

Remote Runway Operations

A guide for BAE Systems Regional Aircraft Operators of the BAe 146 and Avro RJ



Remote Runway Operations - Preface

This publication gives an overview of potential operations of the BAe 146/Avro RJ series of aircraft on remote or under-developed airfields. Whilst it is impossible to control the geographical locations of areas of commercial attractiveness, the capabilities of the BAe 146/Avro RJ allow for optimum performance in even the most challenging of scenarios.

The ability of the aircraft to deliver goods and services to remote areas sets it apart from other jet aircraft types, further proving the quality of the original design.

The information provided in this brochure is intended to promote understanding of the types of environment the aircraft might be exposed to in remote areas. It also advises how the aircraft may be modified to optimise performance in such environments. Topics covered include Unpaved Runways, Narrow Runways, Steep Approach Operations, High Altitude Airfield Operations, Adverse Climates and Island Operations.

A further section on Operating Independence delivers information on equipping the aircraft for airfields where there is little or no ground support. Possibilities for aircraft Fuel Capacity Improvements are discussed along with information on the Performance Software options available to Operators.

It should be emphasised that this document does not provide a means of approval of operation outside the Aircraft Flight Manual, AFM 5.1. This document is intended to promote the capabilities of the aircraft, those capabilities being realised through Flight Manual amendments, appendices, FCOM information, or other approved means.

Please contact Flight Operations Support at raftops@baesystems.com for any further information or advice.

Access to Remote Runways can support key Industries Worldwide



Contents

INTRODUCTION	4	ADVERSE CLIMATES	20
		Cold Operations	20
		Hot Operations	21
UNDERSTANDING REMOTE RUNWAYS	6	HIGH ALTITUDE AIRFIELD OPERATIONS	22
Runway Surface Types	6	General Considerations	22
Pavement Strength Classification Methods	6	Hot and High Operations	22
Runway Slope	8	High Altitude Modifications	23
Paved Runway Operations with Low Pressure Tyres	8	Operating in Mountainous Regions	23
UNPAVED RUNWAY OPERATIONS	10	ISLAND OPERATIONS	24
Unpaved Runway Surfaces	10	Allocating Sufficient Fuel for an Island Operation	24
California Bearing Ratio (CBR)	11	Extended Over-water Operations	25
Unpaved Runway Operations with Low Pressure Tyres	12	FUEL CAPACITY IMPROVEMENTS	26
Landing on an Unpaved Runway with Low Pressure Tyres	13	Auxiliary Fuel Tanks	26
Take-off from an Unpaved Runway with Low Pressure Tyres	13	Range Extension Performance	27
NARROW PAVED RUNWAY OPERATIONS	14	PERFORMANCE SOFTWARE	28
Landing	14	Take-off Data calculation Software (ToDc)	28
Ground Handling	14	Pacelab CI OPS Cost Index Software	29
Take-off	14	SUMMARY	30
STEEP APPROACH OPERATIONS	16	APPENDIX GLOSSARY	31
OPERATING INDEPENDENCE	18	LIST OF AFM APPENDICES	31
Flyaway Kit Option	18		
Modifications for Operating Independence	19		

Introduction

The fundamental capabilities of the BAe 146/Avro RJ series of aircraft can be traced back to the original design influences. The aircraft was initially intended for short field operations where it could fully capitalise on its remarkable Short Take-Off and Landing (STOL) abilities on rough or unprepared runways around the World. Such early influences are distinguishable in the aircraft's characteristic configuration of high wing, T-tail, four engines, large Fowler flaps and clam type tail mounted airbrakes. This configuration allows the aircraft to have a relatively low approach speed which when combined with the airbrakes and spoilers, results in the short landing capability. The four engines make it ideally suited for short take-offs where even with one engine inoperative, the aircraft still retains three quarters of its performance. Such features have allowed the aircraft to perform uniquely in its class with years of niche operations into London City airport contributing to its exemplary service history.

Consequently, the BAe 146 and Avro RJ have continued to find commercial success in a variety of diverse operational scenarios while maintaining the capability to explore some less conventional environments or remote and challenging terrain. That success has allowed Operators to cover a uniquely wide range of markets, perhaps best proven by the global presence of some 222 aircraft reported in service with 63 Operators Worldwide in 2011.¹

Many years after the early design stages, Regional Aircraft are still finding new and exciting roles for the highly capable BAe 146/Avro RJ. The company endeavours to support customers in their operations while providing dynamic solutions and certification to new concepts for the aircraft. It is therefore no surprise to see it performing in the kinds of challenging environments it was designed to operate in. One might even suspect that as it proves its revenue earning potential in new markets, more and more customers may opt to use the aircraft to support their operations to remote runways, wherever they may be.

As our industries change or develop in the most remote of areas in countries far and wide, customers need a cost and time efficient means to directly place their goods or their services into the right places. The BAe 146 or Avro RJ can meet this need.

The aircraft design itself is well suited to remote runway operations. Whether it is a cargo or a passenger operation, the aircraft exhibits a good balance between capacity and performance. Operators of the aircraft benefit from a combination of impressive short field performance and competitive still air range. The steep approach capability, available as a modification, may also support operations into remote airfields where the approach may be restricted by obstacles or high ground.

The high wing keeps the engines clear of the runway surface helping to mitigate ingestion of loose gravels, dust or Foreign Object Debris (FOD). The engines themselves, of modular design, are comparatively easy to maintain with singular change times reported to be one tenth of the time expected for a larger twin engine aircraft. The three engine ferry capability from paved remote runways allows the Operator to ferry the aircraft on three engines to a maintenance base, significantly reducing the potential for downtime or service disruption. Fast turnaround times, characteristic of this aircraft type, may also be possible in remote areas with the APU-powered systems, waist-high baggage holds and optional integral airstairs.

In short, this really is the right aircraft for this role. Augmented by a dedicated support team who work to optimise and improve operations, the BAe 146/Avro RJ will continue to demonstrate its versatility and adaptability for future roles in young and developing markets. In the sections which follow, the suitability of the aircraft for this developing remote operations market is explained along with recommendations for aircraft modification or application of best practice procedures.

The BAe 146/Avro RJ has a global operating market base making it...

¹ Ascend Online Database, February 2011, as presented at the 2011 Flight Operators Conference
<http://www.ascendworldwide.com/>



**...the right aircraft for
the right routes**

Understanding Remote Runways

Remote airfields exist all over the World. They are remote in the fact that they exist in areas often far from civilisation and hard to reach by ground based means of transport. In some countries, these kinds of airfields may be common due to the nature of movements between rural towns and cities or the lack of suitable infrastructure to support a full air transportation service. In fact, transport movements to a particular location might be so infrequent or specific to one group of individuals that it is just not economically viable to develop an airport link.

This might be especially true of operations to remote mines, drilling sites or scientific sites. Although the list is not exhaustive, Today's examples can be found in Australia, Canada, Africa, South America and Antarctica.

Runway Surface Types

The runway surface type is often a consequence of the geographical location and should be a key consideration for any aircraft operator wishing to access a remote airfield. Runway surfaces can be considered to be either paved or unpaved. The following information discusses paved runways. Unpaved runways are discussed later in this publication.

Paved Runways

A paved runway is a sealed hard surface such as tarmac or concrete and is capable of supporting the operational weight of an aircraft for the intended period of use. The following are standard definitions for paved runway surface types.²

Tarmacadam Pavement - Uniformly sized stones rolled or compacted in-place, and usually sealed by an asphalt treatment that penetrates into the uppermost portion of the surface, or coated with tar or bitumen. Usually such surfaces are thin by typical airport standards, on the order of 1 to 2 inches (2 to 5 centimetres) thick.

Flexible (Asphalt Pavement) - A runway, taxiway, or ramp that is surfaced with a mixture of asphaltic materials (asphalt and aggregate) of from 3 to 5 inches (8 to 13 centimetres) or more in thickness.

Rigid (Concrete Pavement) - A runway, taxiway, or ramp that is surfaced with a mixture of concrete materials of from 6 to 20 inches (15 to 51 centimetres) or more in thickness.

Pavement Strength Classification Methods

Aircraft Classification Number (ACN)/Pavement Classification Number (PCN)

The Aircraft Classification Number (ACN)/Pavement Classification Number (PCN) is a method of reporting the pavement strength and the relative effect of an aircraft on that pavement.

Agreed in the 1980s by the International Civil Aviation Organisation (ICAO) and the member states, the rating system applies to the bearing strength of paved runways intended for aircraft of apron (ramp) mass greater than 5,700 kg (12,566 lbs). Information contained within the BAE Systems Airplane Characteristics for Airport Planning Manual or AFM 5.1 give reference to the PCN values relating to paved covered surfaces such as tarmacadam or concrete and also ACN values for each aircraft sub-type.

The method distinguishes between pavement type, subgrade strength category, maximum allowable tyre pressure category and pavement evaluation method as follows³:



² Boeing 'Runway Pavement Surface Type Descriptions'
http://www.boeing.com/commercial/airports/faqs/boeing_pavement_surface_types.pdf



Pavement Classification Number (PCN) Code

The pavement classification number, used in conjunction with the Aircraft Classification Number, helps to protect an aircraft ramp, runway or taxiway from overloading or excessive wear. PCN is expressed as a 5 part code as follows:

- The first part of the PCN code is a number relating to the assessed strength of the pavement.
- The second part of the code refers to the pavement type. A rigid (concrete design) pavement is defined by a letter **R**. A Flexible (asphalt design) is defined by a letter **F**.
- The third part is a letter from A to D. This letter defines the bearing strength of the subgrade soil beneath the pavement. A letter **A** defines the strongest subgrade material and a letter **D** defines the weakest subgrade. Further information on subgrade category strength is provided in the table below:

- The fourth part is a letter which defines the maximum allowable tyre pressures that the pavement can support. The scale ranges from **W** to **Z** and is shown opposite.
- The fifth and final letter gives an indication of the evaluation method used to classify the pavement. The letter **T** indicates that a specific technical evaluation of the pavement was conducted and that pavement behaviour technology was applied as part of that evaluation. The letter **U** indicates that the evaluation is conducted 'Using Aircraft Experience', representing knowledge of a specific type and mass of aircraft satisfactorily being supported under regular use.

Pavement Class	Maximum Tyre Pressure
W (High)	No Pressure Limit
X (Medium)	1.5MPa (217psi)
Y (Low)	1.0MPa (145psi)
Z (Ultra Low)	0.5MPa (72psi)

Subgrade Strength Category	Flexible Pavements		Rigid Pavements	
	CBR* Standard (%)	CBR* Range (%)	Strength Standard (MN/m ³)	Strength Range (MN/m ³)
A (High)	15	>13	150	>120
B (Medium)	10	8 to 13	80	60 to 120
C (Low)	6	4 to 8	40	25 to 60
D (Ultra Low)	3	<4	20	<25



* Refer to Unpaved Runway Operations section for information on CBR

Aircraft Classification Number (ACN) Code

The Aircraft Classification Number (ACN) is a number expressing the relative effect of an aircraft on a pavement for specified subgrade strength. The procedure for calculating ACN is given in the ICAO Aerodrome Design Manual, Part 3.⁴ The ACN value for an aircraft is calculated by taking into account the aircraft Centre of Gravity (CG) location, the tyre pressure, tyre size and tyre spacing.⁵ ACN values for the BAe 146 or Avro RJ can be found in the Airplane Characteristics for Airport Planning Manual which can be accessed through iSAPPHIRE.

If the ACN for an aircraft is lower than or equal to the reported PCN for an airport pavement, the aircraft can operate without weight restriction on that pavement subject to any limitations such as maximum allowable tyre pressure. If the ACN is higher than the PCN, it may be that the operator can agree a PCN dispensation with the airport authority, possibly with conditions attached relating to airframe and runway inspections. The operator may also reduce the aircraft weight to comply with the PCN limitation.

ACN-PCN Method Example**PCN 50/F/B/W/T**

The above code reports that the runway of flexible (asphalt) design, and resting on a medium strength subgrade, has been assessed by technical evaluation to be of PCN 50 and with no tyre pressure limitation.

For **ACN < 50**, the aircraft can operate without weight restriction.

For **ACN > 50**, the aircraft must operate at reduced weight or agree a dispensation.

Typically, Pavement Classification Number (PCN) is not used for unpaved runways. For the strength rating of unpaved runways, the California Bearing Ratio (CBR) is used and this ratio is described in the Unpaved Runway Operations section of this publication.

Load Classification Number (LCN)

The Load Classification Number (LCN) method of evaluating pavement strength was adopted in 1956 as one of the ICAO standards for rating pavement strength.⁶

To use the system, An LCN value must be provided for both the pavement and the aircraft. The pavement LCN can only be reported if some surface specific information is known. For a flexible pavement, the total pavement thickness is required and for a rigid pavement, the radius of relative stiffness (or L-Value) is required.

LCN of the aircraft is related to tyre pressure, contact area, pavement thickness and Equivalent Single Wheel Load (ESWL). If the LCN of the aircraft is less than or equal to the LCN of the pavement, then the aircraft can operate on that pavement. This method was superseded by the ACN-PCN method in 1983 as the official ICAO pavement rating system.

Runway Slope

As stated in the Limitations section of AFM 5.1 (section 2-024-10, page 1), the maximum effective runway slope uphill or downhill is 2%. An appendix to the Flight Manual can be considered for runway slope greater than 2%. This would be subject to the capability of the aircraft to operate from the particular airfield considering aspects such as runway length, elevation and any other pertinent physical characteristics of the airfield.

For further information or advice, contact Flight Operations Support at: raftops@baesystems.com



⁴ ICAO Aerodrome Design Manual, Part 3, 'Pavements', Document 9157

⁵ Boeing 'Description of the International Civil Aviation Organisation (ICAO) ACN/PCN Pavement Strength Rating System' (http://www.boeing.com/commercial/airports/faqs/icao_acn_pvmt_rating_system.pdf)

⁶ Boeing 'Precise methods for Estimating Pavement Classification Number', document number D6-82203 (<http://profemery.info/aviation/Boeingestimatingpcn.pdf>)

Paved Runway Operations with Low Pressure Tyres

In situations where the aircraft is fitted with low pressure tyres and is to be operated on a paved runway, operators should purchase AFM 5.1 Appendix 29, entitled 'Operation with Low Pressure Tyres on Paved or Unpaved Runways'. For more information on obtaining this appendix, contact the modifications department at:

ramodifications@baesystems.com

Part 1 of this appendix deals specifically with paved runway operations with low pressure tyres. It should be noted that the information contained within the appendix is advisory and does not act as a means of approval. Such approval must be obtained from the relevant National Aviation Authority, in accordance with the operator's flight operations procedures. Some operational points from Part 1 of the appendix are given in this section.

If low pressure tyres are installed on the aircraft, larger wheel rims must also be fitted to accommodate the larger tyres. Two common wheel rim types are the AHA 1490 and the AHA 1900 and the correct choice of wheel rim depends on the aircraft sub-type.

It should be noted that the wheel rim type influences the aircraft Maximum Take-Off Weight (MTOW) when operating from a paved runway. For more information or advice on operating restrictions for low pressure tyres on a paved runway, please contact Flight Operations Support.

Landing on Paved Runways with Low Pressure Tyres

For landing on paved runways with low pressure tyres there is a correction made to the Landing Distance Available (LDA) due to a performance penalty. The penalty is due to a slight deterioration in braking performance such that the LDA is reduced by around 3%. An equivalent LDA which accounts for this penalty can be established using charts in AFM 5.1 Appendix 29 Part 1.

The maximum landing weight for Landing Distance Available can then be calculated with reference to the appropriate chart in AFM 5.1, Chapter 6.

Take-off from Paved Runways with Low Pressure Tyres

A take-off from a paved runway with low pressure tyres does carry with it a slight performance penalty in comparison to that achieved with standard tyres. The penalty is a reduction in Take-off Distances Available of about 1%. This is due to the fact that braking performance is slightly deteriorated.

It should also be noted that low pressure tyres heat up more quickly than standard tyres so fast taxi speeds and high brake temperatures should be avoided wherever possible.



Unpaved Runway Operations

An unpaved runway differs from a paved runway in that its surface is not sealed or covered with a rigid pavement material. Unpaved runway surfaces may therefore have surface stones or soils which are free to displace and the load bearing characteristics of such runways may be somewhat different from their paved counterparts.

Unpaved Runway Surfaces

Operation from an unpaved runway requires the surface condition to be well compacted and the bearing strength to be adequate to support the weight of the aircraft under the climatic conditions, for the intended period of use. There should be no standing water, deep ruts, large stones or deep loose gravel on the runway. The following are some typical unpaved runway surface types:

Laterite and Lateritic Soils

Laterites are soil types formed in hot and humid areas by the extensive weathering of pre-existing rocks. The soils are characterised by the presence of iron or aluminium oxides or hydroxides and can be red, brown or yellow in colour. Land areas covered with laterite may be found between the tropics of Cancer and Capricorn on the flat planes of Africa, in parts of South America or in Australia. The image below shows the terrain in Niger.

Murrum is an example of a lateritic soil that can be compacted to give a mechanically stable material. Operation from hard, smooth unpaved runway surfaces such as murrum or laterite is permitted so long as the surface is dry and the bearing strength of the runway is shown to be adequate to support the weight of the aircraft.

Gravel Runways

A gravel runway consists typically of a mixture of compacted soils and stones, with a surface that is not bound by any additives such as asphalt or cement. As the loose surface material is free to displace, aircraft operations may alter the surface condition of the runway. Frequent surface inspections may therefore be required.

Depending on the surface type, the ability of an unpaved runway to bear load may be lower than that experienced on a paved runway. This load bearing capacity is measured by the California Bearing Ratio (CBR).





California Bearing Ratio (CBR)

The California Bearing Ratio was developed by the California Department of Transportation for determining the load bearing capacity of soils used as the foundation for building roads. The ratio has since been used to measure the strength of unpaved runway surfaces or the bearing strength of soils under paved runways. The ratio is found by comparing the pressure required to penetrate a soil sample with the pressure needed to achieve equal penetration of a standard material (crushed California Limestone of CBR 100).

The relationship, expressed as a percentage, is shown here:

$$\text{CBR} = \frac{\text{Measured Force}}{\text{Standard Force}} \times 100\%$$

Operational points relating to California Bearing Ratio are described later.

Strengthening of Unpaved Runways

Perhaps the simplest way of increasing the bearing strength of an unpaved runway is by compacting the runway surface such that the constituent materials form a 'hard packed' top layer. Since the materials are not bound or sealed in any way, continued runway inspection and maintenance may be necessary. There are however some more permanent ways of strengthening an unpaved runway.

Aircraft operation from unpaved runways can cause the surface loose stones or soils to be displaced. Potholes and rutting can develop from continued use and small surface gravels or dust particles known as fines can be blasted from the runway resulting in impeded pilot vision and an increased need for aircraft and runway maintenance procedures. Resinous or asphaltic fluid binding materials or spray

sealants may be applied to the runway surface to bind the soils together. The procedures may result in the raising of the runway surface CBR, a reduction in dust and fines displacement and a smoother runway surface.

The bearing strength and fatigue life of an unpaved runway may also be increased by placing a ground reinforcing grid under the runway surface. This reinforcing grid works by interlocking and confining granular materials to provide a more robust surface capable of supporting heavier loads.



Unpaved Runway Operations with Low Pressure Tyres

Operators wishing to make use of unpaved runways should purchase AFM 5.1 Appendix 29, entitled ‘Operation with Low Pressure Tyres on Paved or Unpaved Runways’. For more information on obtaining this appendix, contact the modifications department at: ramodifications@baesystems.com

Part 2 of this appendix, dealing specifically with operations on unpaved runways with low pressure tyres, is summarised in this section.

It should be noted that the information contained within the appendix is advisory and does not act as a means of approval. Such approval must be obtained from the relevant National Aviation Authority, in accordance with the operator’s flight operations procedures.

Condition of Aircraft

The appendix advises that the aircraft should be fitted with both nose and main gear low pressure tyres. While there is no appreciable difference in construction between low pressure tyres and the standard tyres normally installed, the slightly larger and wider main gear low pressure tyres provide a greater tyre footprint. This allows the aircraft load to be spread over a greater surface area helping to prevent excessive runway damage. The main gear tyres require that larger wheel rims are also installed and the choice of wheel rim type depends on the aircraft sub-type.

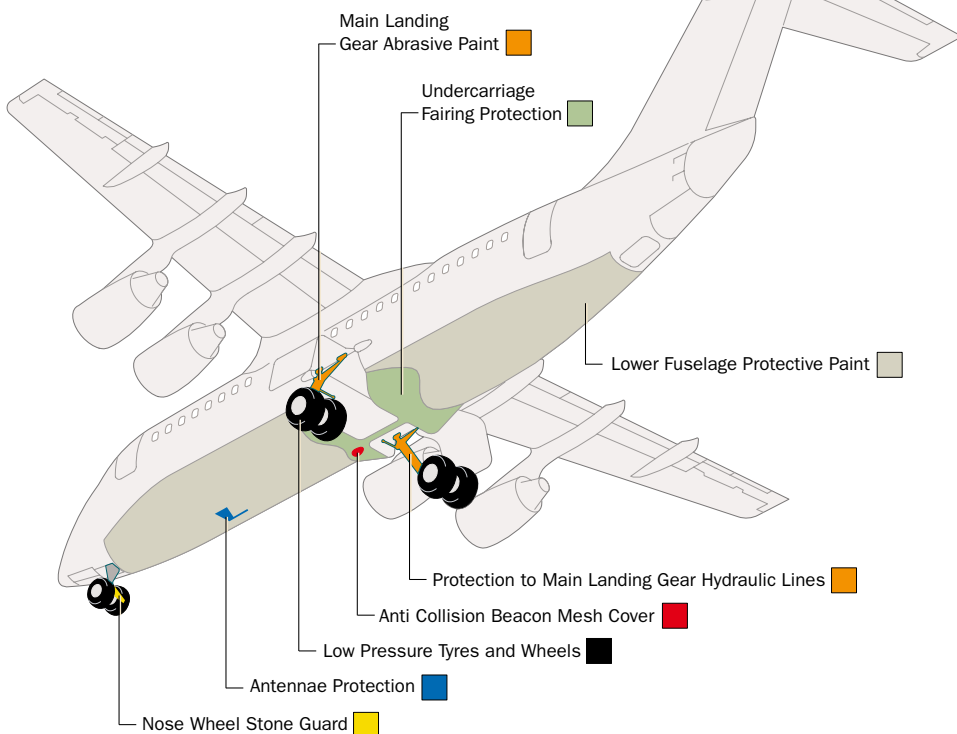
The appendix also advises that when operating from surfaces where there are loose stones or gravel, that the aircraft should be protected

from stone damage by embodiment of modifications. The recommended modifications depend on the aircraft certifying authority and aircraft type. Although the list is by no means exhaustive, the modifications may generally fit into the following categories:

- Nose and Main Gear Stone Guards
- Undercarriage component guards
- Antennae Protection
- Improved Paint Protection
- Mesh Protection for anti-collision beacon
- Protection of electrical or hydraulic lines

Kit options are also provided which encompass a combination of these modifications. The unpaved runway protection kit, fitted via a Service Bulletin (SB) may mitigate the possibility of damage to aircraft components and may decrease the likelihood of costly maintenance repairs. The kit includes nose and main gear low pressure tyres, larger main gear wheel rims, a nose gear stone guard, lower fuselage and main gear protective paint, an anti-collision beacon mesh cover as well as protection for main landing gear hydraulic lines and the installation of more durable antennae. A full listing of the kit components is shown in the diagram:

Unpaved Runway Protection Kit



Weight Limitations

Depending upon the certifying authority and aircraft type, there could be limitations with Maximum Ramp Weight, Maximum Take-off Weight or Maximum Landing Weight when the aircraft is fitted with Low Pressure tyres and operating on an unpaved runway.

These weight restrictions are driven by either structural limitations or tyre rolling speed limits at a given tyre deflection value. Higher tyre deflection values result in a flatter tyre which in turn causes a greater footprint and a greater friction requiring higher take-off speeds. The deflections of 32% and 35% are generally used for operation from unpaved runways.

General Operational Points

The following points are extracted from AFM 5.1 Appendix 29 Part 2 and apply to unpaved runway operations with low pressure tyres:

1. Operation of the aircraft is only permitted from:
 - Unpaved surfaces, when wet or dry, without standing water, deep ruts or areas of deep loose gravel deficient in fines
 - Hard, smooth, unpaved surfaces such as murrum or laterite, when dry
 - Unpaved surfaces with a minimum California Bearing Ratio (CBR) of 30.
2. The anti-skid must be operative and selected ON.
3. Fast taxi speeds and high brake temperatures should be avoided where possible because low pressure tyres heat up more quickly than standard tyres.
4. Brake temperatures at the start of the take-off roll must not be above 200°C.
5. The maximum and minimum aerodrome altitudes for take-off or for landing are 8,000 ft and -1,000 ft respectively. For altitudes above 8,000 ft, contact Flight Operations Support.

Landing on an Unpaved Runway with Low Pressure Tyres

For landing on unpaved runways with low pressure tyres, there are charts within AFM 5.1 Appendix 29 Part 2 that give a maximum landing weight for landing distance available. These charts are to be used instead of the charts in chapter 6 of AFM 5.1.

The resulting weights will be less than achieved when landing on a paved runway with standard tyres but the weight penalty will be variable dependant on runway length and elevation. The landing distances are based upon a flap setting of 33 degrees.

Take-off from an Unpaved Runway with Low Pressure Tyres

Start Up Area

A start up area is a dedicated paved or covered surface located adjacent to an unpaved runway to allow an aircraft to perform engine start and run-up procedures. Jet blast from the engines can cause significant displacement of the surface materials on an unpaved runway, not only degrading the surface covering of the runway but potentially causing excessive fatigue to the aircraft fuselage. By performing the spooling up of the engines in a designated start-up area, damage to the airframe from debris thrown up by the jet efflux could be significantly reduced.

Take-off

Take-off from a gravel or unpaved runway carries with it a penalty of around 10% in comparison to a paved runway of similar length. AFM 5.1 Appendix 29 Part 2 contains a chart that allows equivalent distances for Take-off Distance, Take-off Run and Accelerate Stop Distance to be determined which take account of the penalty.

These equivalent distances should then be used to calculate the take off performance with reference to Chapter 6 of AFM 5.1. The charts are based upon a CBR of 70 and so further corrections to runway distances would need to be made for CBR values less than 70, down to a recommended minimum value of 30. Equivalent Take-off Distance, Take-off Run and Accelerate Stop Distance should be reduced by 0.5% for each incremental reduction of Δ CBR = 10 as shown here:



Unpaved Runway CBR	Reduction in Take-off Distance Available
70	No Reduction
60	Reduce by 0.5%
50	Reduce by 1.0%
40	Reduce by 1.5%
30	Reduce by 2.0%
Minimum Permitted CDB is 30	

Narrow Paved Runway Operations

The Limitations section of AFM 5.1 for the BAe 146/Avro RJ (section 2-024-10, Page 1) states the minimum runway width for take-off and landing is 30 metres (100 ft). Subject to certain conditions, a Technical Operational Response (TOR) may be issued for operation on a paved narrow runway, stating No Technical Objection. The TOR would represent a deviation from the Type Design Standard, and as such would require the agreement of the local Airworthiness Authority. Therefore the responsibility for operations from paved narrow runways of width less than 30 metres would lie with the operator and the approval would lie with the local authority.

Any such TOR would be airfield and runway specific. The declared airport data would be required including the runway width. A statement of what lies at the sides of the runway, such as any ridge at the edge that might damage tyres or wheels if run over, would be sought. The TOR would then be offered with advice and instruction for an operator wishing to use that paved narrow runway. In recent times, runway widths down to 23 metres have been addressed. The following gives examples of the types of advice which may be offered:

Landing

Landing on a narrow runway is to be carried out in dry runway conditions only and the crosswind component should be less than 10 knots. Landing with an inoperative engine is not advisable, and a diversion should be carried out to a more suitable airfield. The aircraft spoilers, anti-skid and Nose Wheel Steering (NWS) must be serviceable and the autopilot should not be used for landing on a narrow runway.

The handling pilot must be in control of the NWS which must be used as the primary means of steering the aircraft once the nose-wheel is on the ground. Care must be taken not to over control when using the NWS at high speed. A narrow runway may lead to depth perception problems for those unused to landing on such runways. When landing on a narrow runway, there may be a tendency for pilots to feel that they are much higher than they are, and this could lead to heavy landings.

Ground Handling

The runway should be bordered by a hard strip with a bearing strength able to support the weight of the aircraft. The aircraft should only perform 180 degree turns in the turning circles at the runway ends, and the turning circle and runway edge borders should be checked relative to wing and engine overhang and engine ingestion of loose objects. The minimum turning circle for an Avro RJ85 based on a straight approach and a 180 degree turn is 22.3 metres, as shown in the turning radii diagram overleaf. Specific turning radii information may be viewed in either the BAe 146 Series or BAe RJ Series Airplane Characteristics for Airport Planning Manual, Section 3, pages 6-8.⁷

Take-off

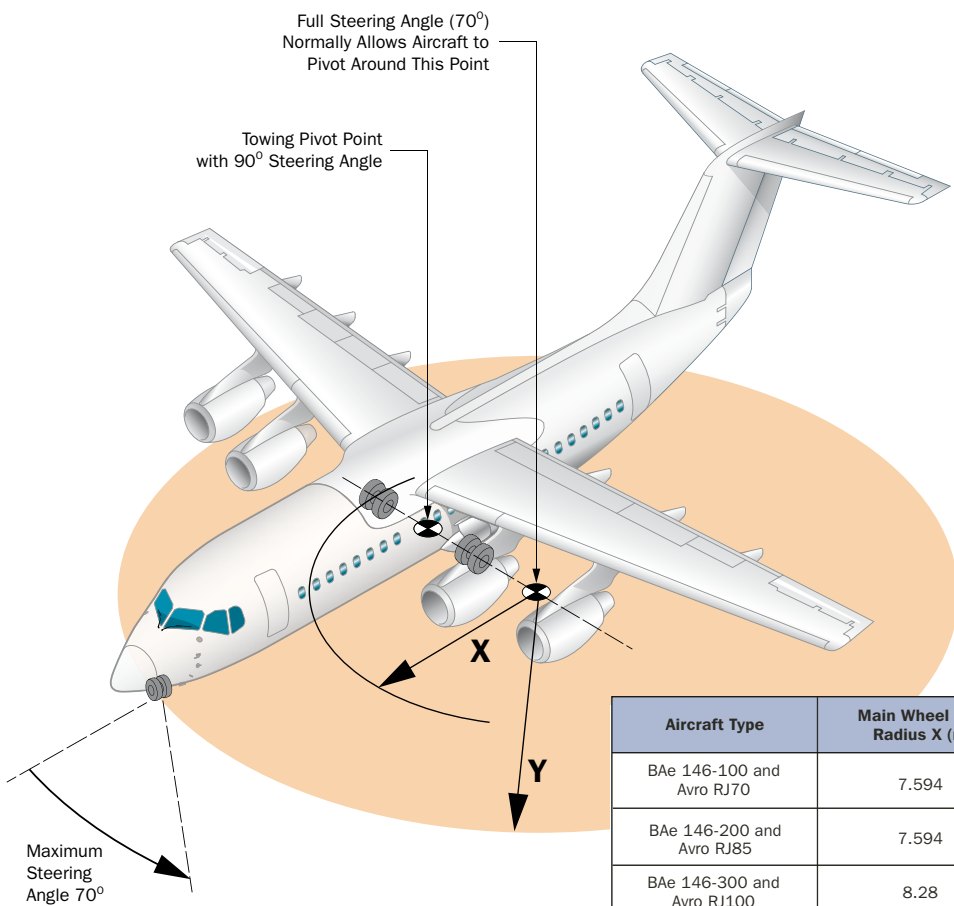
For narrow runway operations, the decision speed should be set equal to the rotation speed for take-off, and the Regulated Take-off Weight should be computed for this. Setting $V1 = VR$ helps ensure the Minimum Control Speed on take-off is met.

Take-off from a narrow runway is to be carried out in dry runway conditions only. A rolling take off is not recommended and it is important that the aircraft is correctly lined up on the runway prior to take-off. The crosswind component should be less than 10 kts and the spoilers, anti skid and NWS must be serviceable.

The handling pilot must be in control of the NWS and this must be the primary means of steering the aircraft up to V1. The pilot must be prepared to use NWS in the event of engine failure on take-off. In order to address potential controllability issues, three engine ferry take-off should not be carried out from Narrow runways.



⁷ BAE SYSTEMS Airplane Characteristics for Airport Planning Manual Manual Reference APM 146.1 and APM RJ.1



There are currently no known BAe 146/Avro RJ narrow runway operations onto unpaved runways. This would introduce further considerations and possible performance penalties. Flight Operations Support should be contacted for advice at: raftops@baesystems.com

Aircraft Type	Main Wheel Turn Radius X (m)	Nose Wheel Turn Radius Y (m)	Minimum Runway Width* (m)
BAe 146-100 and Avro RJ70	7.594	11.53	21.35
BAe 146-200 and Avro RJ85	7.594	12.55	22.35
BAe 146-300 and Avro RJ100	8.28	13.97	24.45

Note: All values given above are based on a 70 degree left steering angle
* Assumption is straight approach and 180 degree turn

Steep Approach Operations

The steep approach capability of the BAe 146/Avro RJ is one of the fundamental factors contributing to its commercial success. The ability to combine its characteristic quiet operation with a steep approach made the aircraft suitable for niche operations into noise regulated inner city airports. The most notable example of this is the operations into London City airport involving a short runway and a unique steep approach.



The feature is applicable to operations onto runways where the approach may be restricted by obstacles or high ground. Steep approach is available through modification and permits glideslopes of up to 6° increased from the standard 3° where approach aids are available. It should be noted that the maximum permitted glideslope depends on the aircraft sub-type and certifying authority.

AFM 5.1 Appendix 7 contains the approved limitations, information and performance data required when the aircraft is operated in a steep approach configuration. Operators intending to conduct such approaches should purchase the appendix and the associated aircraft modifications. Information on obtaining the appendix is available by contacting the modifications department at:
ramodifications@baesystems.com

If the aerodrome is approved for a screen height of 35 ft, and a PAPI (associated or not to an ILS) is in use, the landing distance available may be increased by an amount depending on the aircraft type and whether the runway is wet or dry. This landing distance available may be used to establish the permissible landing weight by reference to the chart entitled 'Maximum Landing Weight for Landing Distance Available - Flap 33°' in AFM 5.1 Section 6. It should be noted that in all other cases, the actual distance available must be used.

Operators should review the appendix in full to determine the approved limits for their aircraft sub-type.



The BAe 146/Avro RJ continues to be the dominant aircraft at London City Airport due to its steep approach and take-off obstacle clearance capability

Operating Independence

Remote airfields in sparsely populated areas may be less likely to have personnel available to carry out standard ground handling tasks. Operators may therefore wish to consider carrying their own ground handling crew possibly consisting of a maintenance engineer and a loadmaster. This would nominally add 200kg to the Operating Weight Empty (OWE) of the aircraft, which would now include a crew of 4 plus any flight attendants. The carriage of the ground crew, although adding weight, would facilitate the capability to carry out tasks that a standard flight crew of pilots may be unable or unqualified to conduct.

The engineer would be qualified to deal with maintenance problems or could conduct aircraft technical inspections. Even having deemed a component unserviceable, the engineer could fit spare parts preventing the costly grounding of the aircraft or the need to send an engineer from the operator home base. Spare parts are normally carried in the form of a 'flyaway kit' as described in the following section.

Flyaway Kit Options

A flyaway kit is a collection of spare parts which may be carried in the aircraft hold for the purposes of providing the means to conduct remote maintenance or repairs. The carriage of the kit requires a maintenance engineer to be part of the crew to conduct the repairs. The contents of the kit very much depend on the operation and so a list of pertinent spare parts might change from operator to operator. Common spare parts which might be recommended for a remote operation include: main and nose gear tyres, an engine starter motor and Transformer Rectifier Unit (TRU), engine components and oils, hydraulic oils and radio equipment. Also required would be the appropriate tools to carry out the tasks such as landing gear jacks and spanners, a mechanics tool kit, or a three engine ferry kit. The most comprehensive flyaway kits could weigh up to as much as 200 kg and would take up space in the aircraft hold.

To permit wheel changing or undercarriage maintenance procedures, jacking points are provided on each of the nose and main gear legs. These points may allow such procedures to be conducted at weights up to maximum ramp weight. Any remote maintenance should be conducted in accordance with approved methods printed in the Aircraft Maintenance Manual (AMM). For more information on remote maintenance procedures or flyaway kits, contact Customer Engineering on: raengliaison@baesystems.com

If the repairs required on the aircraft are such that they cannot be carried out in the remote airfield, it may be possible to conduct a ferry flight to a suitably equipped aerodrome for maintenance. Such ferry flights are to be conducted from paved runways and it should be noted that the aircraft shall fly only for the purposes of reaching the maintenance aerodrome. No persons other than the required flight crew members are permitted on the flight. Such procedures are provided as appendices to AFM 5.1. For operations in remote areas where ferry flights might be required, Operators should ensure they have the relevant flight manual appendices. The ferry flight options are described in the sections which follow. For more information on purchasing the associated appendices, contact the modifications department at: ramodifications@baesystems.com

Three Engine Ferry from a Paved Runway

If a BAe 146 or Avro RJ is operating from a paved runway in a remote location lacking technical support facilities, and that aircraft experiences a problem with an engine, the 3 engine ferry capability may allow for the aircraft to be flown back to a maintenance base for repairs to be conducted. Appendix 4 to AFM 5.1 entitled 'Ferry Flight in Which One Engine is Inoperative Before Start of Take-off' contains the approved limitations, procedures and performance data applicable to ferrying the aircraft with one engine inoperative from

a paved runway. This capability may prevent significant downtime or service disruption and sets the BAe 146/Avro RJ series of aircraft apart from many other aircraft types.

Ferry Flight with Landing Gear Down

In the case where the aircraft landing gear retraction mechanism is unserviceable, or where one or both of the main gear doors has been removed, the aircraft may be ferried to a maintenance base for repairs. Appendix 2 to AFM 5.1 details the pertinent limitations and performance data applicable to this procedure.

Ferry Flight with Flaps up

Appendix 3 to AFM 5.1 entitled 'Ferry Flight in which Flaps are Inoperative and Retracted Before Start of Take-off' details the procedural information and performance data applicable to such ferry flights with flaps up. Prior to take-off, the flaps must be set to ensure they remain in the fully retracted position throughout the flight. The aircraft must not be operated over water at a horizontal distance of more than 50 nautical miles from the nearest shore line.





Modifications for Operating Independence

There are various modifications available which are specifically designed to allow the aircraft to operate independently. Having landed in a remote location, these modifications may allow the aircraft to carry out a dispatch sequence and be prepared for a departure without the normal level of ground or technical support.

Forward and/or Rear Integral Airstairs

The forward and/or rear airstairs give the means for independent loading and unloading of passengers. Where ground crews would normally dock airstairs to the aircraft, the internally stored stair unit may be extended from the fuselage. This modification is applicable under any circumstances at any airport and is designed for operational flexibility.

Dual Ni Cad Battery/Internal Engine Start Modification

When no external power facilities are available or assistance is limited, the Dual Nickel Cadmium battery provides an additional method of main engine start. The battery needs to be installed with an accompanying aircraft modification which allows the aircraft to perform an internal engine start. The power for main engine start is usually provided by a Ground Power Unit (GPU) or the aircraft internal Auxiliary Power Unit (APU). In a remote location where a GPU may not be present or in the event of the APU being unserviceable, the battery modification provides the means

for engine start without the need for ground personnel support.

LED Navigation Lights

A single Service Bulletin incorporates both wingtip and tail LED Navigation Lights which may be advantageous for remote operations due to their increased reliability compared to standard filament types. The operational advantages of this modification are clear where ground services are lacking in remote areas. The LED lights have a mean time between failures of approximately 10,000 hours compared to 50 hours for the filament types and offer the potential for maintenance and financial advantages. The greater reliability means a lower likelihood of aircraft downtime for parts replacement. Grounding of the aircraft due to unserviceable navigation lights can prove costly.

HF Communications

Remote airfields often have restricted communications due to surrounding terrain or geographical location. The High Frequency Communications modification allows for greater flexibility in voice communications by extending the range of receivable radio signals compared to that available with a VHF radio. An HF Communications radio has the advantage of a global coverage. This may allow for voice communications with home bases from further afield.

Electronic Flight Bag (EFB)

An Electronic Flight Bag (EFB) is a computing platform which allows flight crews the opportunity to access navigational charts, operating manuals, performance material and weather all on a single dedicated screen. It is designed to improve operational flexibility and reduce pilot workload. Crews can plan and operate from the most remote location while cutting down on paper and reference materials in the cockpit. Data may also be sent direct to the aircraft from the operations headquarters allowing pilots to be adequately prepared for even the most remote airfields. Benefits may also include the ability to conduct weight and balance calculations or other associated flight planning tasks. For additional information contact: ramodifications@baesystems.com



Adverse Climates

For operations to some remote areas, the climate might impose some additional challenges which would not be expected in milder climates. Naturally, the operator must understand the expected conditions before planning such an operation and must take all necessary steps to ensure that the operating procedures are suitable and implemented safely. The following section focuses on extremes of climate and delivers some recommendations for both cold and hot operations.



Cold Operations

The main challenges associated with operations in cold climates may be the restrictions caused by the environment and the environment's effect on the airframe. We have already published a substantial technical brochure on icing conditions and cold operations entitled 'Think Ice!'

Whilst it is recognised that aircraft operating in remote areas may not have access to the ground support for providing full anti-icing or cold environment protection, it is recommended that operators take note of the points raised in Think Ice! and take the necessary steps to follow cold operations procedures wherever possible. AFM 5.1 Limitations section (2 - 024 - 10, Page 2) states that the minimum temperature for dispatch is either -40°C or -50°C, depending on the aircraft sub-type. The minimum temperature for a particular aircraft may be found on the flight deck placard.

Some key points for various flight phases have been adapted from Appendix I of the Think Ice! 2010⁸ brochure and are summarised here.



Approach and Landing on Contaminated Runways

If severe icing conditions exist or if residual ice is visible on the airframe, the approach should be adjusted to cross the threshold at VREF + 7 knots. Additionally, if landing with residual ice on the airframe, the maximum landing weight should be reduced in accordance with AFM 5.1. The field lengths required and landing weights achievable on contaminated runways can be obtained for a particular contaminant type and depth using AFM 5.1 charts or operational performance software. More information on the available software may be found on page 28 of this publication.

Taxiing

If icing conditions exist on the ground, engine anti-ice should be selected ON. Wing and tail anti-ice system must not be used during ground operations or for take-off.

Prolonged engine running at ground idle in icing conditions can result in ice accretion on the fan, possibly indicated by unusual airframe vibration. The ice can be shed by periodic increases of thrust which should be timed to prevent a heavy build up. An increase of N1 to 60% will usually be sufficient.

As described in FCOM Volume 3, Part 1 (Chapter 6, Topic 3, page 4) there may be some advantage in shutting down the outboard engines to reduce residual thrust when

the braking action is medium to poor. This should only be done whenever it is safe and convenient to do so when the aircraft is under control and the speed is less than 60 knots.

Brake temperatures should be maintained above 50°C in cold conditions to prevent brakes freezing on. This could occur following the retraction of the landing gear after take-off from a runway where slush or moisture could be deposited on the brakes. It is recommended that brake fans should be selected as follows to minimise brake icing:

Brake Temperature Indicator fitted:

- Select brake fans as required to maintain minimum brake temperature of 50°C. It may be necessary to warm the brakes to 50°C with brake applications while taxiing, exercising caution when braking on low friction surfaces
- Select BRK FANS to either auto (if fitted) or ON for take-off and landing
- After landing, select OFF when brake temperature falls below 200°C.

Brake Temperature Indicator not fitted:

- If brakes are suspected to be below 50°C prior to taxiing for take-off, it is recommended that the brake fans are selected OFF. To warm brakes, use symmetric braking of approximately 500 psi, sufficient to slow the aircraft from normal taxi speed on at least three



occasions, exercising caution when braking on low friction surfaces

- Select BRK FANS to either auto (if fitted) or ON for take-off and landing.

Take-off from Contaminated Runway or Low Friction Surface

Take-off weights from contaminated runways (allowing for the failure of one engine) can be calculated using AFM 5.1 charts or operational performance software. Particular attention should be paid to the value of V1 required for contaminated surfaces and flexible thrust should never be used. A flap setting of 30 degrees must be used for take-off and a rolling take-off is recommended for low friction surfaces. Lift Spoilers, airbrakes, anti-skid and all wheel brakes must be serviceable. Continuous ignition should be selected ON for the duration of the take-off if standing water, slush, ice or snow is present on the runway. Engine bleed air is not to be used for cabin air conditioning during take-off if slush, snow or water is present on the runway in significant quantities.



Hot Operations

When operating in hot climates, the conditions might impose some degradation to aircraft performance. Extended periods of high ambient temperatures might also influence the conditions of the airfield or the runway. AFM 5.1 Limitations section (2 – 024 – 10, Page 2) states that the maximum ambient air temperature for take-off and landing is +50°C at altitudes below 2525 feet and ISA +40°C at altitudes above 2525 feet. The section also states that the maximum en-route ambient air temperature is ISA +35°C.

Aircraft Performance

Air densities will be lower in high elevation airfields, in high ambient air temperatures, and combinations of these, commonly known as hot and/or high airfields. This results in poorer engine performance and poorer wing lift characteristics. The fundamental expression of an aircraft's performance capability is given by the WAT chart for the given flap setting. The Weight Altitude and Temperature (WAT) charts, available in AFM 5.1 Section 6, allow the operator to determine operating weights based on altitude and temperature. These are particularly important in climates where the operating temperatures might limit the aircraft performance and potentially lessen the climb gradients achievable by the aircraft.

If an operator is limited by the field length, the operation may need to be tailored around

the conditions. The most limiting time for operations in hot climates is likely to be during the hottest part of the day, perhaps between mid-morning and mid-afternoon. The most limiting case in terms of performance might be where the operator is planning an operation from a high elevation airfield in a hot climate. In such instances, the operator might wish to plan the operation for early in the morning or after the hottest part of the day. During such times, the more favourable conditions will result in a greater payload carrying capability.

Performance software is available to help Operators plan their operations and is described on page 28 of this publication.

Flight Deck Boost Air

For operations to remote runways in climates of high humidity, the flight crew might be exposed to extended periods of high temperatures. In the most remote of areas, the airfield might simply consist of a purpose built runway, with no normal airfield facilities or buildings. Consequently, the crew might be constrained to the aircraft while they plan their re-departure on a warm flight deck. The Flight Deck Boost Air modification allows the flight crew to work in a more comfortable environment. The modification provides increased airflow to the flight deck which is selectable while the aircraft is on the ground.

High Altitude Airfield Operations

General Considerations

At airfields of high elevation, the performance of an aircraft will be degraded compared to that experienced at ISA sea level conditions. This can be explained by the fact that air density decreases with altitude resulting in poorer aerodynamic performance. Consequently, at a high elevation airfield, an aircraft will require greater runway distances to take-off and will experience a poorer rate of climb. The Indicated Airspeed (IAS) at high altitude will be lower than the True Airspeed (TAS). A landing approach will therefore be faster than that experienced at sea level and the landing roll will be longer. Care should also be taken during the faster take-off run to ensure that tyre speed limits are not exceeded.

For operations to airfields at high pressure altitude (between 8,000 ft and 14,000 ft), operators should purchase AFM 5.1 Appendix 36. For more information on obtaining this appendix, contact the modifications department at:

ramodifications@baesystems.com

The appendix contains the limitations, procedures and performance data necessary to permit operation of the aircraft between these airfield pressure altitudes. Operators should review the appendix in full if they intend to operate from high altitude airfields. The following general operational advice should be considered:

- All engines must be operating at the start of the approach
- The main wheels must be fitted with high speed tyres capable of a ground rolling speed of 210 mph
- A 24 or 33 degrees for landing switch must be installed

- The use of flexible thrust is not permitted
- A high altitude warning switch must be installed to provide an alternative warning at 14,000 ft cabin altitude
- 18 degree flap must be used for take-off
- 24 degree flap must be used for landing
- Landing with flaps up is not permitted
- The maximum airfield pressure altitude for take-off and landing is 14,000 ft
- The maximum tailwind component for landing between 8,000 ft and 14,000 ft airfield pressure altitude is 10 knots
- The temperature range for operations between 8,000 ft and 14,000 ft airfield pressure altitude is -10°C to +30°C.

Hot and High Operations

The combination of high altitude and high temperatures provides the conditions for a reduction in both the aerodynamic performance of an aircraft and the efficiency of its engines. Under such conditions, take-off distances may be greatly increased and climb performance reduced. This becomes particularly pertinent for operations in mountainous regions or where obstacle clearance is required on the take-off climb. Flight crews should be aware of the conditions in which they are operating and should make use of the latest performance software.

For more information on the ToDc performance software contact Flight Operations Support at: raftops@baesystems.com





High Altitude Modifications

There are a number of modifications available for BAe 146/Avro RJ aircraft to allow operations to high altitude airfields (up to 14,000 ft). Such modifications are described here:

High Speed Landing Gear Tyres

To deal with the higher tyre speeds encountered at high altitude, main wheel tyres capable of a ground rolling speed of 210 mph must be fitted to the aircraft. The nose wheel tyres are rated to a maximum speed of 190 mph. This is sufficient because the possible higher touchdown speed will be on the main wheels. The aircraft speed will have dropped by the time the nose wheel comes in contact with the runway.

Cabin Oxygen Modification

If operating to a high elevation airfield up to 14,000 ft and the aircraft is installed with an automatically deployed passenger oxygen system, the standard barometric valve should be replaced with an alternative valve which allows the cabin to reach a pressure altitude of 14,000 ft. The modification is designed to prevent the inadvertent deployment of the passenger oxygen masks on an approach to a high altitude airfield where the cabin pressure altitude levels out with the destination ambient pressure. With this modification installed,

operators may access airfields up to 14,000 ft altitude without encountering the problem. It should be noted that not all aircraft types are fitted with an automatically deployed passenger oxygen system and other systems may require different modifications. For further advice please contact:

ramodifications@baesystems.com

Cabin High Altitude Warning Switch

When the cabin reaches a high pressure altitude, there is a high altitude warning annunciation on the flight deck. The warning annunciation would normally initiate at 9,300 ft pressure altitude. The high altitude warning switch allows the flight crew to switch to a 14,000 ft cabin pressure altitude datum for the annunciation.

Flap Control Systems

To allow for non-standard landing flap settings at high altitude airfields, Appendix 36 advises the installation of the 24 or 33 degrees for landing switch which allows a flight crew to select the 24 degree flap setting for landing without warning. The modification to allow 24 degree flap setting can be purchased from the modifications department. For more information, contact:

ramodifications@baesystems.com

Operating in Mountainous Regions

Mountainous regions pose some unique challenges for flight crews wishing to access remote airfields. The weather in such regions may be both restrictive and unpredictable. Flight crews should plan extensively for high altitude operations in mountainous regions. Operations might only be permitted in Visual Meteorological Conditions (VMC).

Mountain Waves

When wind flow is perpendicular to a mountain and above about 20 knots, the air flow can form waves on the leeward side. These waves might be composed of very strong updraughts and downdraughts and rotating columns of air known as rotors may also form. Lenticular clouds give a visual indication of mountain waves and rotor turbulence and such clouds may be reported in weather information as Altocumulus Standing Lenticular (ACSL) or Cirrocumulus Standing Lenticular (CCSL).

Island Operations

There are few efficient ways of placing goods and services into remote islands. In fact, the transportation of payload to remote islands may only be carried out by aircraft or by ship. Delivery of goods by ship may be slow and would require additional local ferrying of the goods if suitable docking facilities are unavailable. The advantage of accessing remote islands by air is that it may allow the placement of payload exactly where it is needed, in a quick and efficient manner, and at a frequency which may be unrivalled by any other means of transport.

Either due to limitations in their operating envelope or lack of ability to operate to short unprepared runways, there may be few aircraft able to access remote islands. The capabilities of the BAe 146/Avro RJ series may be exploited by operators wishing to reach these areas. Such operators may wish to consider the following points relevant to such operations:

Allocating Sufficient Fuel for an Island Operation

Fuel Policy

EU-OPS 1.255 of the Official Journal of the European Union⁹ sets out the standard basic fuel policy requirements for operators of EASA certified aircraft. The Appendices to OPS 1.255 give further detail of fuel policy requirements for various operational scenarios. The equivalent requirements for operators of FAR certified aircraft are given by FAR 121.639-645.

Given below are some points which may be pertinent to island operations. The commentary, extracted from EU-OPS 1.255, should not be considered a full guide to fuel policy and operators are advised to consult the appropriate regulatory documents in full to plan their particular fuel policy.

Isolated Aerodrome Procedure

An aerodrome may be considered isolated if the fuel required (diversion plus final) to the nearest adequate destination alternate aerodrome is more than, for aeroplanes with turbine engines, fuel to fly for two hours at normal cruise consumption above the destination aerodrome, including final reserve

fuel. Appendix 1 to OPS 1.255 'Fuel Policy' describes the procedure an operator should take for an isolated aerodrome as follows: If an operator's fuel policy includes planning to an isolated aerodrome, the last possible point of diversion to any available en-route alternate aerodrome shall be used as the pre-determined point. For routing direct from departure to destination aerodrome via this point, the procedure states that the amount of useable fuel, on board for departure shall be the sum of:

- a) Taxi fuel; and
- b) Trip fuel from the departure aerodrome to the destination aerodrome, via the pre-determined point; and
- c) Contingency Fuel; and
- d) Additional fuel if required, but not less than, for aeroplanes with turbine engines, fuel to fly for two hours at normal cruise consumption above the destination aerodrome. This shall not be less than final reserve fuel; and
- e) Extra fuel if required by the commander.

Point of No Return (PNR)

The Point of No Return (PNR) for a flight is the point at which an aircraft holds just enough fuel, plus any planned reserves, to return back to the departure airfield and make a landing. Specific to island operations, or where the aircraft is routing over an ocean without diversion airfield options, the point of no return is the point past which the option to turn back no longer remains a possibility. The diagram opposite illustrates the case where an aircraft has additional fuel to fly for two hours at normal cruise consumption above the destination aerodrome.



⁹ Official Journal of the European Union (20.9.2008); Commission Regulation (EC) No 859/2008



Extended Over Water Operation

As stated in AFM 5.1, Section 2-024-10, page 7, extended over-water operations are not approved unless the aircraft is altered by the embodiment of dedicated modifications. Specifically, without the alterations, EASA certified aircraft must not be operated for the purposes of public transport, over water at a horizontal distance of more than 400 nautical miles from the nearest land suitable for making an emergency landing.

FAA certified aircraft must not be operated for the purpose of public transport over-water at a horizontal distance of more than 50 nautical miles from the nearest shoreline without the modifications.

Operators intending to conduct extended over-water operations are advised to seek the approval of their National Airworthiness Authority. The following aircraft modifications are available for such operations:

Fuselage Strengthening Modifications

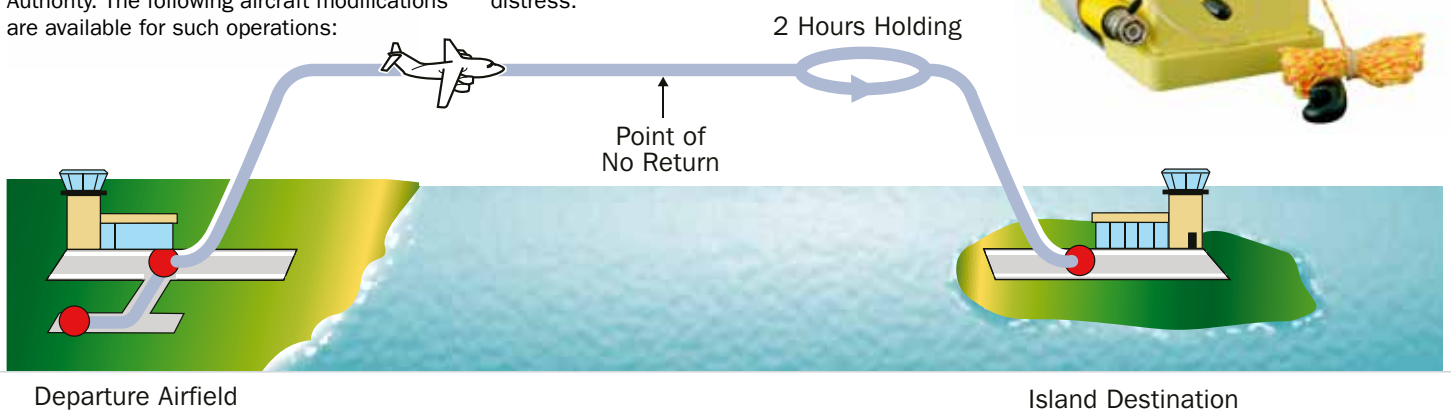
BAE Systems provide modifications which introduce strengthening to the centre and rear fuselage sections to meet ditching requirements. The modifications consist of new sub frames, strengthening of existing frames and reinforcing of skin panels. In some cases, this strengthening may have been included at the manufacture stage. Operators are advised to check that their aircraft is suitably equipped for extended over-water operations. Additional information on these modifications may be obtained by contacting: ramodifications@baesystems.com

Emergency Locator Transmitter (ELT)

An Emergency Locator Transmitter (ELT) is a device installed on an aircraft which provides satellite aid to search and rescue operations in the event that an aircraft should get into distress.

EU-OPS 1.820 states the minimum requirements for the carriage of ELT devices. Operators are advised to refer to this document in full to understand how they can comply with the regulations.

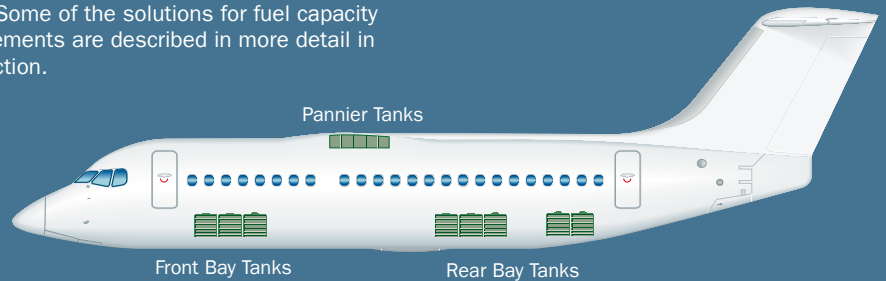
The Kannad 406AP triple frequency ELT is offered as a modification and is approved on the BAe 146 and Avro RJ. The device may be installed on the aircraft and configured to meet customer requirements. For full details on the various options for ELT installations, contact: ramodifications@baesystems.com



Fuel Capacity Improvements

Aircraft operations may be limited by the amount of fuel that the aircraft can carry. Based on fuel policy and planning, some operations of interest might become unfeasible if the required range is over and above that possible with the fuel load on board. Remote operations might also mean that en-route aerodromes with refuelling opportunities are sparse or even non-existent. In such instances, fuel capacity improvements may provide an ideal means to extend range and allow for non-stop operations. Engineering solutions may be available on request which may be tailored to an operator's requirements and specifications.

Once installed and operational on the aircraft, these solutions may unlock the revenue earning potential of some previously unexplored routes whilst preventing the wasted downtime associated with refuelling stops. Some of the solutions for fuel capacity improvements are described in more detail in this section.



Auxiliary Fuel Tanks

Pannier Tanks

Pannier tanks are additional fuel tanks which can be installed as a retrofit mod on the BAe 146/Avro RJ. The tanks provide an increased fuel capacity leading to an extended range. The extra capacity for trip fuel and reserve fuel may be particularly useful for longer range remote locations where there are fewer alternates or refuelling opportunities.

The pannier tanks increase the useable fuel by 936kg. Payload range charts are shown in the sub-section entitled 'Range Extension Performance'. The charts clearly show the operational advantages of the installation.

Baggage Bay Auxiliary Fuel Cells

BAe 146/Avro RJ aircraft may be modified to allow for significant fuel capacity improvements. Auxiliary fuel cell installations in the front and rear baggage bays may be used in addition to pannier tanks to significantly extend range. Such capabilities prevent wasted downtime or inconvenient stoppages with the potential of landing fees.

Some routes deemed unviable with a standard fuel load may become possible with this modification.

It should be noted that for long range routes, any increase in fuel load may decrease the

Fuel Tank Type	Applicability	Structural Weight (kg)
Pannier Tanks	All	146.5 (73.25 kg per tank)
Pannier + Rear Bay Tanks	146-100 & Avro RJ70	550.2
	146-200, 300 & Avro RJ85, 100	640.9
Pannier + Rear Bay + Front Bay Tanks	146-200, 300 & Avro RJ85, 100	931.2

amount of payload which may be carried by an operator. However, this modification may be particularly suited to those operators who wish to carry lower payloads over a greater range. The picture opposite shows a rear baggage bay fuel cell installation.

For further information on the engineering solutions available contact the modifications team at: ramodifications@baesystems.com

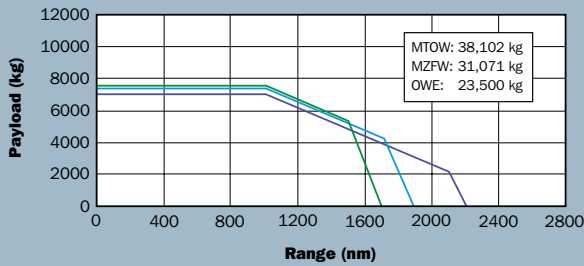
Fuel Tank Configuration	Applicability	Additional Fuel Load (kg)	Additional Fuel Load (Litres)	Total Fuel Load (kg)	Total Fuel Load (Litres)
Standard	All	0	0	9362	11701
Standard + Pannier	All	936	1170	10298	12871
Standard + Pannier + Rear Bay	146-100 & Avro RJ70	2615	3270	11977	14971
	146-200, 300 & Avro RJ85, 100	3047	3810	12409	15511
Standard + Pannier + Rear Bay + Front Bay	146-200, 300 & Avro RJ85, 100	4342	5430	13704	17131

Conversions above are based on Specific Gravity (SG) of Jet A1 Fuel of 0.8

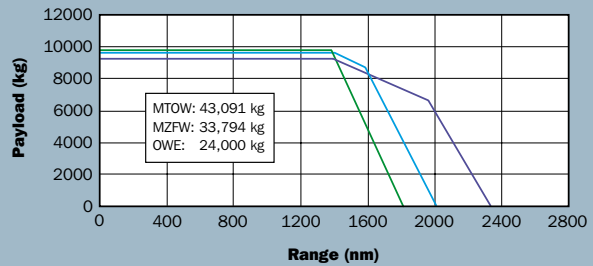
Conversions

- 1 US Gallon = 3.785 Litres
- 1 US Gallon = 6.68lbs
- 1 Imperial Gallon = 4.546 Litres
- 1 lb = 0.45 kg

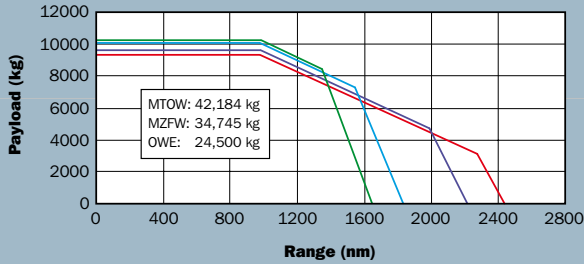
BAe 146-100



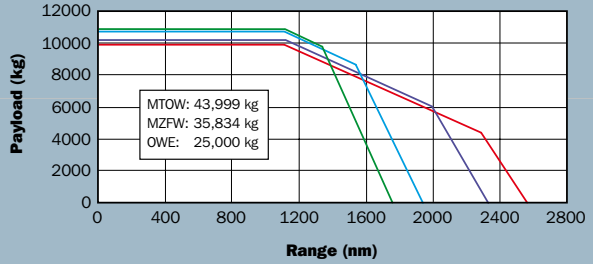
Avro RJ70



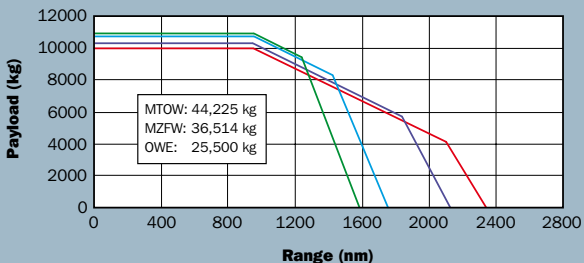
BAe 146-200



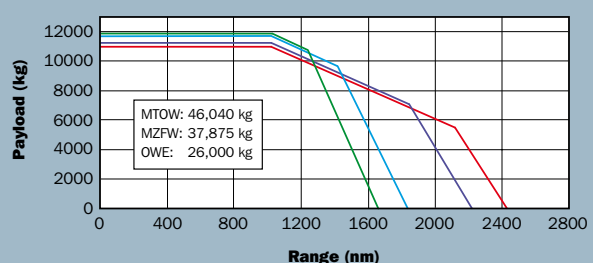
Avro RJ85



BAe 146-300



Avro RJ100



Structural Weights

The above payload range diagrams have been created using the CAPECS software. This software is used to conduct route studies and is a good source of aircraft performance data and worldwide airfield data.

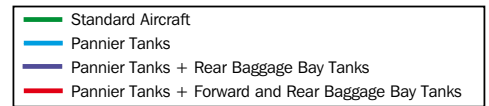
The software has the capability to provide the fuel, distance, time and payload for any route and uses fuel burn data extracted from FCOM Volume 2 (Performance). The user can also select from a number of operating conditions such as temperature and flap setting. Operators wishing to use such software to understand the feasibility of routes of interest should contact Flight Operations Support at: rafftops@baesystems.com

Range Extension Performance

Assumptions

The charts above show the aircraft range for a given payload and the effect of adding various supplementary fuel tanks to a standard fuel tank configuration. They were created assuming the highest typical Maximum Take-Off Weight (MTOW) and a typical Operating Weight Empty (OWE) for each aircraft sub-type. Other operational assumptions are given below and the legend for the charts is shown on the right:

- ISA, Still Air
- Long Range Flight Technique
- Sea Level Airfields
- Fuel Tank Structural Weights as shown opposite
- Fuel Loads as shown opposite.



The structural weight of the additional fuel tanks adds to the Operating Weight Empty (OWE) of the aircraft and thus slightly reduces the maximum payload. This is clear in the charts by the difference in payload between each of the lines for a given aircraft sub-type.



Above: baggage bay auxiliary fuel cell



Above: rear bay tank installation



Performance Software

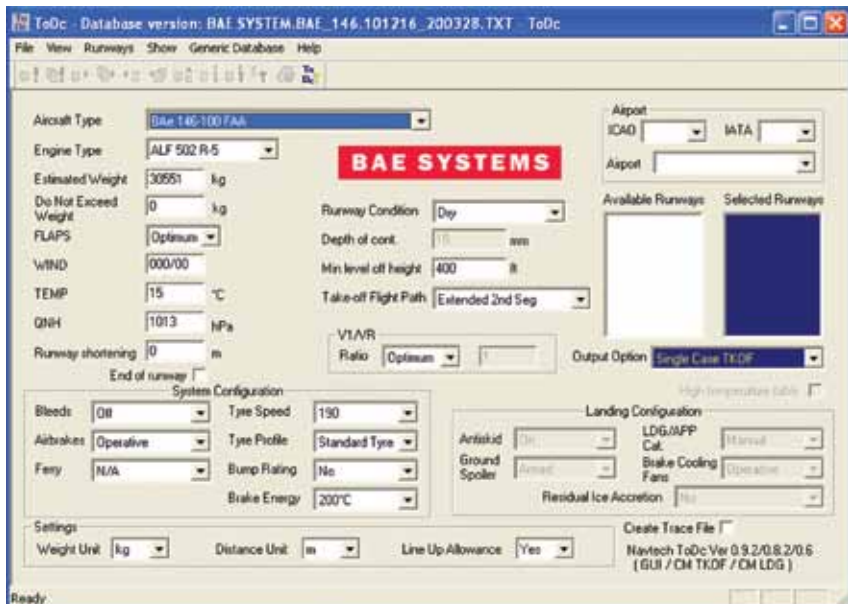
Take-off Data Calculation Software (ToDc)

The Take-off Data Calculation Software (ToDc) is a Navtech product with the BAE Systems Manufacturers Module (MM) as its core. The MM datasets for each sub-type of BAe 146 and Avro RJ are directly representative of the AFM 5.1 performance charts for that sub-type.

The ToDc can generate Regulated Take-off Weight (RTOW) and Regulated Landing Weight (RLW) charts for dry, wet, contaminated, unpaved and narrow runways for the available flap settings. The software may be used to calculate aircraft performance for airfield elevations up to 14,000 feet. Datasets can be provided for high altitude airfields and for the cases of three engine ferry, flaps up ferry and gear down ferry.

For more information on the ToDc performance software contact Flight Operations Support at: rafitops@baesystems.com or Navtech on: info@navtech.aero

Navtech product information may also be accessed through their website at: www.navtech.aero



Graphical User Interface (GUI) for the Navtech ToDc as used by BAE Systems Regional Aircraft





Pacelab CI OPS Cost Index Software

The Pacelab CI OPS is an advanced cost index operations software designed by PACE Aerospace Engineering and Information Technology and is now available for the Avro RJ. It may be used during the flight planning stages or to support real-time tactical on-board decision making. The software is designed to optimise flight phases by calculating airspeeds and trajectories to minimise fuel burn and emissions.

Pacelab CI OPS will run on a variety of electronic devices including Electronic Flight Bags and may be particularly applicable for optimising longer range remote routes such as island operations. PACE state that the CI OPS software may reduce fuel burn and emissions by at least 2 percent compared to constant Mach speeds.¹⁰

More information on the Pacelab CI OPS software may be obtained from Flight Operations Support at: raftops@baesystems.com or by contacting: info@pace.de

PACE product information may also be accessed through their website at: www.pace.de



PACE CI OPS example graphical output

Use the latest Performance Software to plan your operations

Summary

This publication is intended to outline the suitability of the BAe 146/Avro RJ for remote runway operations. The capabilities described in each of the sections may be realised either through Flight Manual amendments, appendices, FCOM information, or other approved means. Such capabilities, contributing to the versatility of the aircraft, are summarised here.

If you intend to conduct a remote operation, you should consider the following points:

- Check your AFM 5.1 for the appropriate appendices to conduct procedures outside the flight manual. Appendices may be obtained by contacting the modifications department
- Ensure your aircraft is fitted with the appropriate modifications in accordance with the relevant appendices
- Understand the environment you are intending to operate in and how it may alter your standard procedures
- Ensure your operations are approved by the relevant local Airworthiness Authority
- Consider aircraft fuel capacity improvements for longer range operations
- Use the latest performance software to plan your operations and consider using an Electronic Flight Bag solution.

For additional information on any of the subjects described in this publication, please do not hesitate to contact us:

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Appendix Glossary

ACN	Aircraft Classification Number
ACSL	AltoCumulus Standing Lenticular
AFM	Aircraft Flight Manual
AMM	Aircraft Maintenance Manual
APM	Airport Planning Manual
APU	Auxiliary Power Unit
BRK FANS	Brake Fans
CBR	California Bearing Ratio
CCSL	Cirrocumulus Standing Lenticular
CG	Centre of Gravity
EASA	European Aviation Safety Agency
EFB	Electronic Flight Bag
ELT	Emergency Locator Transmitter
ESWL	Equivalent Single Wheel Load
EU	European Union
FAA	Federal Aviation Administration
FAR	Federal Aviation Regulations
FCOM	Flight Crew Operations Manual
FOD	Foreign Object Damage
GPU	Ground Power Unit
HF	High Frequency
IAS	Indicated Airspeed
ICAO	International Civil Aviation Organisation
ISA	International Standard Atmosphere
LCN	Load Classification Number
LDA	Landing Distance Available
OWE	Operating Weight Empty
PSI	Pounds per Square Inch
MPH	Miles Per Hour
MTOW	Maximum Take-Off Weight
NWS	Nose Wheel Steering
PCN	Pavement Classification Number
PNR	Point of No Return
RJ	Regional Jet
SB	Service Bulletin
SG	Specific Gravity
STOL	Short Take-Off and Landing
TAS	True Airspeed
ToDC	Take-off Data Calculation
TOR	Technical Operational Response
V1	Take-Off Decision Speed
VR	Take-Off Rotate Speed
VREF	Threshold Airspeed

List of AFM 5.1 Appendices

AFM 5.1 Appendix 2	Ferry Flight with Landing Gear Retraction Mechanism Unserviceable or with One, or Both, Main Gear Doors Removed
AFM 5.1 Appendix 3	Ferry Flight in which Flaps are Inoperative and Retracted Before Start of Take-off
AFM 5.1 Appendix 4	Ferry Flight in Which One Engine is Inoperative Before Start of Take-off
AFM 5.1 Appendix 5	Operations from Contaminated Runways
AFM 5.1 Appendix 7	Steep Approaches
AFM 5.1 Appendix 12	Use of 33° Flap for Take-off
AFM 5.1 Appendix 16	Operation Through La Paz Airport, Bolivia
AFM 5.1 Appendix 18	High Altitude Net Take-off Flight Path Data
AFM 5.1 Appendix 29	Operation with Low Pressure Tyres on Paved or Unpaved Runways
AFM 5.1 Appendix 36	Operations between 8,000 ft and 14,000 ft Airfield Pressure Altitude

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