger on the side of the canopy pointed at the leader		
You are on fire	Draw hand across throat		

<b>Meaning</b>  <b>(a)</b>	<b>Preparatory Signal</b>  <b>(b)</b>	<b>Executive Signal</b>  <b>(c)</b>
<p>What is your fuel state?</p>	<p>Clenched fist, thumb to mouth as though drinking, then:</p> <p><u>Tornado to Tornado:</u></p> <p>My Fuel State is 2300 kg. Display clenched fist 2 times (once per 1000 kg) and then 3 fingers (1 per 100 kg).</p> <p><u>Tornado to Other Aircraft:</u></p> <p>Iaw STANAG 3379, report estimated flying time remaining, ie estimated time until minimum landing fuel. To indicate less than 10 min of fuel remaining, give the 'wish to land at the nearest airfield' signal. To indicate a greater amount of fuel remaining, clench fist with the appropriate number of fingers extended as follows:</p> <p>10 - 20 min Forefinger</p> <p>20 - 30 min 2 fingers</p> <p>30 - 40 min 3 fingers</p> <p>40 - 50 minutes 4 fingers</p> <p>50 minutes 5 fingers</p>	<div data-bbox="846 642 1117 799" data-label="Image"> </div> <div data-bbox="938 1403 1024 1539" data-label="Image"> </div> <p data-bbox="834 1569 1133 1597">FUEL REMAINING 30 - 39 MIN</p>

<b>Meaning</b>  <b>(a)</b>	<b>Preparatory Signal</b>  <b>(b)</b>	<b>Executive Signal</b>  <b>(c)</b>
<p style="text-align: center;">Desired approach speed</p>	<p>To indicate desired approach speed, tap shoulder with an open hand. This indicates a desired approach speed of 130 kt.</p> <p>For each desired increase of 10 kt above 130 kt, hold a closed hand at or above eye level with one finger extended vertically per 10 kt.</p> <p>For desired approach speeds in excess of 180 kt, extend one finger horizontally for each desired increase of 10 kt above 180 kt.</p> <p>eg tap a shoulder and show three fingers extended vertically for a desired approach speed of 160 kt</p> <div style="text-align: center;"> </div>	

