The Dassault Mirage F1
in South African Air Force service

Revision 1
January 2025

Revision 1

Revision 0 of this document was published in September 2024. Subsequent to that, I received several valuable comments and corrections from various sources and it was decided to incorporate these into an updated revision 1. This has resulted in significant updates to the original content as presented in Revision 0.

As part of this update, Martin Strümpfer and I started a dialogue lasting around 3 months in which many changes were made based on additional research and information obtained from other sources. Martin is the man in charge of the refurbishment of Mirage F1CZ #213 at the SAAF Museum Ysterplaat and has a wealth of insight into the SAAF F1s both from his interaction with #213 and his personal research. Thanks also to Greg Swart for sharing his extensive SAAF Mirage F1 image records obtained through years of internet research.

Where possible, information provided which can be considered "anecdotal" has been avoided with a focus rather on confirming the accuracy and validity of the data presented.

The main changes therefore included in the 5 volumes of this updated document on the SAAF Mirage F1s are:

Volume	Page / section	Correction	Originator
All volumes		Corrections of some general typos and grammatical content.	-
Vol 1	Section 1.7	Correction to the alleged MiG-21 kill by CZ #203.	MiG Diaries
Vol 1	Section 1.12	New section added as 1.12 and subsequent sections renumbered. 1.12 addresses the F1 cleared external stores in 1975.	Dassault document
Vol 1	Section 1.11	Updated research on SAAF F1 self-protection systems – radar warning system, RIMS and active countermeasures pods (Bikini)	Martin Strümpfer
Vol 1	Section 1.13	Data added on the development of air-to-air missiles for the F1AZ/CZ	Martin Strümpfer
Vol 1, 3 and 5	Vol 1, 3 and 5	Reference updates to some of the stores carried by the F1. This includes some excerpts for Dassault F1 documents pertaining to the SAAF F1s external stores at time of delivery. Refer to Section 1.12 – Dassault SAAF Mirage F1 weapons options.	Dassault F1 documents
Vol 2	Section 4	CZ low visibility blue-grey camouflage development	Martin Strümpfer / Geoff Timms
Vol 4	Various	Added more detailed content relating to the development of the various Mirage F1AZ camouflage schemes including the low visibility blue/grey camouflage schemes.	Martin Strümpfer
Vol 4	Section 4.4	Interim camouflage scheme data and text updated based on further research.	Martin Strümpfer
Vol 4	Section 4.5	Final camouflage scheme data and text updated based on further research.	Martin Strümpfer

Introduction

Research forms an essential part of the scale modeling experience. There has been much written about the Mirage F1 in service with the South African Air Force (SAAF). Most of this available content addresses the service and operational history of the F1. It is therefore not the intent of this document to replicate this data (a reference list of excellent works is provided at the end of Volume 1 of this document). This document instead will focus on technical details, camouflage and markings and weapons systems used by the SAAF Mirage F1CZ and AZ.

This document is image rich and therefore, to keep electronic file size limited, it is produced in five volumes, each as a separate PDF document :

- **Volume 1** provides a high-level summary of the Mirage F1CZ and F1AZ in SAAF service. The bulk of volume 1 focuses on the details of the AZ and CZ demonstrated with images of several surviving aircraft taken by the author.

- **Volume 2** focusses on the various colour schemes and markings as applied to the Mirage F1**CZ** during SAAF service.

- **Volume 3** focusses on the external stores used by the Mirage F1**CZ** during SAAF service.

- **Volume 4** focusses on the various colour schemes and markings as applied to the Mirage F1**AZ** during SAAF service.

- **Volume 5** focusses on the external stores used by the Mirage F1**AZ** during SAAF service.

In compiling this document, data has been obtained from various Internet sources and individual contributors. This data has been cross-referenced where needed to ensure, as much as possible, the consistency and correctness of that data. There have been many contributors to various Internet forums relating to the SAAF Mirage F1 and the Unofficial SAAF Website (saairforce.co.za). Without the efforts of fellow Mirage enthusiasts in providing this written and photographic documentation of the history of the F1 in SAAF service, this narrative would not have been possible. Many of the images sourced from the Internet have been used without specific permission of the originators as, in many cases, these are unknown. Others have been included with the originators' details retained and unedited as sourced from the Internet. The images have been included in this document on a "fair use" basis for the purposes of historical research and the recording thereof. This document is offered as a free E-book and in no way does it provide a source of income for the author or any other party.

Most digital images of SAAF Mirage F1s sourced from the Internet tend to be of low quality (some less than 50kB in size), which makes it difficult at times to interpret specific details. Notwithstanding this lack of quality, these low-resolution images have been included to address specific aspects of the Mirage F1AZ and CZ. These images have been used as sourced from the Internet and have not been subject to any adjustments (hue, saturation etc.) and have not been sharpened.

This document uses terminology from the operating period of the Mirage F1 in SAAF service. As an example, names such as South West Africa (now Namibia) are used in their historical context and not as an expression of the author's political views.

Volume 1 – the Dassault Mirage F1 in South African Air Force Service

- Section 1.1 – A very brief introduction to the Mirage F1 in SAAF service
- Section 1.2 – SAAF Castles
- Section 1.3 – Differences between the AZ and CZ :
- Section 1.4 – Nose profile comparison – AZ to CZ
- Section 1.5 – Intake shock cones ("mice")
- Section 1.6 – Avionics and antenna locations
- Section 1.7 – Mirage F1CZ #203 details
- Section 1.8 – Mirage F1CZ #207 details
- Section 1.9 – Mirage F1AZ #235 details
- Section 1.10 – Mirage F1AZ #227 details
- Section 1.11 – Mirage F1 self-protection upgrades
- Section 1.12 – Dassault SAAF Mirage F1 weapons options.
- Section 1.13 – South African Air-to-Air Missile Development 1966 – 1990
- Section 1.14 – SMR-95 engine installation on AZ #216.
- Section 1.15 – AZ nose details.
- Reference list

Volume 2 – Mirage F1CZ camouflage and markings

- Section 2.1 – Mirage F1CZ Colours and Markings
- Section 2.2 – F1CZ #200 – pre-delivery scheme
- Section 2.3 – Original delivery scheme
- Section 2.4 – CZ low visibility blue-grey camouflage
    - Section 2.4.1 – camouflage development (research by Martin Strümpfer)
    - Section 2.4.2 – Later low visibility 3-tone blue/grey camouflage
    - Section 2.4.3 – CZ #203 "Le Spectre" low visibility camouflage trials scheme
    - Section 2.4.4 – CZ Low visibility 3-tone blue/grey camouflage – fleet application
- Reference list

Volume 3 – Mirage F1CZ external stores

- Section 3.1 – stores and weapons carried by the CZ
- Reference list

Volume 4 – Mirage F1AZ camouflage and markings

- Section 4.1 – Mirage F1AZ Colours and Markings
- Section 4.2 - Pre-delivery AZ #216
- Section 4.3 – AZ Delivery camouflage scheme
- Section 4.4 – Interim camouflage scheme
- Section 4.5 – Final dark earth/green/medium grey camouflage
- Section 4.6 – AZ in low visibility 2-colour / 3-colour blue-grey camouflage
- Section 4.7 – AZs operated by other air forces
    - Section 4.7.1 – Gabonese Air Force AZs
    - Section 4.7.2 – Congo-Brazzaville Air Force AZs
- Reference list

Volume 5 – Mirage F1AZ external stores

- Section 5.1 – stores and weapons carried by the AZ
- Reference list

To keep things simple, this document refers simply to the "AZ" and "CZ", the "Mirage F1" being dispensed with. Instead of using "aircraft tail number", this document uses the symbol "#". So, AZ tail number 216 is written as AZ #216.

Assistance in researching for these documents was provided by the SAAF F1 fan group :

- Geoff Timms
- Jonathan Durant
- Marc Conti
- Martin Strümpfer
- Greg Swart
- Herman Penderis
- Zander Labuschagne – specially providing photos of Squadron diaries

Particular thanks goes to Martin Strümpfer for reviewing the draft documents and providing an essential quality check and much needed technical input.

This E-book was compiled by Malcolm Reid
malcolmreid1136@gmail.com
Pretoria January 2025

The Dassault Mirage F1
in South African Air Force service

VOLUME 1

Mirage F1AZ and CZ

Revision 1
January 2025

South African Air Force Mirage F1 – Volume 1
F1AZ and CZ in SAAF service with detailed photos of four aircraft

Section 1.1 – A very brief introduction to the Mirage F1 in SAAF service

The South African Air Force (SAAF) operated a fleet of 16 Mirage F1CZs and 32 Mirage F1AZs. These were manufactured by Dassault in France. The "Z" was a suffix allocated by Dassault to designate those aircraft supplied to South Africa. The SAAF F1s were allocated the following SAAF serial numbers :

- F1CZ – serial 200 to 215
- F1AZ – serial 216 to 247

The first deliveries of the CZ and AZs to the SAAF were in 1975. The CZ was operated by 3 Squadron and was retired from service in 1992. The AZ was operated by 1 Squadron and was retired from service in 1997. Both the CZ and AZ flew a significant number of combat operations in the South West Africa / Angola Border War, with combat sorties flown over the Southern Angola region.

The CZ was designed for air-to-air missions and carried an air intercept radar (Cyrano IV). The AZ was designed for the ground attack mission and the Cyrano radar was thus removed. The AZ nose profile was modified to accommodate a smaller ranging radar and a laser targeting system which was located in a prominent fairing beneath the nose. The revised nose design of the AZ accommodated a retractable aerial refueling probe. The CZ did not have an aerial refueling capability. There were also different avionics and instrument panel details between the CZ and the AZ. For example, the AZ had a moving map display unit located on the instrument panel whereas the CZ had the radar scoped fitted with a prominent anti-glare shroud over it.

Several modifications were brought into effect for both the AZs and CZs based on combat experience in the 1980s over Southern Angola. These included :

- A locally developed radar warning system (RWS) which consisted of a number of small antennas to provide 360-degree radar threat warning.
- A locally developed chaff and flare dispenser system called Radar and Infrared Misleading System (RIMS). This consisted of chaff and flare dispensers located in modified ventral stabilizers located on the rear fuselage. A separate RIMS chaff/flare dispenser could also be fitted to inboard wing station "0", but it is unlikely that these were used operationally (in combat).
- ELT-555 electronic warfare pods carried externally on the wings.

After having been withdrawn from SAAF service, several AZs were exported to the air forces of Gabon and Congo-Brazzaville.

Specific details and differences between the AZ and CZ will be presented in the images in this document.

The following airframes are represented in detail in this volume ::

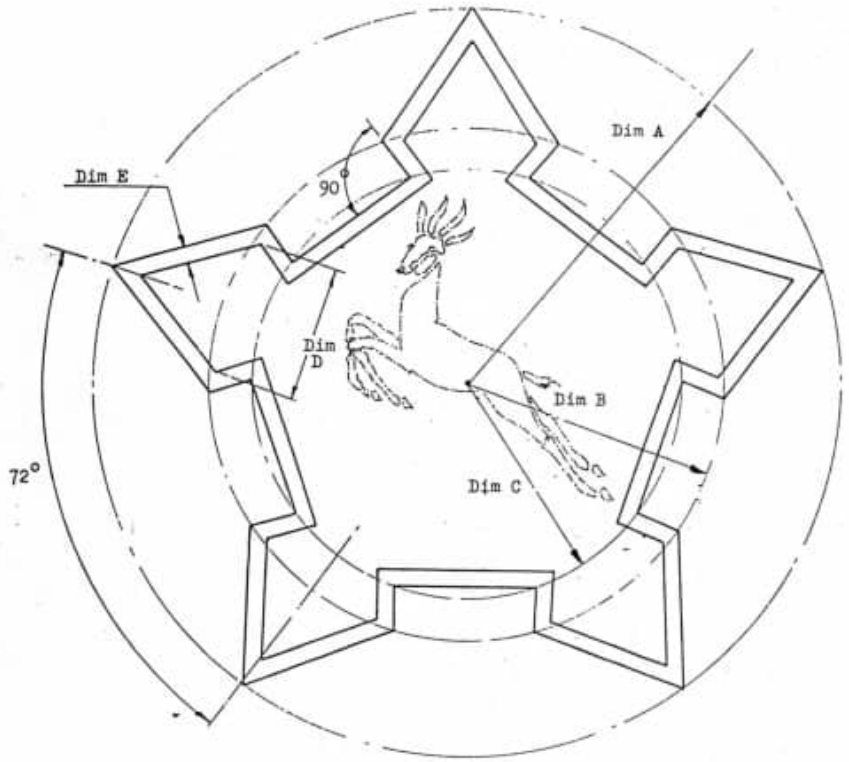
- Mirage F1CZ #203 – this is currently preserved at the SAAF Museum, Swartkop Air Base, Pretoria
- Mirage F1AZ #235 – this is currently preserved at the SAAF Museum, Swartkop Air Base, Pretoria
- Mirage F1CZ #207 – this is currently preserved at Stellenbosch Airfield in the Western Cape
- Mirage F1AZ #227 – as seen at the Africa Aerospace and Defence (ADD) expo held at Waterkloof Airbase in 2004

Section 1.2 – SAAF Castles

The SAAF Castles applied to the Mirage F1AZ and CZ were 24" in diameter when measured by tracing a circle around the apex of each leg of the Castle. The Castle was dark blue with a white surround. A **gold** (not yellow !) Springbok was applied to the blue portion of the Castle. The Springbok would face forward on the Castle when applied to the fuselage and inwards towards the fuselage when applied to the wings with the legs towards the wing trailing edge. Generally the Castles were applied in six locations – on the engine intakes just aft of the intake leading edge and on the upper and lower wing surfaces, towards the wing tips. However, there were variations to this depending on the actual camouflage scheme applied.

Some of the AZs in the final camouflage scheme had the Springboks replaced with the SAAF Eagle.

SOUTH AFRICAN AIR FORCE NATIONAL MARKINGS.



Colours: Castle - Aircraft Blue BS 381C - 108
Outline - White
Springbok - Pale Gold

Standard Insignia Sizes.

BASIC SIZE		A	B	C	D	E	
304	12"	152	104	87	50	7	
457	18"	229	156	130	76	10	
610	24"	305	207	174	102	13	
762	30"	381	259	217	127	16	
912	36"	457	311	260	170	19	
1220	48"	610	415	347	203	19	
1372	54"	686	467	390	230	19	
1525	66"	838	556	479	314	25	

Dimensions are in mm.

Section 1.3 – Differences between the AZ and CZ :

	AZ	CZ
Radar	Aida ranging radar with small conical radome plus laser range finder on lower forward fuselage. The overall nose profile was different to the CZ.	Cyrano radar with large conical radar nose.
Pitot probe	Located on a fairing beneath the forward nose.	Extends from the tip of the radome.
Inflight refuelling probe	Retractable refuelling probe on the nose ahead of the windshield and offset to starboard.	None.
Cockpit	Navigation rolling map display centrally located on instrument panel.	Radar scope with viewing shroud located on the instrument panel.
UHF blade antenna	Upper spine aft of canopy.	Initially beneath forward fuselage then later moved to upper spine aft of canopy (as with AZ). Move assumed to have coincided with installation of RWS (see later in document).
Night intercept spotlight	None.	Located on the left hand intake.

Details to note :

- Note 1 - differing sizes of the nose gear small side opening doors. Refer to photos in this volume. This detail applies to both the AZ and CZ.
- Note 2 - the intake shock cones (or "mice" as Dassault called them), were much longer on the SAAF Mirage F1s (both the AZ and CZ) than on F1s operated by other air forces. Refer to photos in this volume.
- Note 3 – the F1 had wing leading-edge **slats** outboard and leading-edge **flaps** inboard.

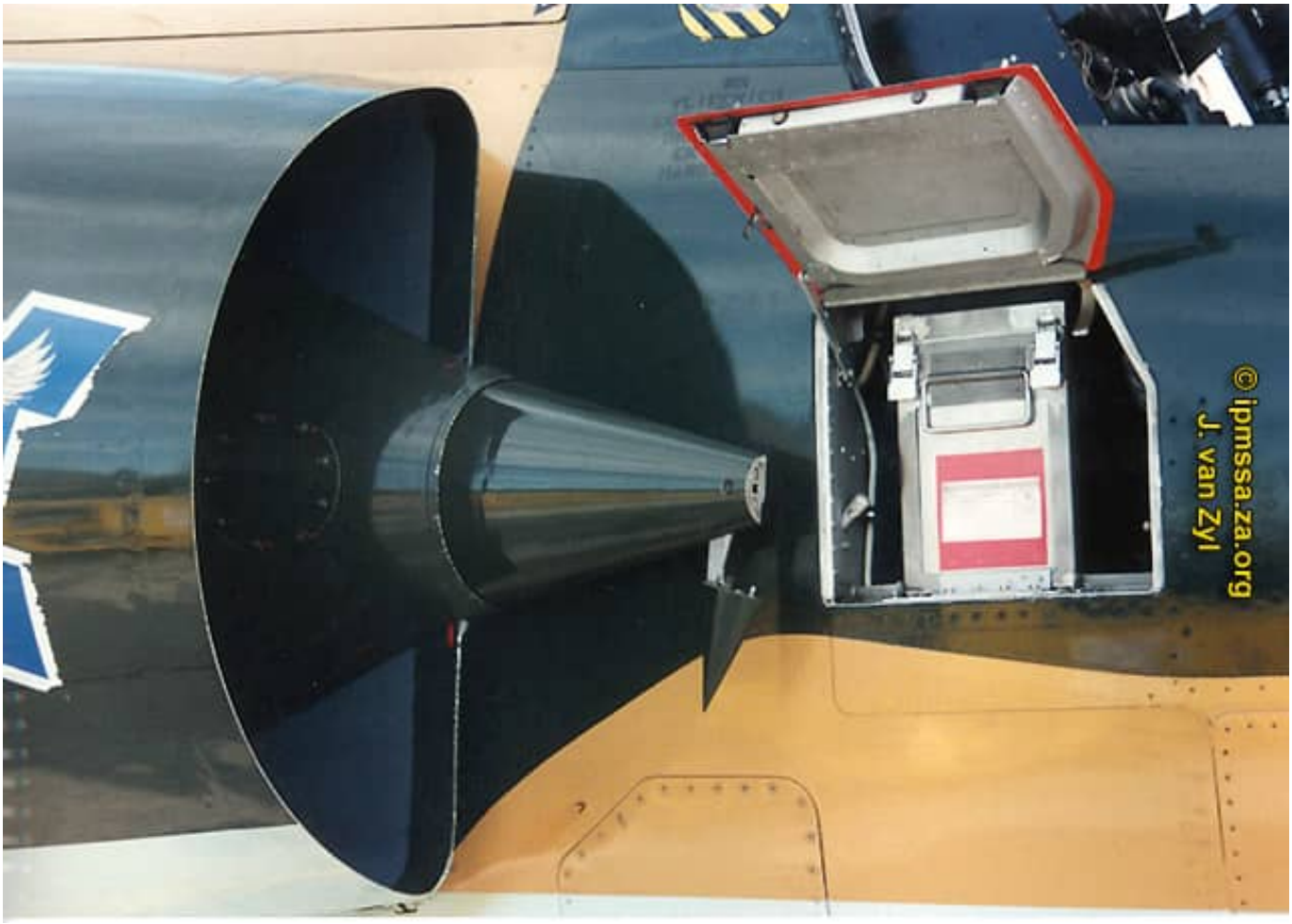
Section 1.4 – Nose profile comparison – AZ to CZ

AZ nose profile. Note the small black ranging radar and the laser designator beneath the nose. There are also access panels both sides of the AZ nose. The pitot probe is located beneath the ranging radar.

CZ nose profile. The nose shape is more symmetrically conical to house the Cyrano IV radar. There are no access panels. The pitot probe extends from the tip of the nose.

Section 1.5 – Intake shock cones (“mice”)

Comparison of configuration and length of the intake shock cone - French F1C above, SAAF F1CZ #203 below (AZ similar to CZ). Note the “double triangular” or “bi-conic” shape is for the CZ and how far forward the tip of the intake shock cone is so that it overlaps the small inspection panel (for access to the Liquid Oxygen or LOX system).

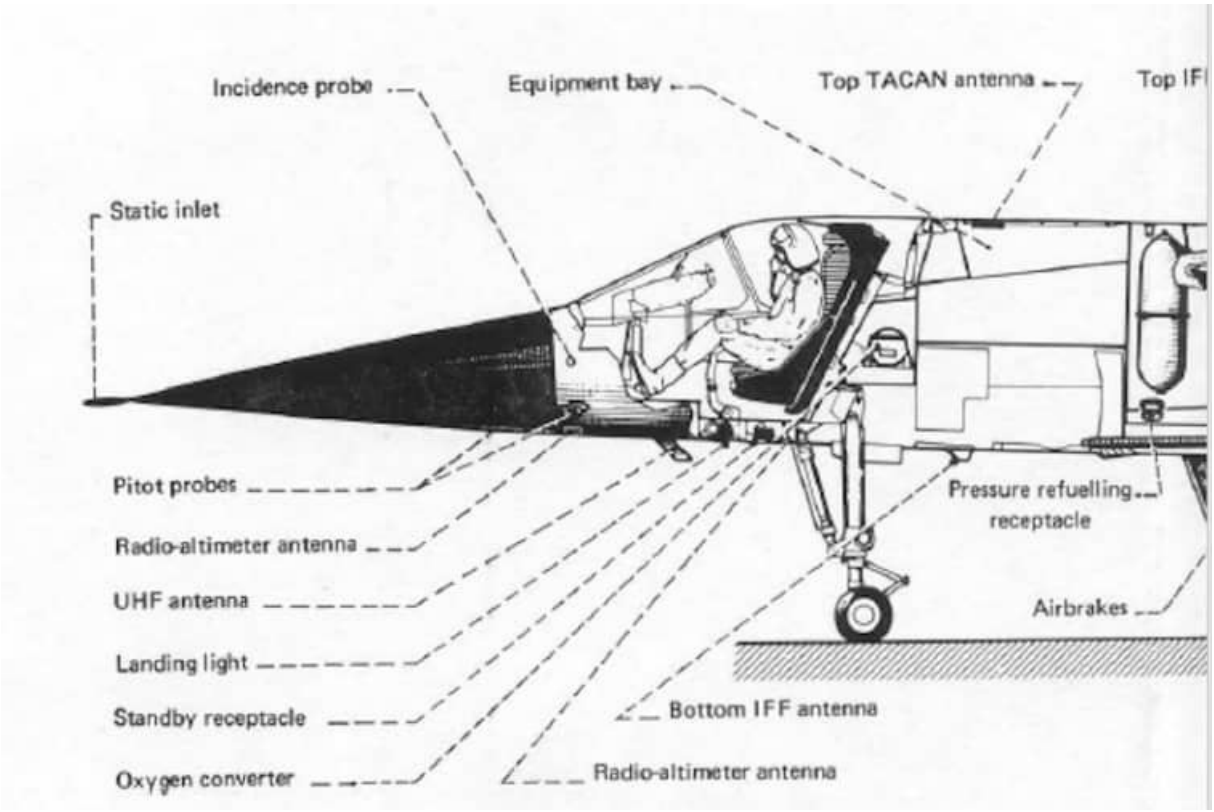


The front part of the shock cone on the AZ and CZ hinges downwards on both sides of the fuselage to provide access to the battery.

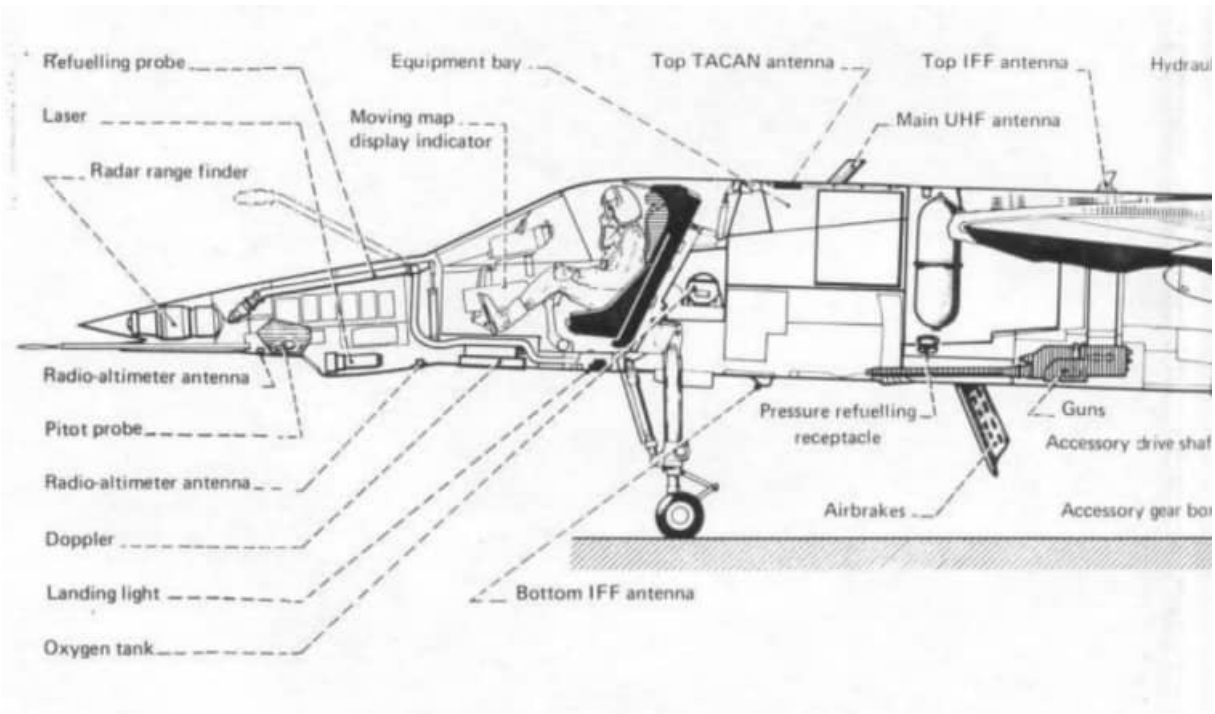
During initial development trials with the F1, Dassault was testing a bi-conic shock cone shape which was theoretically considered to provide a better engine intake pressure recovery at high Mach numbers and therefore improved engine / aircraft performance. The SAAF opted for this bi-conic arrangement under the rationale that in the lower density air over the hot and high South African highveld the improved pressure recovery would retain the Mach 2 performance of the aircraft. In practice however it was realized that it provided limited improvement in performance. The French and other users of the F1 opted for the simpler shock cone shape.

Section 1.6 – Avionics and antenna[1] locations

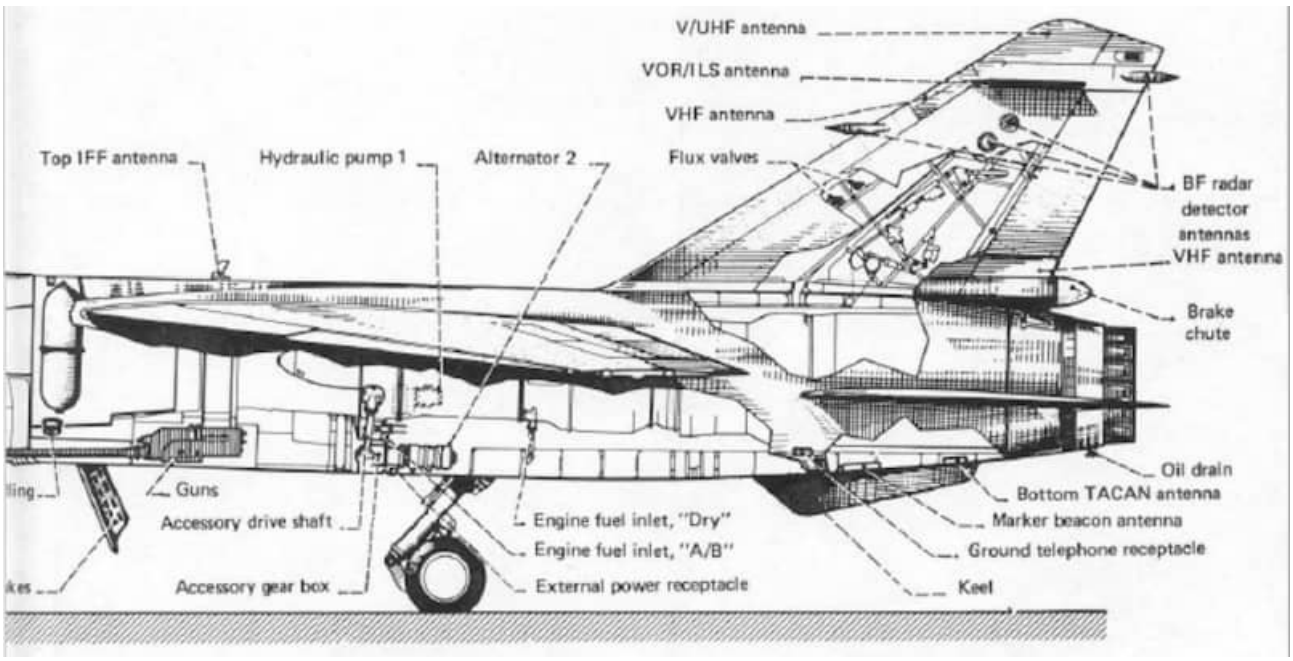
The images on the following pages have been extracted taken from the CZ and AZ Flight Manuals – these show the arrangements of avionics and antenna locations as well as some of the differences between the CZ and AZ.



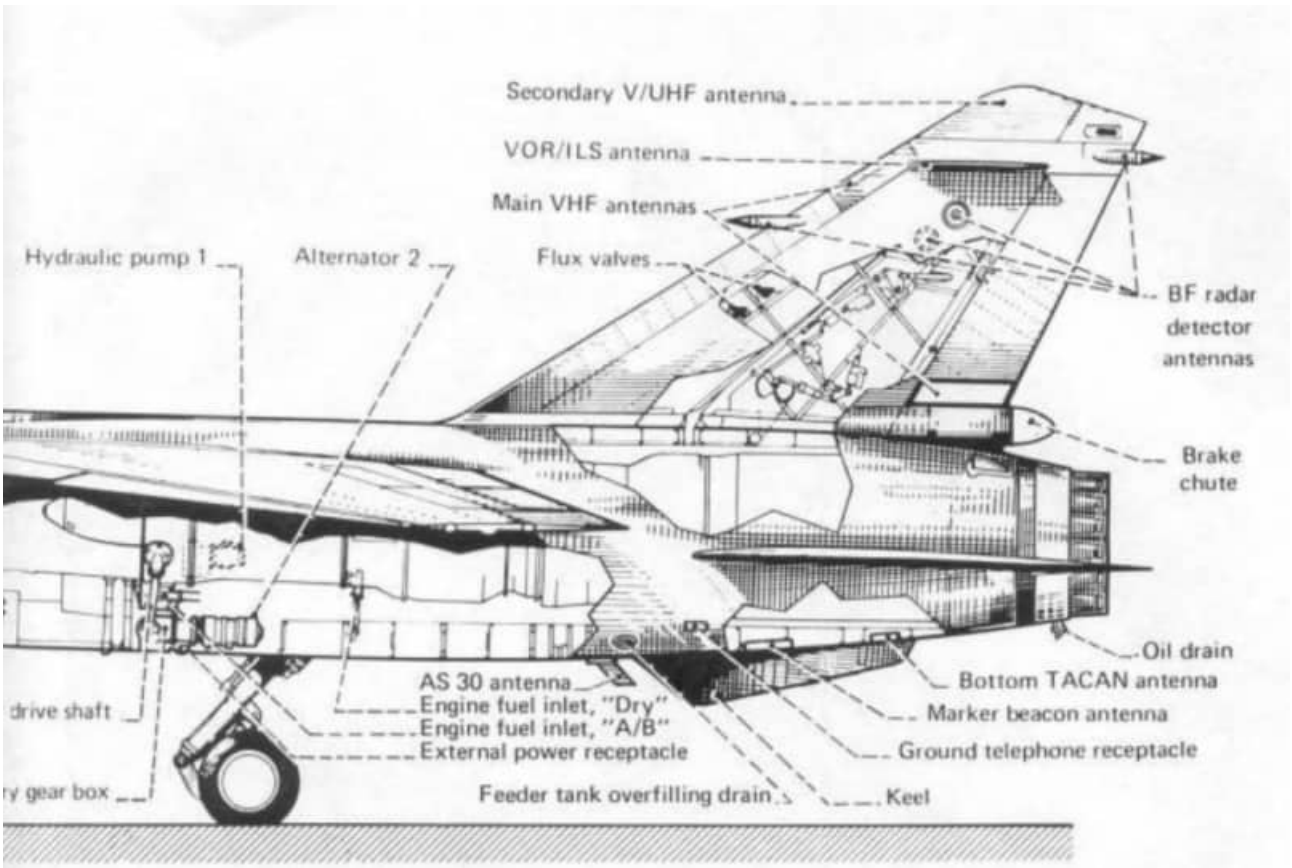
CZ above, AZ below. The major difference lies in the nose – conical nose for the CZ to house the Cyrano IV radar, whereas the AZ nose houses a smaller ranging radar, a laser target designator beneath the nose and the aerial refueling probe (shown in the extended position). There are also differences in the location of the main UHF radio antenna and pitot probes.

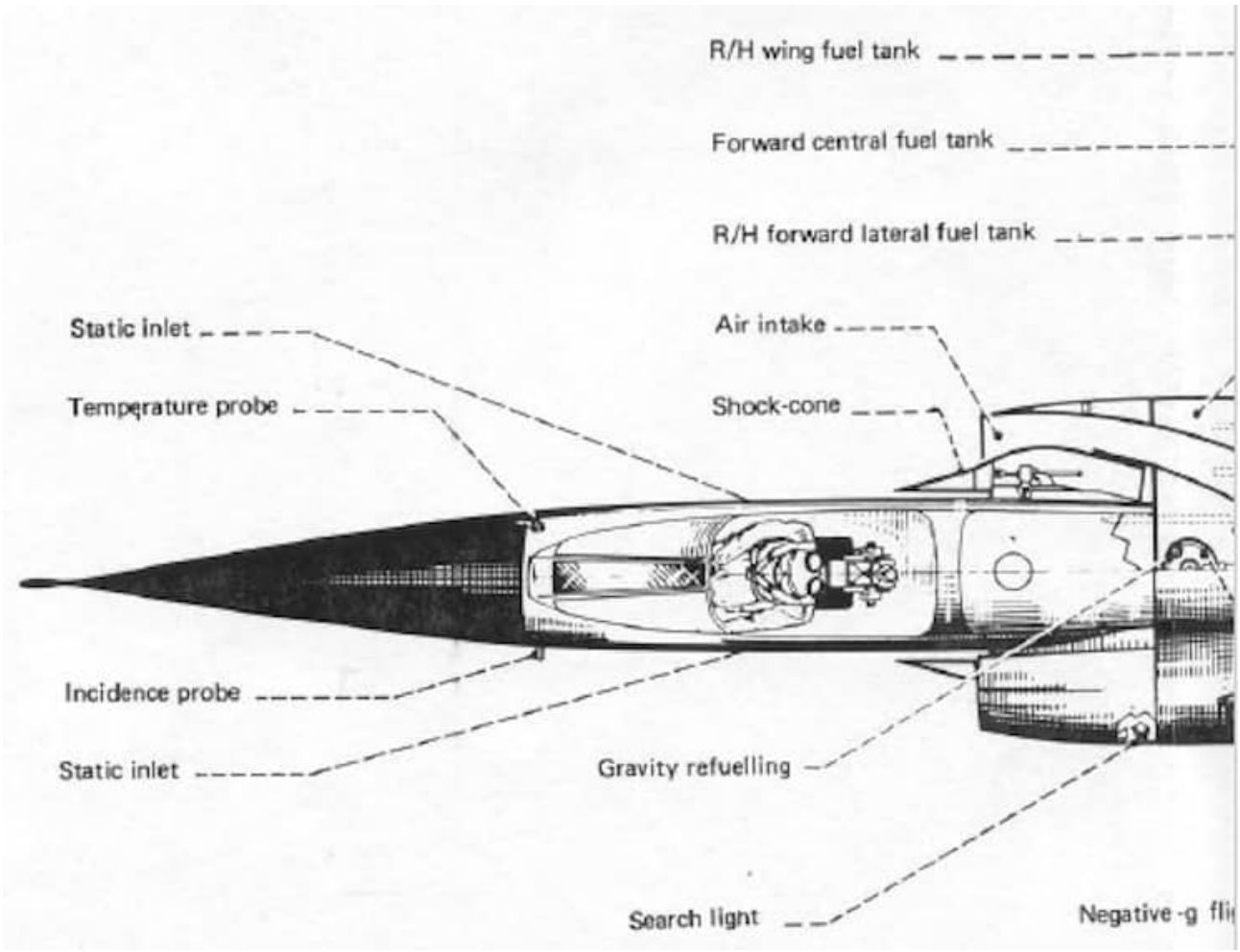


[1] The plural noun form of "antenna" comes in two flavors: "antennas" and "antennae." If you look up antenna in an English dictionary, you'll see that the plural, antennas, is used to refer to electrical instruments, and antennae, to the protuberances found on the heads of insects.

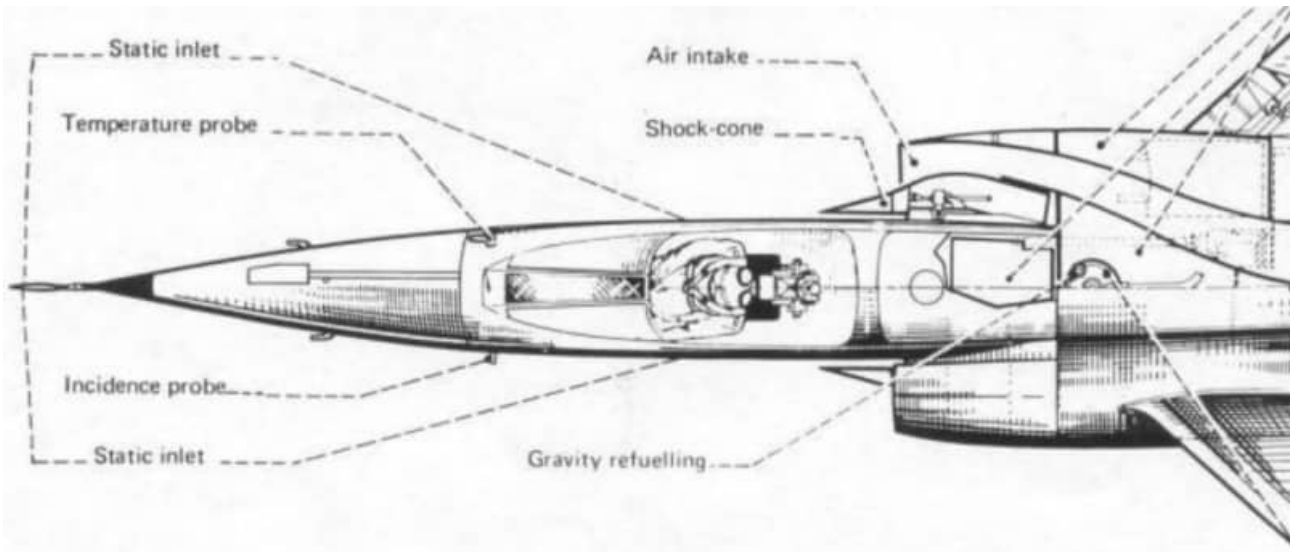


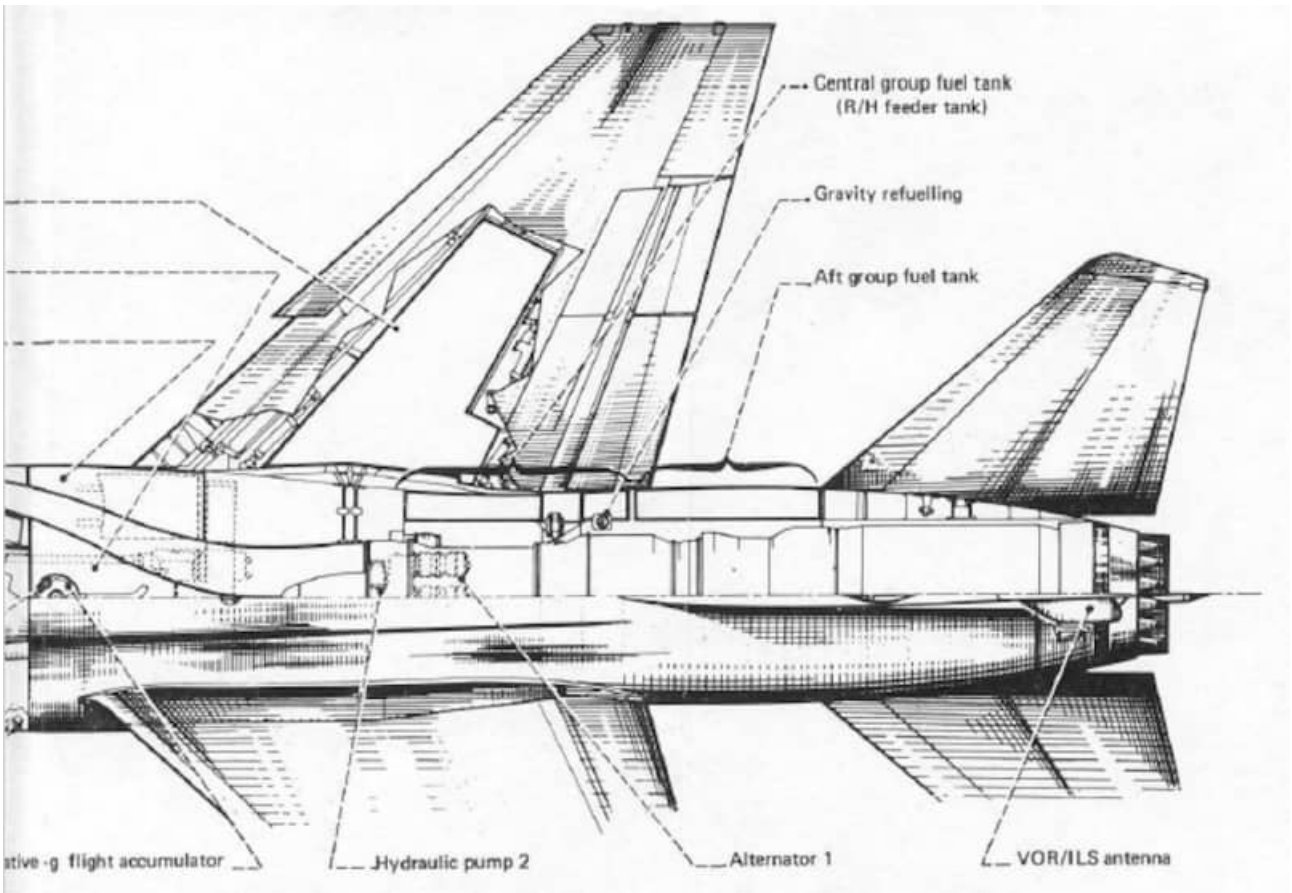
CZ above, AZ below. The notable difference is that the AZ has an blade antennas on the lower rear fuselage for command guidance of the AS 30 air to ground missile. Both of these flight manual images show the AZ and CZ in pre-RIMS and RWS mod state – the original French supplied BF radar detector antennas are shown on the vertical stabilizer.



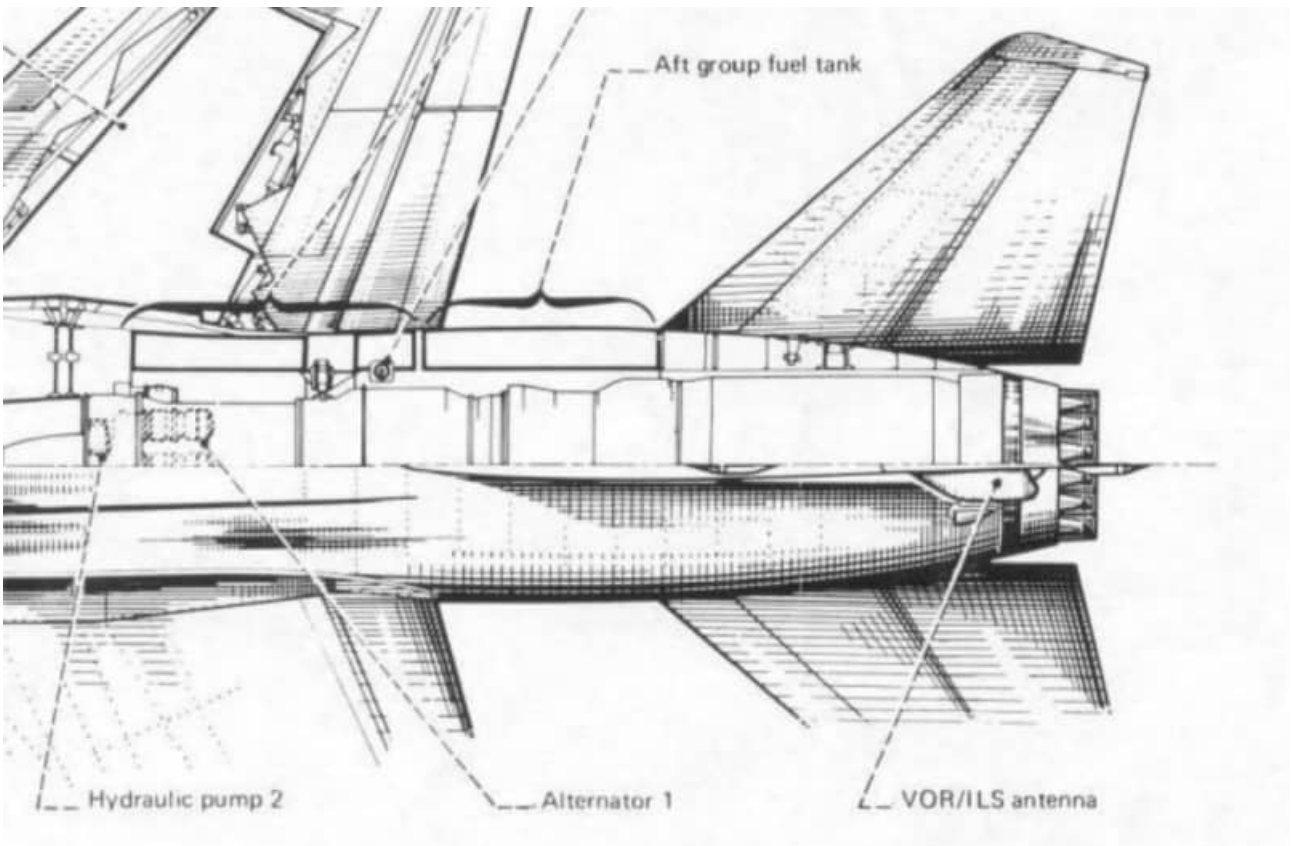


CZ above, AZ below. The CZ has the conical radar nose whereas the AZ has the revised nose shape with retractable aerial refueling probe for the AZ. The pitot probes are also asymmetrically located on the nose. The CZ is equipped with a search light on the port intake.





CZ above, AZ below.



Section 1.7 – Mirage F1CZ #203 details

CZ #203 is preserved at the SAAF Museum at Swartkop Air Base in Pretoria. This aircraft is painted in the final low visibility 3-tone blue/grey camouflage and represents the final mod state of the CZ in SAAF service i.e. updated aircraft protection systems (RIMS and RWS).

CZ #203 cockpit with MB.Mk.4 ejection seat and the distinctive shroud over the Cyrano radar display unit on the upper right of the instrument panel.

MB.Mk.4 in **CZ** #203

MB.Mk.4 in **AZ** #235

CZ #203 is displayed in the final low-visibility three tone blue grey colour scheme. Note the kill mark indicating the demise of an Angolan Air Force MiG-21MF serial C-40 on 5 October 1982. It should however be noted that #203 did not actually achieve the MiG-21 kill. Although gun camera footage from #203 showed a large explosion as the MiG was hit by the CZ's 30mm cannon rounds, the MiG in fact landed safety, albeit with a rather large hole in the wing care of a ruptured wing fuel tank. This event is well documented in the book "The MiG diaries". The only true MiG-21 kill was achieved by CZ #213.

All markings appear to have been slightly over sprayed with the base camouflage colours.

Aircraft tail number is in the standard location on the lower rear fuselage (black, 8” high.) This is typical for ALL SAAF F1s in any of the colour schemes. In this case, it has been lightly over sprayed with the base camouflage. The external fuel tank is an RP35 of 1,200 liter capacity.

3 Squadron badge on vertical stabilizer, oversprayed with the base camouflage. One of the RWS antennas can be seen at the top left of the vertical stabilizer. Note the afterburner cooling intake at bottom left of the photo just beneath the drag chute cone. This is present on both sides of the fuselage and is common to both the AZ and CZ. The other smaller vent to the right was only present on the starboard fuselage.

Standard SAAF Castle with gold Springbok. Castle dimension is 24” diameter when drawing a circle around the extremities of the Castle.

The F1CZ had a spotlight for night intercepts on the forward port intake. The AZ did not. The interior of undercarriage and airbrake bays were bare aluminum. Note the structural details of the airbrake.

Details of underside vents, external fuel tank and pylon. Note the red edging to the various access panels – this to allow ground / flight crew to identify open panels easily prior to start-up.

Port side gun trough to the top left.

Intakes and vents on the left rear fuselage underside.

Rear underside view looking forward. The black stripe is the “false” vertical stabilizer painted to confuse the enemy in a close turning fight. This was only applied to the F1CZs painted in the three-tone blue/grey camouflage. Note the modified ventral fins which contain the RIMS chaff and flare dispensers.

203 is equipped with the locally produced ventral fin with integral RIMS chaff/flare cartridges. The shape is more angular than the original French supplied units. The actual fin is also a lot wider to accommodate the cartidges.

RWS button antenna on the right-hand forward nose gear door. Undercarriage legs (nose and main) are painted aluminium. The black painted area forms part of the “false” canopy marking on the underside of the forward fuselage as applied to CZs in the low visibility blue-grey camouflage.

The black false canopy painted on underside is visible in this image. The cylindrical black object is the RWS CD/DF direction finding antenna fitted to the CZ. To the top right can be seen another of the RWS antennas, which are located symmetrically on the port and starboard forward fuselage. The last two digits of aircraft tail number are painted on the lower forward undercarriage door in light grey. Note that this door is slightly offset to port in relation to the nose landing gear leg.

Details to note :

- Red wing walkway lines on both the wings and the wing-fuselage joint.
- The “KEEP OFF” text on the aileron and the Afrikaans version (“BLY AF”) on the inboard flap.
- The missile on the wingtip station is a French Matra R550 infrared homing air to air missile.
- The white larger missile on the ground near the nose of the CZ is a Matra R530 SARH air to air missile which was carried only on the inboard wing pylons..
- The other object beneath the wing is the ELT-555 electronic counter measures pod, used by both the F1s and the Buccaneer during SAAF combat operations.
- The red missile is also an R550.

Section 1.8 – Mirage F1CZ #207 details

Mirage F1CZ #207 is preserved at the Stellenbosch Airfield. It was donated by the University of Stellenbosch where it resided indoors at the Mechanical Engineering faculty for many years indoors. Unfortunately, this aircraft was painted in a non-representative overall blue colour. It was subsequently re-painted in a scheme which was intended to represent the original buff / grey delivery scheme , but unfortunately the colours used are totally inaccurate. #207 is representative of the late mod state configuration of the F1CZ in SAAF service including RWS and RIMS.

Details to note : The forward facing starboard black RWS antenna. The silver probe ahead of the windshield is the impact temperature probe. The probe on the underside is one of two pitot tubes. The cylindrical RWS direction finding antenna is located behind this on a panel standing proud of the fuselage. The round hole above the RWS antenna is the crash tow tube.

Visible are the dual pitot probes and the black cylindrical and spherical RWS antennas. Note the shape of panel onto which the cylindrical RWS antenna has been located. This panel appears to be of a different arrangement to that originally fitted to the F1s. This necessitated the relocation of the UHF blade antenna from this position to the fuselage spine aft of the canopy. The black cylindrical antenna is for directional / azimuth data for the RWS and was installed only on the CZ and not the AZ. The back object at the top left of the image is a protective cover over the incidence probe.

Landing light – this drops down during landing and takeoff. The red object is the radar altimeter antenna.

Note the asymmetric arrangement of hydraulic tubes on the sides of the nose gear retraction piston.

Here is a detail missed by model manufacturers : the front landing gear side opening doors are not the same size. This is because the forward door (image left above) is offset to port. Although the landing gear is located along the fuselage centerline, the door is offset due to the arrangement of hydraulic lines on the one side of the retraction piston as can be seen in the lower two images on the previous page.


Image Malcolm Reid 2019
mistralwindsurf@gmail.com


Image Malcolm Reid 2019
mistralwindsurf@gmail.com


Image Malcolm Reid 2019
mistralwindsurf@gmail.com


Image Malcolm Reid 2019
mistralwindsurf@gmail.com

#207 does not have the engine installed. When fully loaded the F1 had a distinct nose up stance.

The main landing gear legs are a marvel of mechanical design, and the retraction sequence is fascinating to watch.

Details to note – structural ribbing and access holes between the undercarriage bay and engine bay. The covers over these access holes have been removed.

Detail of wingtip without missile launcher.

The SAAF Castle applied to #207 is totally inaccurate both in size and the width of the white border. Note the shape and length of the intake conical shock cone.

Note the unloaded tail up “stance” of the aircraft without the engine fitted.

Details to note : shape of RIMS chaff/flare quipped ventral fins and RWS antennas at the top of the vertical stabilizer. The bullet shaped antennas on the leading edge of the vertical stabilizer was the standard Dassault factory fitted French Radar Warning Receiver (RWR) antenna. These remained on SAAF F1s throughout service. Note also the two cooling intakes on the starboard upper rear fuselage. The rear one is replicated on both sides of the vertical stabilizer.

Flap actuators. The aerodynamic cover on the inboard one is missing.

The Mirage F1 had outboard leading-edge slats and inboard leading-edge flaps. The outboard slat and inboard flap hinge arrangements are visible in the image below. The slat would move down and forward creating an aerodynamic slot between the slat and the wing and resulting in increased camber. The flap was simpler and hinged downwards without creating an aerodynamic slot but increasing wing camber.

Perforated airbrake detail.

RWS antennas on the vertical stabilizer. The two horizontal blade antennas are for the VOR/ILS system. The rudder actuator is present on the starboard side.

Details of the locally produced ventral fin with integral RIMS chaff/flare cartridges. These replaced the original Dassault ventral fins and were installed on both the AZ and CZ fleet. The three empty bays for the RIMS cartridges can be seen in the image below.

#207 was repainted in totally inaccurate colours. But the good news is that a fresh coat of paint protects the airframe from the elements and it is now located inside one of the hangars at Stellenbosch airfield. The markings are more representative of the original CZ markings than when #207 was painted in overall blue.

Section 1.9 – Mirage F1AZ #235 details

AZ #235 is preserved at the SAAF Museum at Swartkop Air Base in Pretoria. Unfortunately, this aircraft appears in a non-standard white and blue gloss colour scheme. This was applied to #235 when it was used as an avionics test aircraft. This is not representative of any SAAF operational F1 colour scheme and certain aspects of the avionics and RWS antennas are non-standard.

The last two digits of tail number appear on the nose undercarriage door.

The location of the two forward facing RWS antennas can be clearly seen in this image. The clear window for the laser range finder can be seen beneath the nose.

Details of AZ nose. The profile is different to that of the CZ radar nose. The fairing for the laser designator can be clearly seen on the underside of the nose. The access panel details on the AZ nose do not appear on the CZ's radar nose. #235 has the later Castle with golden SAAF Eagle applied.

Note the curved shape to the intake upper and lower edges. There are also thin reinforcing strips between the upper and lower intakes and the forward fuselage.

The retractable refueling probe doors can be seen offset to starboard on the nose ahead of the windshield.

The location of the forward RWS antennas and those on the upper vertical stabilizer can be seen. The round shaped antenna on the leading edge of the vertical stabilizer was specific only to this AZ as part of the avionic development project.

There are two thin probes, one on each side of the forward fuselage : the port one is the incidence probe and the starboard one is the impact temperature probe.

The two objects protruding from the underside of each wing are the attachment points for the inboard RIMS chaff/flare dispenser units (store Station “0”).

The rudder actuator on the vertical stabilizer is offset to starboard.

Note the angular shape of the ventral fins equipped with the RIMS chaff/flare cartridges. The two antennas on the leading edge of the vertical stabilizer are not standard for SAAF F1AZs. The same applies to the center small black antenna on the upper trailing edge above the rudder. The two larger black antennas either side of this appear to be similar to the standard RWS antennas fitted to SAAF F1AZs and CZs.

Section 1.10 – Mirage F1AZ #227 details

AZ #227 as seen at the AAD show at Waterkloof Air Base in 2004. This is accurately representative of the final colour scheme and RIMS/RWS mod state applied to the SAAF F1AZ fleet.

AZ nose panel detail with the refueling probe in the extended position.

The final AZ colour scheme included revised SAAF Castles which replaced the Springbok with the SAAF Eagle. The Eagle always faces forward on the fuselage or inwards towards the fuselage on the upper wings. The Castle / Eagle marking was not applied to the lower wings.

As with the CZ, the AZ had the longer intake shock cone overlapping the access panel behind it. The last two digits of tail number were painted in black on the upper surface of the intakes. These were oriented to face the refueling operator of the B707 aerial tankers. Note the dark grey leading edge to the intake. All markings are of the low visibility grey type. The blue pilot's name beneath the canopy was non-standard.

#227 is equipped with the RIMS chaff/flare ventral fins. The large stores on the wings are the 4 bomb carriers (referred to as CLB8 or A26) developed for the F1AZ. These were not used in combat. Note the nose up stance of the F1 (compared to the engineless CZ #207 at Stellenbosch airfield).

Main undercarriage compressed correctly imparting nose-up stance to the aircraft. Compare this to the images of the unloaded undercarriage of CZ #207 earlier in this document.

The SAAF used the centerline CLB4 4-bomb carrier in combat (on both the AZ and CZ). Note the difference in longitudinal angle between the fuselage and the CLB4 which is angled down towards the front.

The front of the wing inboard leading-edge flap and the vertical stabilizer are painted in a darker grey. Note that outboard leading-edge slats are extended and inboard leading edge flaps are lowered. F1s would be seen variably at rest with flaps/slats extended/drooped or all retracted.

The rear end of the centerline CLB4 bomb carrier. The rear two bomb shackles were angled differently to the front two, with the rear bombs having a slightly more nose down attitude.

SAAF Castle with Eagle on port upper wing. These did not appear on the lower wing surfaces for this colour scheme. Another detail to note is the dark grey no walk stripe ahead of the ailerons.

Details of the CLB8 / A26 4-bomb carrier on the wing. These are fitted to the standard F1 inboard pylon. The drooped flaps are of the double slotted type. Note the vertical strakes on the outboard edges of the flaps.

Variable droop angles of inboard and outboard double slotted landing flaps. Note the grey painted wear area on the flaps.

Landing flap actuator detail.

Forward end of centerline CLB4 bomb carrier showing the bomb sway braces. Bombs were carried symmetrically, unlike the configuration of the wing CLB8 / A26 4-bomb carriers shown in the image below where the bombs were staggered. Note the standard NATO symbology in dark grey.

Details of the wing mounted CLB8 / A26 4-bomb carrier with the staggered arrangement of bomb shackles. The slots aft of the bomb shackles are for the bomb fins, indicating that these were carried in a cruciform arrangement (hence the staggered arrangement) unlike those on the centerline which were carried such that the fins were in a diagonal arrangement. #227 as it appears in these images, represents the 14-bomb configuration (typically 14 x 125kg Mk. 81 bombs, including one each on the outboard pylons). Range in this configuration would have been limited. The inboard RIMS chaff / flare dispenser is seen in the image on the right located on Station “0”. It is unlikely that these were used by the SAAF on combat operations.

Details of wing CLB8 / A26 4-bomb carrier. Recesses are for the bomb fins. Note the RIMS dispenser pod behind this with three empty bays for the chaff / flare cartridges. These dispensers appear to be wider than those fitted into the ventral fins.

Outboard wing leading edge slat in extended position showing the aerodynamic slot. The outboard pylon is equipped to carry bombs – note the bomb sway braces. This station could also be used for the carriage of the V3S Snake air to air missile.

Atar 09K50 engine afterburner and exhaust nozzle details.

Details of the retractable refueling probe bay which is offset to starboard on the AZ nose. The bay aft cover is fixed to the probe itself. The forward bay door (to the right in the image above) rotates to the left.

Characteristic nose up attitude of the horizontal stabilizers when the F1 is at rest. Note the grey leading edge as well as black walkway markings. The drag chute cone is missing. The port side afterburner cooling intake is visible ahead of the exhaust.

Note the grey area aft of the extended slat and the drooped flap. Note also that the grey is applied to the leading edge of the inboard flap and not the slat.

Non-standard blue text for pilot call sign was apparently applied as part of the retirement of the F1AZ from SAAF service. The scripted "*Mirage F1AZ*" was variably applied to AZs painted in this camouflage scheme. "*Mirage F1AZ*" was not applied to the AZs painted in the interim dark earth/green or low visibility grey-blue schemes (refer to Volume 4 for more detail).

Head on photo of an AZ. Note the offset location of the refueling probe on the upper nose and the small black ranging radar.

Section 1.11 – Mirage F1 self-protection upgrades (this section researched and compiled by Martin Strümpfer)

Introduction

The SAAF operated in a high threat ground-based air defense environment over southern Angola care of Cuban and Russian anti-aircraft systems. Due to the large number of SAM systems and types, the airspace over Angola at the time was considered some of the most contested on the planet. Because of this, the F1 fleet was upgraded with locally developed radar warning and self-protection systems using Israeli assistance.

Radar Warning System (RWS)

The SAAF AZs and CZs were delivered with the factory fitted French Thompson-CSF BF RWR (Radar Warning Receiver) antennas located in prominent bullet shaped fairings on the leading and trailing edge of the vertical stabilizer. These are indicated as "BF radar detector antennas" in the Flight Manual images presented earlier in this document. The BF system provided the pilot with an audio warning and a general direction of the threat using a set of dashboard display lamps. It had a limited ability to indicate general classes of radars.

Combat experience over Angola in the late 1970s already indicated the need for a more advanced RWR package to offer better protection to aircraft which were considered irreplaceable under the International Arms Embargo. Thus, the old BF RWR was replaced with a new digital Radar Warning System (RWS). The new RWS was developed in conjunction with Israel which approached the SAAF due to their ongoing experience facing the latest Soviet SAM systems. The eventual South African RWS was however unique and adapted specifically to the SAAF's requirements.

The RWS consisted of four spiral antennas covering the four quadrants of the aircraft. They were placed such that at least two, sometimes three antennas, depending on a threat radar's position relative to the aircraft, could detect an emitting radar. By continually comparing the detected signal strength between each antenna the system could determine the position of the emitting radar relative to the aircraft. The four spiral antennas covered the 2 to 18GHz frequency range where search and track radars typically operate.

Two other antennas form part of the RWS suite covering the frequency range 0,5 to 2 GHz. They are omnidirectional antennas consisting of the button and blade antenna. The button antenna purely scanned for the continuous wave illumination signal of the long-range SAM-6 when guiding towards the aircraft and thus served as launch warning detection. The blade antenna covered the rest of the frequency spectrum and was optimized for the guidance signals of the SAM-2 and SAM-3 missiles – again functioning as launch warning detection.

A display unit on the instrument panel provided the pilot with an indication of the threat type, the direction relative to their aircraft, and whether they were within or outside the detected SAM's engagement range. The RWS was equipped with a threat library so that detected signals could be matched to the exact type of threat, informing the pilot accordingly so that appropriate defensive actions could be taken. The library could be updated as new threat signatures were identified and was typically programmed before a deployment, based on intelligence about the expected threats. A recording function was also included for post-flight analysis of any new radar signals detected during a mission.

The AZ was one of the first SAAF types to be fitted with a full RWS via SAAF/MOD/MIR/187 starting in the first half of the 1980's with the earliest picture proof found by the author in 1983. As part of the fleet embodiment of the RWS modification program, the rear facing BF RWR antenna was removed from the top of the vertical stabilizer and replaced with the two rear quarter spiral antennas. The forward-facing BF RWR antenna housing was retained on the leading edge of the vertical stabilizer, but the equipment was removed. The two forward spiral antennas were mounted on the lower nose of the aircraft, just ahead of the windshield with the two omnidirectional antennas being mounted on the nose gear doors.

Several AZs fitted with the RWS saw active combat operations from the early 1980's and all aircraft deployed operationally by the end of the war were equipped with the RWS suite. From Dick Lord's book titled *Vlamgat* (in which he describes the Mirage F1 service with the SAAF), he notes during operations over Angola in 1987 the following: *Recordings from the radar warning receiver (RWS) equipment in both aircraft verified the presence of SA-3s and SA-8s*.[2] In another excerpt from his book he notes that on 20 February 1988, the following occurred : *Approaching Lubango from the south-east, the compact radar warning receiver (sic)[3] started picking up the indications of Russian-built Barlock and search radars on the air*[4]. These extracts show the value the addition of the RWS gave from both a self-protection and an intelligence gathering point of view.

In contrast to the AZ fleet, the CZ fleet was very slow in receiving their RWS upgrades. They were fitted with the Compact Radar Warning System (CRWS) under SAAF/MOD/MIR/282. Visually the CRWS and RWS had little difference in terms of antennas but had differences in their avionic functioning. In terms of aircraft protection and pilot warning they gave the same functionality. However, the CZ benefitted from local EW developments in its RWS suite and shared advancements introduced during the Cheetah E and D programme.

Visually this can be seen in a large cylindrical antenna nicknamed the "Cake Tin" being installed underneath the nose of the aircraft. This antenna superseded the blade and button antennas of the RWS suite although the CZ retained the button antenna. The "Cake Tin" is listed as the CD/DF antenna in the CZ Flight Manual extract below and covered the frequency range 0,5 to 2 GHz. It thus also provided launch warning detection. Unlike the two omnidirectional antennas on the AZ however, it could provide directional information about the source of an attack - particularly useful when multiple SAMs of the same type were tracking the aircraft.

The installation of the CD/DF antenna necessitated the relocation of the main UHF blade antenna on the CZ from beneath the nose to the spine, aft of the cockpit. The four spiral antennas took in the same positions and required the same modifications as on the AZ. To accommodate the forward two spiral antennas on the CZ, the two pitot probes mounted on the nose had to be relocated lower down on the nose. On the AZ these antennas were further to the front on the aircraft nose, and thus did not need to be relocated.

Operational use of CRWS was limited to only a few CZs. Based on the author's research, tail number 203 was the first aircraft to receive the CRWS and was equipped with the system by late 1984. However, the CZ fleet was notably slow in receiving the upgrade compared to the AZ fleet, with only a few aircraft being operationally deployed with the CRWS. As late as June 1988, CZs deployed to Ondangwa were still noted as not being fitted with the upgraded CRWS.

Radar and Infrared Misleading System (RIMS)

The RIMS was designed to reduce the effectiveness of enemy anti-aircraft systems or at least provide a higher probability of survival. The RIMS installation on the F1s consisted of two phases. Initially the chaff/flare fit consisted of two large dispensers housing eight chaff/flare cassettes each mounted on the specially added Station 0 underneath the wings, inboard of the Station 1 pylon. It has been recorded that these large containers may have had a detrimental effect on aircraft handling as they negatively affected the aircraft's area ruling and thus limited aircraft speed. The mounting bolts for this mod was applied to most of the AZ fleet and only some CZs. This was implemented through SAAF/MOD/MIR 521 as reflected in the revised flight manual dated 1990. There does not appear to be photographic proof that this mod was used operationally by the SAAF F1s.

A revised approach, which did not have a noticeable effect on aircraft performance, involved designing new ventral fins, which held the chaff/flare cassettes. Simultaneously, this design addressed issues of fatigue

---

[2] Page 174 of Vlamgat. SA-3 and SA-8 were Russian designed surface to air anti-aircraft missile systems.

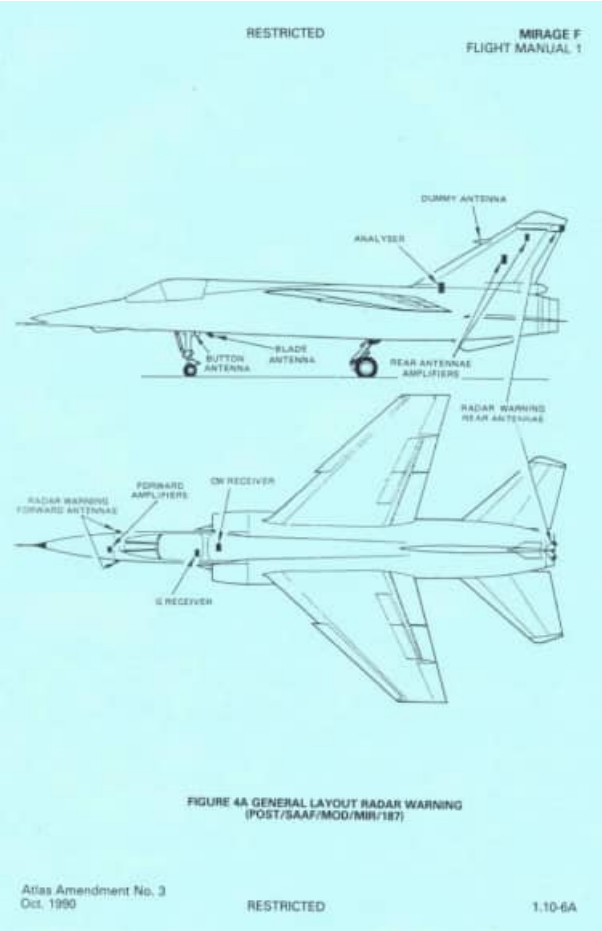
[3] Only the F1AZ was still deployed operationally on the border by that time was not equipped with CRWS.

4 Page 191 of Vlamgat.

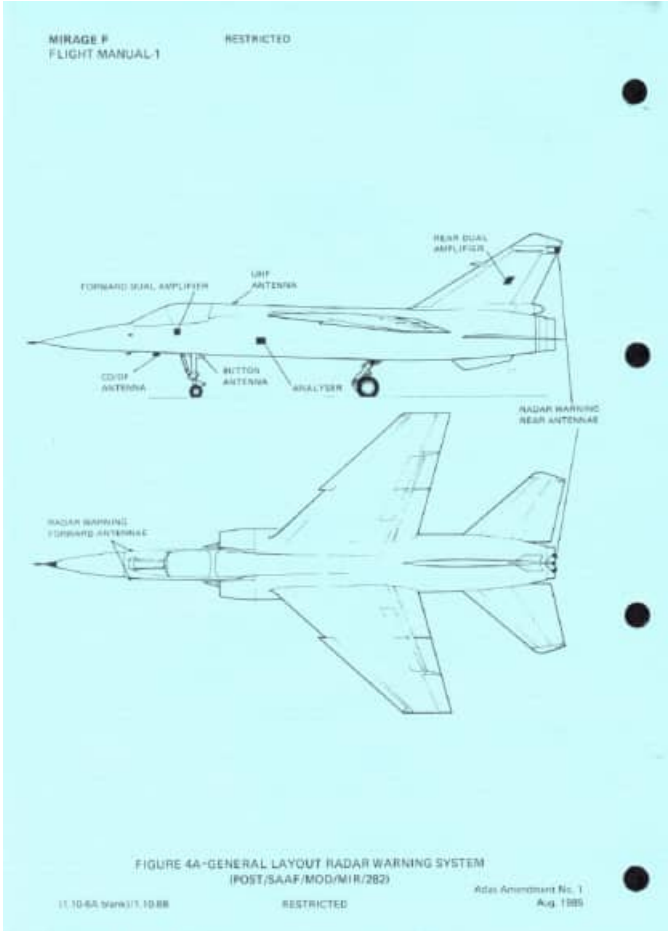
cracks that were being detected in the original factory fitted ventral fins. Each ventral fin held three cassettes with each cassette containing 10 cartridges of either chaff or flare. These modified ventral stabilizers are much thicker in cross section and have a more angular shape compared to the original factory fitted ventral fins, but had no noticeable impact on aircraft performance.

Work on this modification began around mid-1986. Initial trials were conducted using fins made of carbon composite, and the design proved highly effective. However, at -56°C and 50,000 ft - the F1's maximum specified altitude - the composite fins began delaminating. Operational heights on the border, however, rarely exceeded a few hundred feet, and operational heights in South Africa rarely exceeded 30,000 ft. Despite the urgent need to fit the RIMS fins to the aircraft for the added protection they offered on the border, rigid decision-making prevented their installation - even with altitude restrictions that would have enabled their use in the operational area. Instead, the new fins had to be cleared for the full operational envelope of the F1 before being approved for service. As a result, the RIMS fins had to be redesigned with an aluminum construction. The delay caused by the redesign meant the RIMS fins only began reaching squadron service after both aircraft types had left the operational theater. Based off the author's research there appears to be no photographic proof that any F1s (AZs and CZs) were deployed on Border combat operations with either of the two types of RIMS fits as described above.

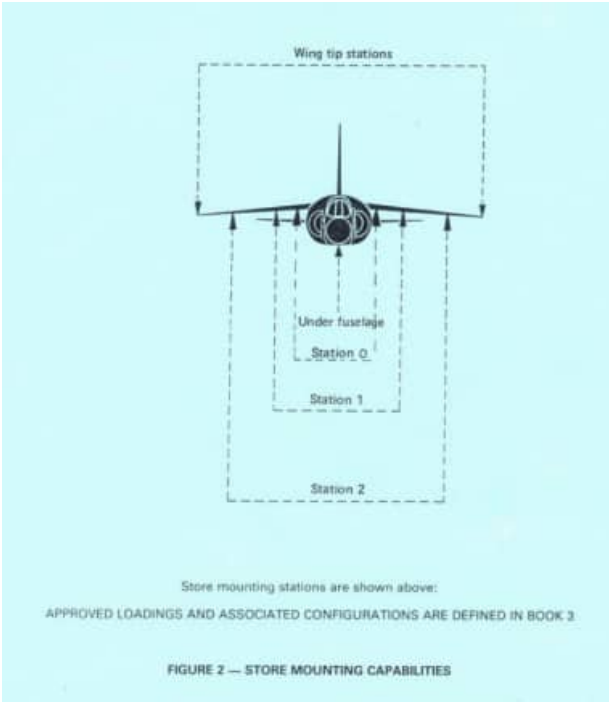
On the AZ, RIMS was implemented through SAAF/MOD/MIR 151 as reflected in the revised flight manual dated 1990. For the CZ it was implemented through an amendment to SAAF/MOD/MIR 282 mentioned earlier.

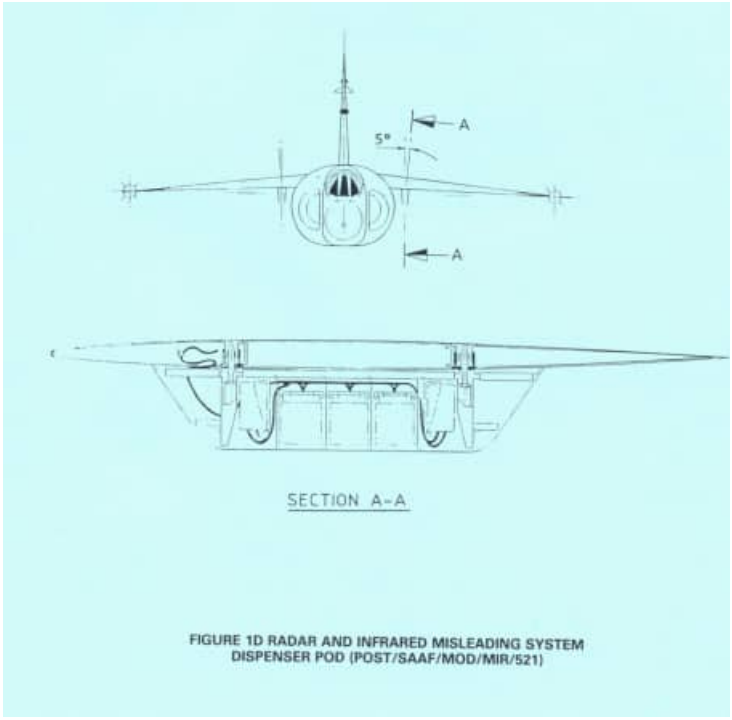


RWS as fitted to the AZ.

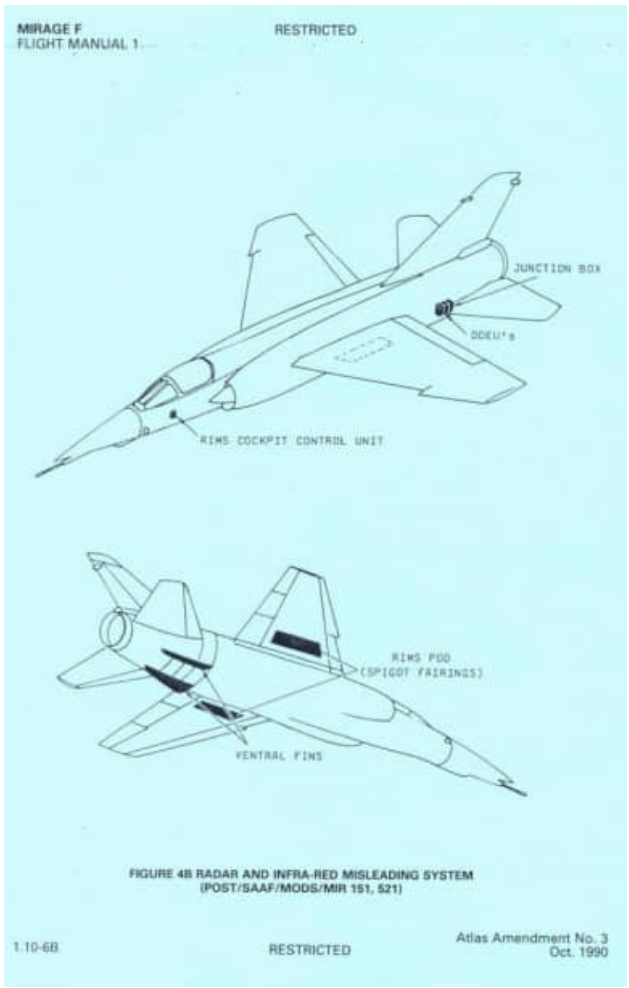


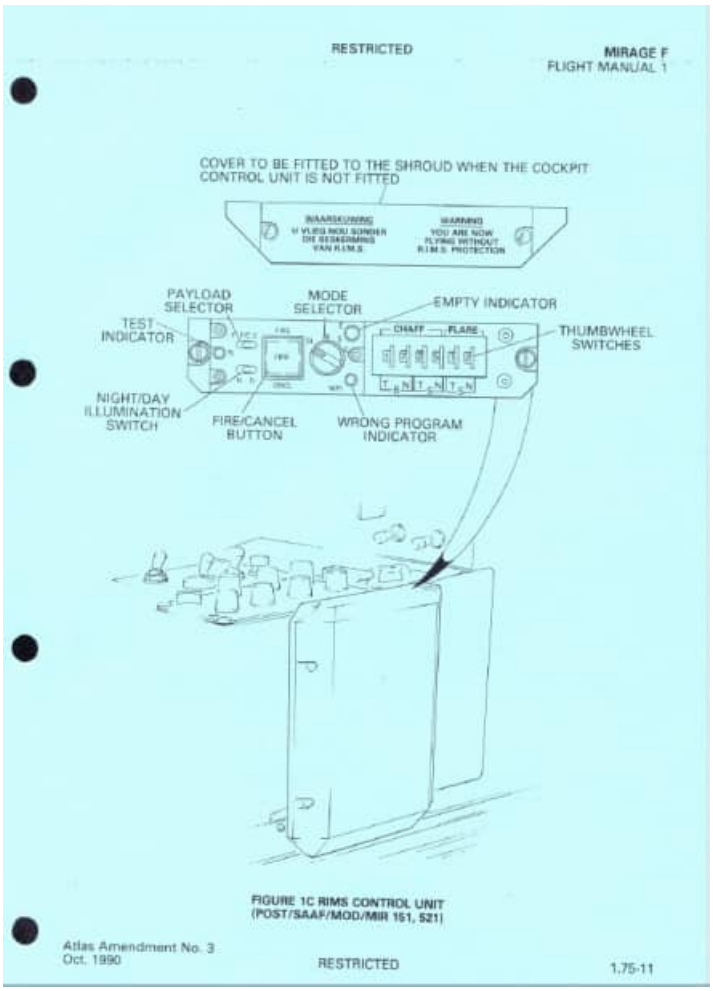
RWS as fitted to the CZ. Note the cylindrical “CD/DF Antenna” located beneath the nose ahead of the nose landing gear and that the UHF antenna has been relocated to the fuselage spine aft of the canopy.



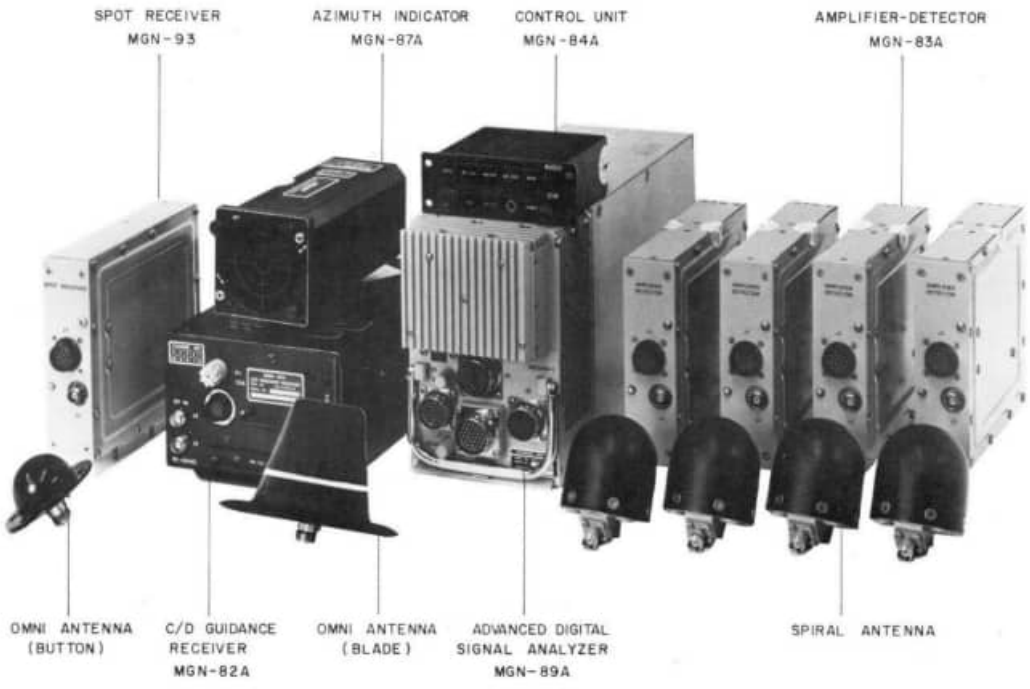


Images taken From the SAAF F1 Flight Manual showing “Station 0” beneath the wings where the RIMS dispenser would be installed.

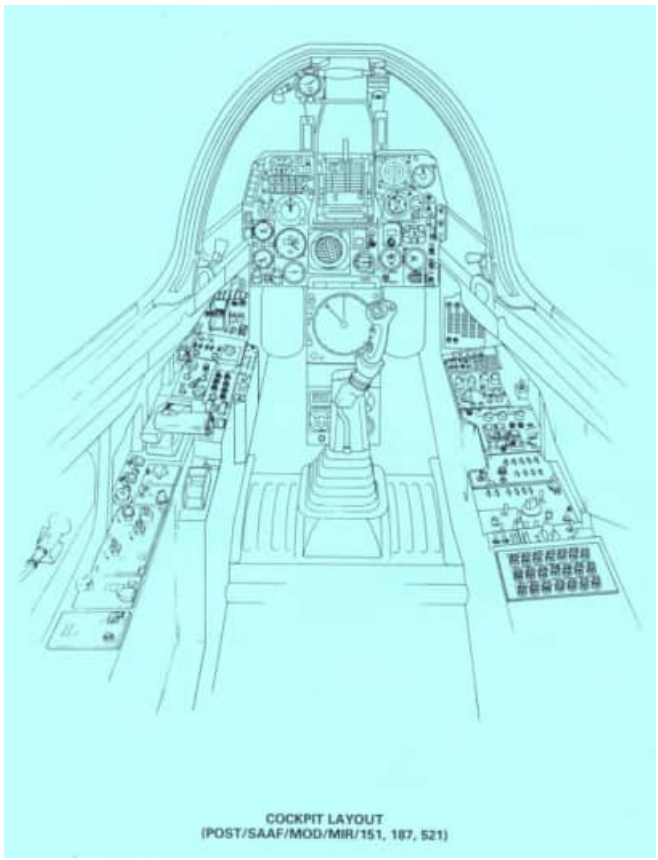




The RIMS control panel was located on the cockpit left side console as can be seen above



Some details of the various RWS avionic boxes and the antennas as fitted to the AZ under SAAF/MOD/MIR/187.



Above : Schematic and photo of the AZ cockpit post RIMS and RWS upgrades. The RWS threat indicator (the round display with concentric circles) is at top right of the instrument panel next to the Heads Up Display. The large round display at lower center of the instrument panel is the moving map display typical to the AZ. The RWS control panel is the rectangular panel with 10 small buttons at the top left of the instrument panel.

Compare the image above to the unmodified AZ instrument panel pre-RIMS/RWS shown below. Note how the coaming of the instrument panel in the image above has been modified to accommodate the additional instruments.

In this image dated from 1983, an AZ is taxiing out for a strike with four rocket pods. The port forward black RWS spiral antenna is visible above the nose landing gear leg. The RIMS ventral fins are not fitted – these are clearly of thinner section when compared to the later RIMS units.

F1CZs deployed to AFB Rundu in the latter end of 1987. While not very clear, the relocated UHF antenna on the spine and the just visible "Cake Tin" antenna under the nose indicates that the aircraft has been fitted with the RWS. The rounded profile of the ventral fins however indicates that the aircraft does not have the RIMS fins installed.

CZ tail number 203 is seen here in August 1984. The relocated UHF antenna is visible aft of the canopy on the upper fuselage, the CD/DF antenna on the underside of the nose and the spiral antennas replacing the rear facing BF RWR antenna on the upper vertical stabilizer trailing edge can also be seen. (*Photo: Dave Becker*)

In this screengrab of a news program from September 1984 regarding Exercise Thunder Chariot, CZ #203 is shown taking off. The relocated UHF antenna and CD/DF antenna are clearly visible. Of interest is what appears to be a blade antenna as used on the AZs aft of the IFF antenna on the nose gear door. This antenna was not fitted to any other CZs being upgraded with CRWS and was eventually removed and blanked off on 203 too.

In this picture of an F1CZ on standby at the Ondangwa revetment is dated June 1988. The aircraft is fitted with neither the RWS nor the RIMS.

Post combat operations image of a CZ showing the RIMS and RWS installation. Note the two black antennas at top of the vertical stabilizer and cylindrical CD/DF antenna beneath the nose. The black button antenna on the nose gear door as well as the starboard forward-facing antenna are also just visible. The RIMS chaff/flare cassettes are visible in the ventral fins.

F1CZs deployed to AFB Grootfontein in August 1988 after the conclusion of the “Bush War”. The aircraft nearest the camera has been fitted with RIMS ventral fins. The relocated UHF antenna on the spine and the just visible “Cake Tin” under the nose indicates that the two aircraft nearest the camera have been fitted with the upgraded RWS while the other four aircraft have not.

AZ #229 showing both RIMS and RWS installation. Note the two black antennas at top of the vertical stabilizer and the starboard forward-facing antenna on the nose. are also just visible. The black button antenna is visible on the small nose gear door and the black blade antenna is visible on the larger nose gear door. The ventral fins have a more defined angular plan view compared to the original fins (which had more rounded corners).

Active Countermeasures System (Bikini) Pod

The story of electronic countermeasures (ECM) in the SAAF began with Israel, as did most projects of the era. In the early 1980s, the SAAF was approached by Israel, who offered to co-develop and equip SAAF aircraft with electronic jammers. However, the proposed jamming system did not meet local requirements.

Project Bikini was thus initiated to acquire jamming pods for SAAF aircraft. The desired pods needed to be external to the aircraft to allow for quick replacement if any faults were detected before a mission. Additionally, the pods were required to have their own power generation capability to avoid placing strain on the host aircraft's onboard power systems. While the performance impact of an external store was acknowledged, it was considered an acceptable trade-off for the operational benefits provided.

The Italian company Elettronica SpA provided the solution with its ELT-555 series of self-contained jamming pods. These pods were largely self-contained, featuring a ram-air turbine at the front to generate the power required for the onboard electronics. They were designated the Active Countermeasures System (ACS) pod but were often referred to as the "Bikini pod" after the name of the acquisition project.

However, the delivered pods had a limited effective jamming range. Furthermore, they were unable to differentiate between various tracking radars, instead employing the same ECM technique regardless of the type of tracking used. This limitation was far from ideal and often rendered the pods ineffective. As the threat over Angola evolved and its capabilities improved, it became increasingly clear that the pods, as procured, could no longer provide the necessary protection.

The pods were subsequently reworked locally to enhance their threat response- and range capabilities. These upgrades enabled the pods to identify radars and deploy threat-specific jamming techniques tailored to each radar type. Like the RWS, the upgraded ACS pods were now programmable with threat libraries, enabling them to recognise specific radar threats and tailor the jamming response accordingly. This adaptability significantly improved their effectiveness in complex threat environments.

There were two variants of the ACS pod in SAAF service: a noise jammer and a deception jammer.

The noise variant consisted of a family of four pods, each covering a specific frequency range. The overall frequency range of 2 to 18 GHz was divided into four bands: 2 to 4 GHz, 4 to 8 GHz, 8 to 12 GHz, and 12 to 18 GHz. These pods utilised an ECM technique known as noise gate pull-off. This technique involves generating a strong noise signal that initially mimics the characteristics of the true return echo. Over time, the jammer gradually increases the noise level while simultaneously reducing the strength of the legitimate return echo, causing it to become obscured by the artificial noise. As the radar becomes overwhelmed by the high noise level, it eventually fails to differentiate between the true target and the noise, resulting in a loss of lock on of the target.

The noise pod was typically employed in a stand-off escort jamming role or in lower-threat environments. Visually, this variant can be identified by the two T-shaped antennas on its underside.

The deception variant operated within the 7 to 17 GHz frequency range. It employed an ECM technique known as range gate pull-off. This technique begins by transmitting a jamming signal that mimics the radar's return echo, aligning with the target's actual position. Gradually, the jammer introduces a delay to this false signal, creating the illusion that the target is moving away from the radar. As a result, the radar adjusts its tracking window away from the true position of the target. Once the tracking window has shifted sufficiently far from the actual target, the radar loses track of the aircraft.

The deception pod was the preferred variant for use in high-threat environments and was commonly seen on the AZ fleet during the final years of the border war. Visually, the deception pod can be identified by the two

lump-shaped antennas on its underside, which are present in place of the T-shaped antennas found on the noise pod.

An AZ equipped with a deception ACS pod at AFB Grootfontein during the final phases of the border war. AZ's typically flew with a single deception ACS pod mounted on the port station 2 hardpoint as seen here.

CZ tail number "205.5" (the forward fuselage of #205 mated with the rear fuselage of #206) over the Hammanskraal range in the early 1990s. It is equipped with two ACS pods – a rather atypical configuration on the CZ.

Although ACS pods were also cleared for use on the CZ; however, the author has found no evidence that they were used operationally by CZs on the border. The performance impact on the CZ, which was already marginal against Angolan MiG-23's, likely contributed to their limited use.

Section 1.12 – Dassault SAAF Mirage F1 weapons options.

Throughout this compilation, there are many images of the various external stores and weapons carried by both the AZ and CZ. These include operational (combat) loads as well as training and theoretical loads. These are dealt with in more detail in :

- Volume 3 - external stores used by the Mirage F1CZ during SAAF service.

And

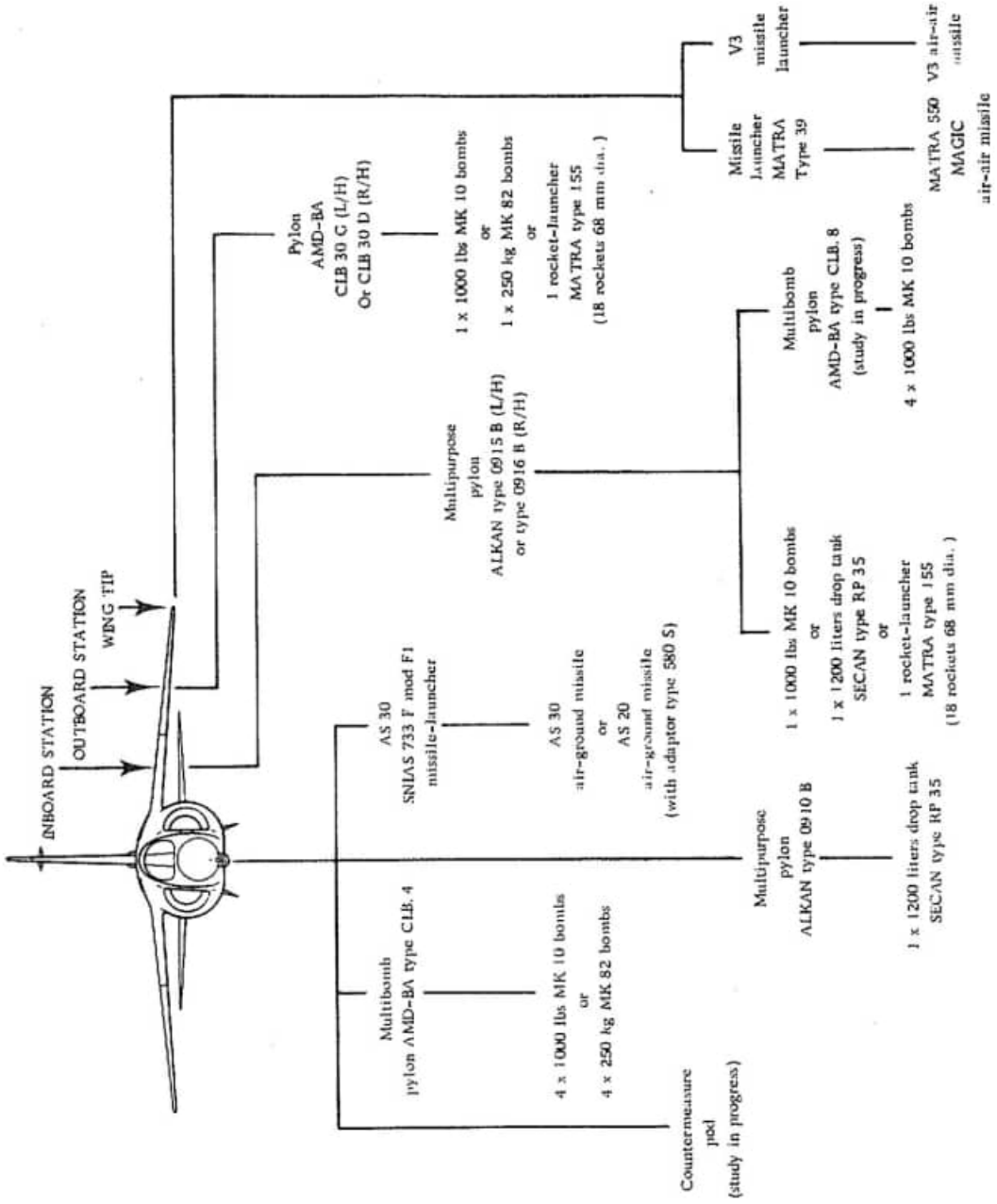
- Volume 5 - external stores used by the Mirage F1AZ during SAAF service.

The chart on the following page is an extract from a Dassault Mirage F1 manual indicating the stores either cleared or in development for the SAAF F1s and is dated June 1975. Specific items to note are :

- On the centerline station – *Countermeasure pod (Study in progress)*. The only countermeasures pods used by the SAAF F1s were the Bikini ACS pods as noted earlier in this volume and these were carried on the outboard wing stations.
- On the Inboard wing station – *Multibomb pylon AMD-BA type CLB8 (study in progress)* which could be fitted with 4 x 1,000lb Mk10 bombs. It would appear that the SAAF referred to these carriers as A26. These carriers were "handed" with the inboard set of bombs carried further forward than the outboard set. The A26 may have been a local SAAF development of the original CLB8 carrier concept. The A26 was not used operationally and, going by photographic records, were only introduced onto the AZ fleet after the end of combat operations in the early 1990s.
- The reference to *1,000lb Mk.10 bomb* (450kg) is the standard British MOD free fall general purpose (GP) bomb which was used by the SAAF before the introduction of the Mk.81 and 82 series of GP bombs.
- Note the reference to *V3 air to air missile*. It is assumed this is a reference to the V3A as the V3B was only developed in the 1980s. In any event, only the AZ carried the V3B. The CZ carried the R550.

This chart therefore addresses the external stores for the F1 either available or planned in 1975 and does not consider later weapons and external stores integrated onto the SAAF F1s during the lifespan of the AZ and CZ. Refer to Volumes 3 and 5 for more details.

This chart is followed by two additional "Loading Configuration" charts from a 1976 version of the F1 flight manual which provides additional weapons load data. To add some confusion, the chart on the following page refers to "**CLB8** multibomb pylon" and "4 x 1,000 lb Mk. 10 bombs" carried on Station 1 (Inboard Station) as described above, whereas the third load chart refers to "**CBL8** 200 bomb rack" carrying four "PRAC (28lb) bombs". The author assumes therefore that the "CBL8" refers to the 4-bomb practice carrier used by the SAAF and that the "CLB8" was ultimately fully developed towards the late 80s and assigned the nomenclature of "A26".



EXTERNAL LOADS

The following two pages show F1 weapons loads from Flight Manual dated 1976. Note reference to V3 missile in the image below.

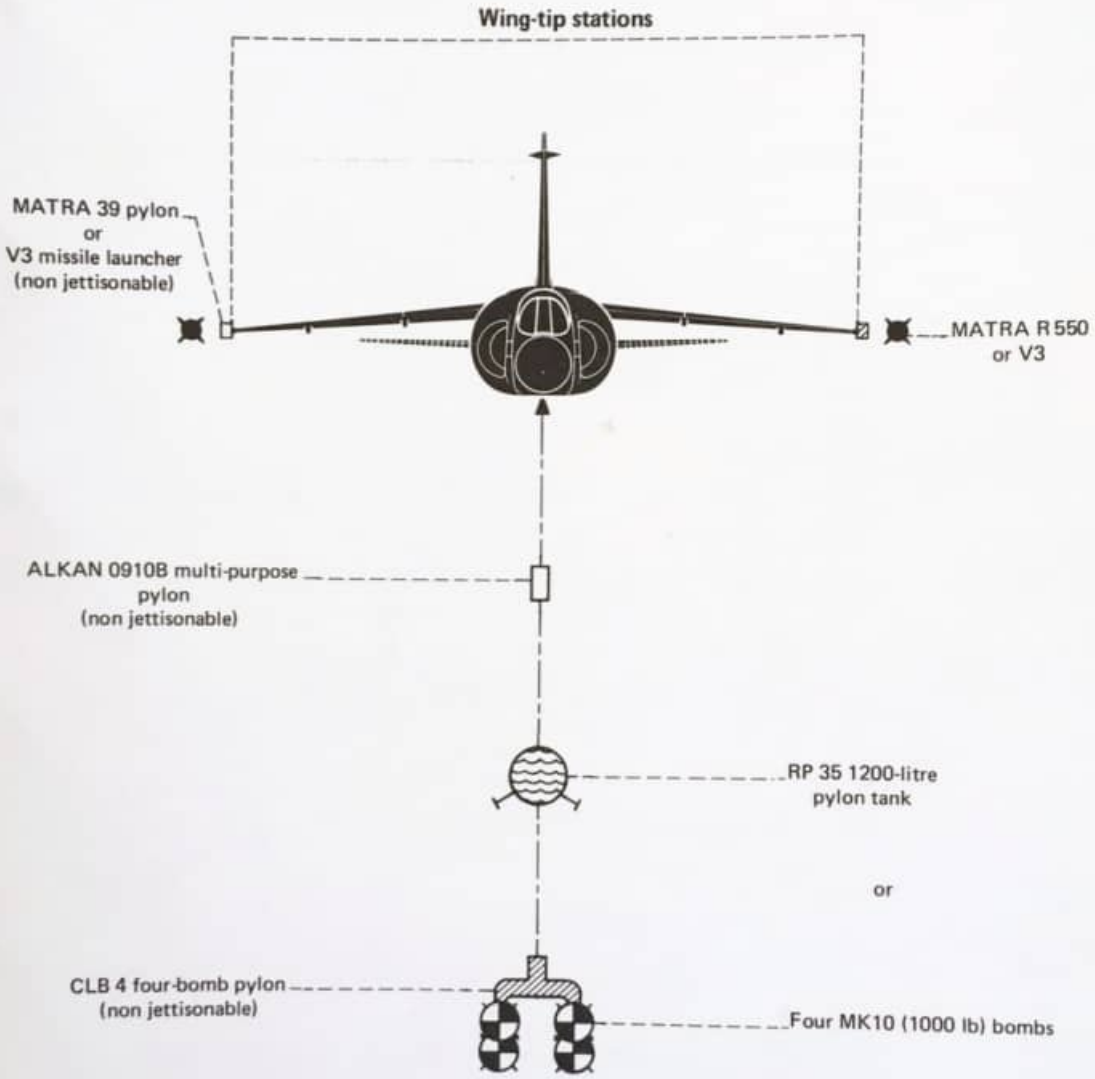
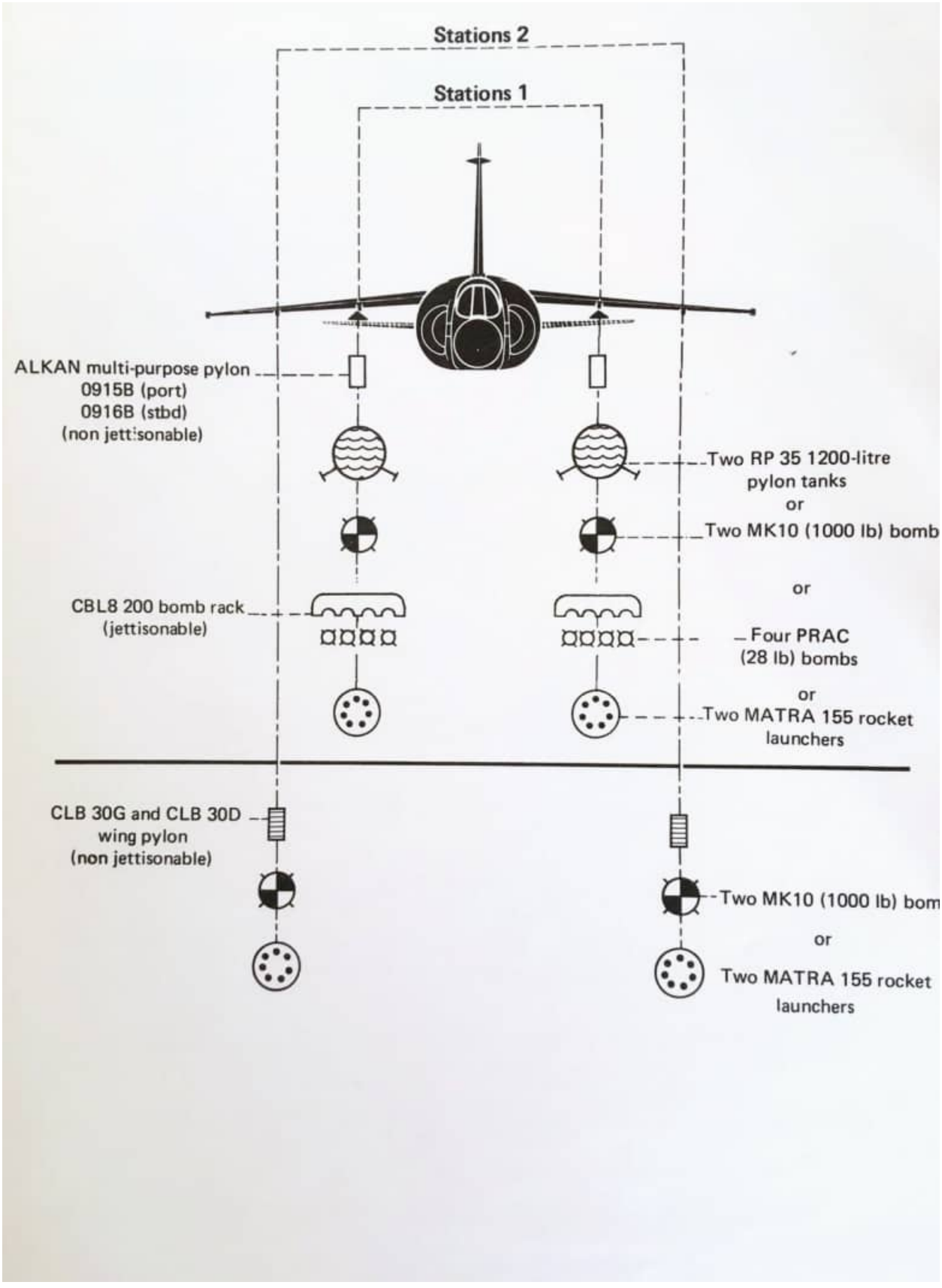
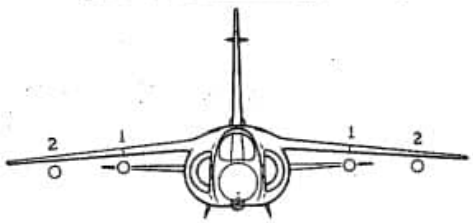


FIGURE 2 - LOADING CONFIGURATIONS


Stations 2
Stations 1
ALKAN multi-purpose pylon
0915B (port)
0916B (stbd)
(non jettisonable)
Two RP 35 1200-litre
pylon tanks
or
Two MK10 (1000 lb) bomb
or
CBL8 200 bomb rack
(jettisonable)
Four PRAC
(28 lb) bombs
or
Two MATRA 155 rocket
launchers
CLB 30G and CLB 30D
wing pylon
(non jettisonable)
Two MK10 (1000 lb) bom
or
Two MATRA 155 rocket
launchers

For interest, some data extracts from the Flight Manual (dated July 1975) relating to rocket firing and bomb release sequences are provided on the following two pages.

ROCKET FIRING OPERATIONAL USE



- ON GROUND :

. Preselection on each rocket launcher nose → [1 / 3 / 6] (For SINGLE control only)

- IN FLIGHT :

. ROCKET FIRING IS ALWAYS MANUALLY CONTROLLED

. SINGLE/SALVO selection
  - SINGLE : At stations 1, 2 or 1+2, depending on selection made on armament control panel
    Each time the pilot depresses the rocket button, 1-3 or 6 rockets per launcher are fired depending on the ground preselection
  - SALVO : At stations 1, 2 or 1+2 as for SINGLE.
    When rocket button is briefly depressed :
    → the rocket salvoes are limited
    When rocket button is held depressed :
    → all the rockets are fired

. RP selected
. Armament master switch safety removed
. Firing trigger tilted
. Rocket button depressed

ROCKET FIRE CONTROL SYSTEM OPERATIONAL USE

SETTINGS

. RP selection
. Firing on moving target is not considered with rockets → no difference between FIX and MOV
. LAS + Δ
. Δ Z value
. Manual gravity drop value.

HUD DATA

. Moving reticle :
  - Gravity drop with incidence correction elaborated in the HUD (elevation deviation)
  - Ballistic drift correction (azimuth correction)
  - Roll angle
. Remaining distance = 0

PILOT'S ACTIONS:

. Altitude resetting
. Dive
. Central dot of moving reticle maintained superposed on the target
. Distance resetting → Remaining distance indication
. When remaining distance = distance for which gravity has been set :
  → Rocket button depressed

FIGURE 17 - ROCKET FIRING

BOMB RELEASE OPERATIONAL USE

- ON GROUND :
  . If bombs stored under fuselage (CLB. 4 pylon), setting (on the armament control panel ) of the number of these bombs (To inform the bombing computer about this number)

- IN FLIGHT :
  NOTE : BOMB RELEASE CAN BE AUTOMATIC OR MANUAL (SEE FURTHER)
  . STATION (F/1/2/1+2/F+1/F+2/F+1+2) Selection
  . SINGLE/SALVO selection
    - SALVO : each time the bomb button is depressed, the pulse distributor sends a train of pulses which results in sequential release of bombs at all selected stations *
    - SINGLE : each time the bomb button is depressed, the pulse distributor sends a pulse directed in the same way as in the SALVO configuration
  . Fuse arming mode (INST - DELAY - SAFE) selected
  . CLEAN or RET BOMB selected
  . Armament master switch safety removed
  . Firing trigger tilted
  . Bomb button depressed

REMARKS

- * The two output pulse distributor, controlled by the bombing computer feeds, in turn, release pulses to a left wing electrical line and to a right wing electrical line, then, if selected to the fuselage station.
  Each pulse causes one bomb to be released

- Release sequence:
  . If F+1+2 selected : L/H 2, then R/H 2, then R/H 1, then L/H 1, then F
  . If F+1 selected : R/H 1, then L/H 1, then F
  . If F+2 selected : L/H 2, then R/H 2, then F .

- Interval :
  . If F or F+1 or F+2 or F+1+2 selected: Δ t between 2 bombs = 270 ms
  . If 1 or 2 or 1+2 selected : Δ t between 2 bombs = 30 ms

- CLB. 4 release sequence :
  . Rear left, rear right, front left, front right (with Δt = 270 ms if SALVO)

FIGURE 16 - BOMB RELEASE (PART ONE)

Section 1.13 – South African Air-to-Air Missile Development 1966 – 1990 (Research by Martin Strümpfer)

Air-to-Air missile history in South Africa started with the acquisition of the Mirage IIICZ fleet in the early 1960's. The missile armament for the new interceptors would consist of :

- For close-in dogfights, the then state of the art Philco Ford AIM-9B "Sidewinder" Infra-Red Homing (IRH) missile.
- for the beyond visual range arena, the Matra Hautes Technologies R530 Semi Active Radar Homing (SARH) missile. This missile would however prove an unreliable weapon, heavily dependent on depot level support, and would not see operational use outside of South Africa nor any local attempts at improving the missile.

The need to become an independent munitions supplier was already recognised at an early stage with South African work on missile technology starting in 1964. By 1966, the CSIR commenced work on improving the proximity fuze of the AIM-9Bs in service by replacing the old system's valve technology with electronic transistors. The upgraded AIM-9B would be named the Voorslag (Whiplash) 1. Only a handful of new fuses were produced.

Focus soon shifted to from upgrading the AIM-9B to local production thereof. The AIM-9B would be reverse engineered and would be named the V2 (Voorslag 2). Reports vary as to whether the locally developed proximity fuse of the V1 was incorporated into the V2. Again, no production run followed and only a small number of prototypes were built.

In 1969 the SAAF indicated the need for a missile which offered improved maneuverability in comparison to the AIM-9B. This request meant further work on V2 would be redundant. Work on an improved missile based on the V2, now named the V3, started in 1971. Two additional fixed canards on the front of the missile along with two larger control surfaces resulted in the desired increased maneuverability. The first successful intercept tests were reported in 1972. Around 20 missiles would be built during the production run starting in 1973 and ending in 1975. The V3 would also be among the first missiles in operation at the time which could be used in conjunction with a South African developed helmet mounted sight.

Further improvements were requested based on operational experience where it was found that the V3's seeker gimble angle was too limited. Work on improving the now named V3A started in 1975. The resultant V3B offered a more sensitive IR seeker with a bigger 'view angle', an upgraded motor improving performance and an increased helmet-sight designation angle. V3B started entering service in 1979. V3B production would continue until 1985 with 450 units being produced.

V3B would be the last AIM-9 derived missile development. For the next generation of missile which would be named V3C, a larger calibre was desired. A larger calibre meant a larger warhead and a larger rocket motor for increased lethality. The longer motor burn time would mean an increase in kinetic energy which could be converted to increased maneuverability and / or range.

Development of the V3C, which would be based on the Matra R550 missile which was procured with the Mirage F1 in the mid-1970s, started in the mid-1980s. While it would retain the outer mould line and fin arrangement of the R550, it would feature a completely new IR seeker with further improvements in the seeker gimble angle over both the R550 and V3B. A new proximity fuse, warhead and rocket motor would also be part of the package. Development of the V3C would however be a long and protracted affair and by 1990, after the end of the border war, the missile was still only seen undergoing operational testing and evaluation. The V3C was thus similar to the R550 with the only external differentiator being the two large "eyes" of the laser proximity fuse present just aft of each of the rear canards.

The protracted development of the V3C left the SAAF without a modern short-range missile during a crucial time when their Angolan MiG-23 opponents boasted the small, but highly maneuverable Vympel R-60MK missile which outclassed both V3B and the R550 and could be fired from a head on aspect. Despite repeated

calls by SAAF pilots for improved missiles since the early 1980s, their requests would not be met. After Arthur Piercy's Mirage F1CZ was damaged by a R-60MK missile fired by an Angolan MiG-23, the acquisition of a new missile was given top priority.

The solution would be found in the Israeli Rafael Python 3 IRH missile. Several missiles were procured and integration onto SAAF Mirages of the now named V3S "Snake" started in 1988. Available in Israeli Air Force service since 1981, the V3S performance was a major step forward over the V3B and R550. Many SAAF Mirage pilots are of the opinion that had the missile been procured earlier, it would likely have changed the outcome of several dogfights between SAAF Mirage F1s and Angolan MiG-23s during 1987 to 1988.

South African missile development between 1966 and 1979. In white is an AIM-9B / V1 with V2, V3A and V3B above it. Light Blue indicates these are trainer missiles without explosives. Live missiles are tan coloured.

V3B or R550 for combat operations ?

Generally, the R550 was used by the F1CZ and the V3B by the F1AZ. Both R550s and V3Bs were carried only on the wingtip stations and were always carried in pairs.

CZ #214 with wingtip mounted R550 IR guided air-to-air missiles.

AZ with wingtip mounted V3B missiles. Note the different canard arrangements between the two as well as the more slender (high aspect ratio) tail fins of the R550.

CZ #212 on airshow display duty with two R530s on the inboard wing stations and two R550s on the wingtip stations
It carries a centerline RP35 1,200 liter fuel tank. The R530 was not used by the SAAF in combat operations.

The V3C was identical to the R550 in appearance. The main visual difference between the two are the large “eyes” of the laser proximity fuse present on V3C, 2 just aft of each of the rear canards.

Two images of CZs carrying V3S missiles on the outboard wing pylons. Notice how the V3S launch rail interfaces to the standard Station 2 pylon through and adaptor. The aircraft above is carrying an R550 missile on the wingtip station, whereas the aircraft below carries a V3B in this location.

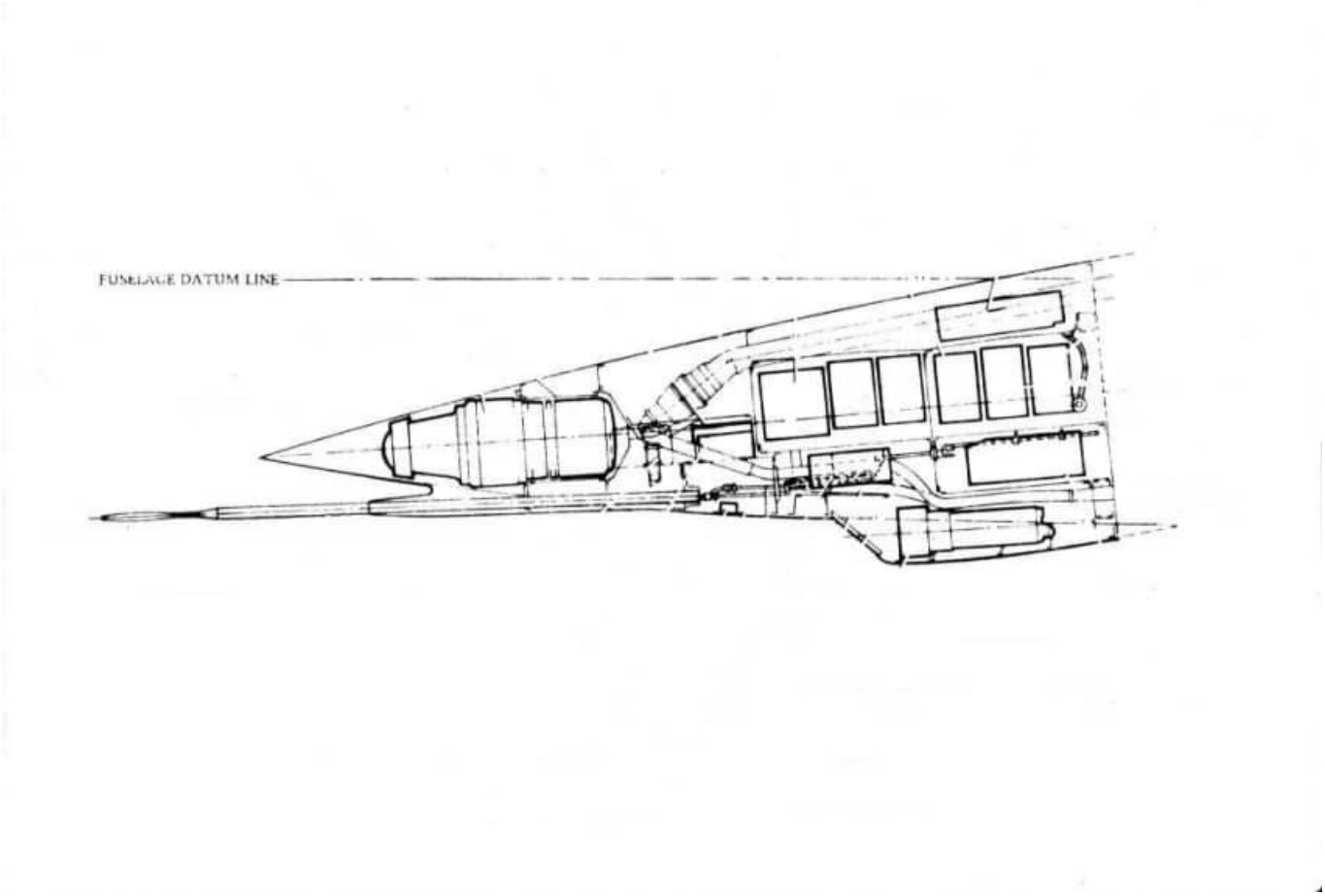
Section 1.14 – SMR-95 engine installation on AZ #216.

AZ #216 was modified by installing a Russian SMR-95 engine. Although successfully test flown, this modification was not incorporated into the F1 fleet.

AZ #233 with standard Atar 09K50 exhaust arrangement.

AZ #216 with Russian SMR-95 engine installed – note the different exhaust arrangement from the Atar 09K50 in the image above. #216 was the only Mirage F1 so equipped.

Section 1.15 – AZ nose details.



The small ranging radar is in the forward section of the nose. The laser designator is in the fairing beneath the nose. The refuelling probe can be seen lying along the top of the nose above the rectangular avionics boxes.

Reference list.

Apart from the Internet, several published reference works were used in the compilation of the three Volumes of this book. These are :

Aircraft of the South African Air Force	Herman Potgieter and Willem Steenkamp	Struik ISBN 0 86977 133 7 1980 first edition
South African Air Force In Profile Artwork (1960 - 1989)	Piet van Schalkwyk	Golden Eagle Artwork, 2022
South African Air Force In Profile Artwork Volume 2 (1985 – 2003)	Piet van Schalkwyk	Golden Eagle Artwork, 2024
Squadrons of the South African Air Force (and their aircraft 1920 – 2005)	Steven McLean	Interpak Books ISBN 0-9584929-4-8 2005
More Than Game – A salute to the South African Air Force	Herman Potgieter	AirReport ISBN 0-620-19213-5 1995
Vlamgat – the Story of the ~Mirage F1 in the South African Air Force	Dick Lord	Covos-Day Books ISBN 0-620-24116-0 2000
The SAAF at war 1940 – 1984	JS Bouwer and MN Louw	Chris van Rensburg Publications (Pty) Ltd ISBN 0 86848 056 7 1989
The MiG diaries – Fighter pilot memoires & accounts of Cuban, SAAF and Angolan air combat in Southern African skies	Lt-Col E. Gonzalez Sarria & Lionel Reid	Burnet Media ISBN 978-1-990956-60-7 2023
75 Years on wings of eagles South African military aviation history	Dave Becker	Colourgraphic ISBN 0 947478 47 7 1995
Africa @ War 54 – War of Intervention Angola Volume 4	A. Fontanellaz, T. Cooper, J.A. Matos	Helion & Company Limited ISBN 978-1-804510-59-9 2021