Limited review of this CAAP by AvioConsult/ Harry Horlings, including recommendations for improvement. Reference is made to papers published on the downloads page of web site www.avioconsult.com and to both FAA and EASA Flight Test Guides.
It is recommended to read the paper for pilots before reviewing this CAAP.

Australian Government
Civil Aviation Safety Authority

5.23-2(0)

This review might bridge the obviously existing gap between experimental flight test crew and flight instructors/ course authors.

Civil Aviation Advisory Publication

July 2007

Multi-engine Aeroplane Operations and Training

This publication is advisory only but it gives a CASA preferred method for complying with the **Civil Aviation Regulations 1988 (CAR 1988).**

It is not the only method, but experience has shown that if you follow this method you will comply with the Civil Aviation Regulations.

Always read this advice in conjunction with the appropriate regulations.

Contents

The relevant regulations and other references

- Civil Aviation Orders (CAO) 20.7.0, 20.7.4, 20.7.1B, 40.1.0, 40.1.7
- Civil Aviation Safety Regulations (CASR) 1998 Parts 23 and 25
- Flight Training-Multi-Engine Rating-R. D. Campbell
- Flying High Performance Singles and Twins–John Eckalbar
- Multi-Engine Flight Manual for Professional Pilots-John Chesterfield
- Multi-Engine Piston-Aviation Theory Centre-David Robson
- Understanding Light Twin Engine Aeroplanes-Russ Evans
- 'Even worse than the real thing' Flight Safety Australia, March-April 2002
- UK CAP 601 – Multi-Engine Piston Aeroplane Class Rating Training Syllabus
- Federal Aviation Administration (FAA) Advisory Circular (AC) 61-9B – Pilot Transition Courses for Complex Single-engine and Light Twin-Engine Airplanes
- FAA Flight Instructor Training Module Volume 2 System Safety – Course Development Guide
- Transport Canada-Instructor Guide - Multi-Engine Class Rating

Who this CAAP applies to

This Civil Aviation Advisory Publication (CAAP) applies to multi-engine aeroplane pilots, flight instructors, Approved Testing Officers (ATO) and Flying Training Providers.

Why this publication was written

Following a number of multi-engine aeroplane accidents caused by aircraft systems mis-management and loss of control by pilots, flight instructors and persons approved to conduct multi-engine training, this CAAP was written to address threats and errors associated with multi-engine operations and provide advice on multi-engine training. In addition this CAAP includes competency standards for multi-engine operations, suggested multi-engine and flight instructor training syllabi and a questionnaire to assist pilots to learn and assess their aircraft systems knowledge.

Status of this CAAP

This is the second CAAP to be written on this subject.

For further information

Telephone Flight Crew Licensing Section on 131 757.

Comments, questions and other feedback to: info@avioconsult.com.

1. Abbreviations

AC	Advisory Circular
AC	Alternating Current
AGL	Above Ground Level
AIC	Aeronautical Information Circular
AIP OPS	Aeronautical Information Publication Operations
amsl	Above Mean Sea Level
AOC	Air Operators Certificate
ASI	Air Speed Indicator
ATC	Air Traffic Control
ATO	Approved Testing Officer
ATPL	Airline Transport Pilot Licence
ATS	Air Traffic Service
ATSB	Australian Transport Safety Bureau
AUW	All Up Weight
BETA	Manually Controlled Mode for Constant Speed Propellers on Turboprop Aircraft
CAA	Civil Aviation Authority (of the UK)
CAAP	Civil Aviation Advisory Publication
CAO	Civil Aviation Order
CAP	Civil Aviation Authority Publication (UK)
CAR	Civil Aviation Regulations
CASA	Civil Aviation Safety Authority
CBT	Competency Based Training
CFI	Chief Flying Instructor
CFIT	Controlled flight into terrain
CG	Centre of Gravity
CP	Chief Pilot
CPL	Commercial Pilot Licence
CRM	Crew Resource Management
CSU	Constant Speed Unit
DA	Decision Altitude
DC	Direct Current
EFATO	Engine Failure After Take-off
ELT	Emergency Locator Transmitter
ENR	En-route
ETP	Equi Time Point
FAA	Federal Aviation Administration (of the USA)
FADEC	Full Authority Digital Engine Control
FOI	Flight Operations Inspector
fpm	feet per minute
FTO	Flying Training Organisation

IAS	Indicated Air Speed
ICAO	International Civil Aviation Organisation
IFR	Instrument Flight Rules
IMC	Instrument Meteorological Conditions
ISA	International Standard Atmosphere
ITT	Interstage Turbine Temperature
kg	Kilogram
Kt	Knot
KIAS	Knots Indicated Airspeed
lbs	Pounds
MAP	Manifold Air Pressure
MAUW	Maximum All Up Weight
MDA	Minimum Descent Altitude
METO	Maximum Except Take Off
N_1	~~Gas Generator~~ Speed
N_2	Second Stage Turbine Speed
N_g	Gas Generator Speed
N_p	Propeller Speed
NTS	Negative Torque Sensing System
NVFR	Night Visual Flight Rules
OAT	Outside Air Temperature
OEI	One Engine Inoperative
PIC	Pilot-in-Command
POB	Persons on Board
POH	Pilot Operating Handbook
PNR	Point Of No Return
psi	Pounds Per Square Inch
RPM	Revolutions per minute
SHP	Shaft horse power
SOP	Standard Operating Procedures
TAS	True Air Speed
TEM	Threat and Error Management
TOT	Turbine Outlet Temperature
UFIT	Uncontrolled Flight Into Terrain
USA	United States of America
USN	United States Navy
VFR	Visual Flight Rules
VLJ	Very Light Jet
VP	Variable Pitch Propellers
VSI	Vertical Speed Indicator
WAT	Weight at Take-off
V	Velocity
V_A	Maximum Manoeuvring Speed

Note:
Isn't N1 the compressor speed?

V_{FE}	Flap Extension Speed
V_{IMD}	Minimum Drag Speed
V_{LE}	Maximum Speed with Landing Gear Extended
V_{LO}	Landing Gear Operating
V_{LO2}	Landing Gear Operation Down
V_{MC}	Minimum Control Speed
V_{MCA}	Minimum Control Airspeed Airborne (Red line speed)
V_{MCG}	Minimum Control Airspeed on the Ground
V_{NE}	Never Exceed Speed
V_{NO}	Normal Operating Speed
V_{S1}	Clean Stall Speed
V_{S0}	Stall Speed with Undercarriage and Flap Selected
V_{S1}	Clean Stall Speed
V_{SSE}	Safe Single-engine Speed
V_{TOSS}	Take-off Safety Speed
V_X	Best Angle of Climb Speed
V_{XSE}	Best Single-engine Angle of Climb Speed
V_Y	Best Rate of Climb Speed
V_{YSE}	Best Single-engine Rate of Climb Speed (Blue line speed)
V_1	Take-off Decision Speed

2. Definitions

Aeroplane/aircraft is balanced: The skid ball in the balance indicator is less than a quarter of the ball diameter from the centre. In a multi-engine, asymmetric aeroplane with bank toward the functioning engine, the aircraft is balanced when the ball is positioned ~~vertically below the fore-aft axis~~.

Replace:
half ball width to the good engine.

(refer to paragraph 5.12.7 on page 46).

Aircraft is trimmed: The aircraft is trimmed within 10 seconds of achieving stabilised and balanced flight, after an attitude, power or configuration change, so that no control input is required from the pilot to maintain this state. During asymmetric operations aircraft trimmed within 10 seconds of Phase 1 actions.

Go-around: A pilot initiated abandonment of a visual approach for a landing.

Safe (ly): Means that a manoeuvre or flight is completed without injury to persons, damage to aircraft or breach of aviation safety regulations, while meeting the standards specified by the Civil Aviation Safety Authority (CASA).

Visual committal height: A nominated height at or above which a safe asymmetric go-around can be initiated, and below which the aircraft is committed to land.

3. Introduction.

3.1 Why this CAAP is issued

3.1.1 An Australian Transport Safety Bureau (ATSB) Aviation Research Report analysed accidents and incidents over a ten-year period caused by power loss in twin-engine aircraft weighing less than 5700 kg. Of the 57 accidents investigated, one third were double engine failures, the majority caused by fuel exhaustion due to mis-management. Eleven of the accidents were fatal and 10 of the fatalities were caused by loss of control of the aircraft. Forty-six percent of the engine failures happened during take-off, rather than any other phase of flight. Additionally, 16% of reported multi-engine accidents were associated with planned power losses during training.

3.1.2 These statistics indicate that fuel mis-management leading to double engine failures caused a significant number of accidents. Asymmetric engine failures led to 10 fatal accidents that were due to loss of control of the aeroplane. It is not unrealistic to assume that inadequate aircraft systems knowledge or practice, lack of familiarity with asymmetric aircraft handling, and inadequate ~~management of~~ asymmetric training are noteworthy reasons that multi-engine aircraft accidents occur.

Note:
Not only inadequate management of asymmetric training, but also conducting inadequate training and inadequate course books.
Recommend deleting 'management of'.

3.1.3 This Civil Aviation Advisory Publication (CAAP) is issued to provide additional guidance to flight manuals, pilot operating handbooks and operations manuals for pilots and trainers to safely operate and control multi-engine aeroplanes.

3.1.4 The ATSB Aviation Research Report B2005/0085 provides additional interesting information and is available at www.atsb.gov.au.

3.2 Who is responsible for competent operation of an aircraft?

3.2.1 Civil Aviation Order (CAO) 40.1.0 Subsection 4, Paragraph 4.4 clearly states that it is the pilot-in-command or co-pilot's responsibility to ensure that they are competent to operate all the aircraft systems, and to perform normal and emergency flight manoeuvres, as well as calculate aircraft performance and weight and balance, and complete all required flight planning.

3.2.2 The difficulty with this requirement is that some pilots may be relatively inexperienced and unable to competently assess their ability to comply with the order. Normally, pilots assume that if they complete their training and are endorsed in their log book then they meet the CAO requirement. This may not always be the case, and the information that follows in this CAAP will help pilots to determine if they meet the requirements of the CAO.

3.2.3 There is a note to this order which states that owners and operators of an aeroplane should ensure that persons who propose to fly the aircraft must meet the requirements stated above. However, the bottom line is that the pilot-in-command is responsible for ensuring compliance with the skills, knowledge and recency requirements to safely operate an aircraft. Step up and accept those responsibilities.

3.3 Who may shutdown an engine in flight?

3.3.1 Any pilot qualified to operate a multi-engine aircraft may shutdown an engine in flight. However, CASA strongly recommends that this only be done with a rated flight instructor with a conversion training approval present, as there is likelihood for errors and engine mis-management. Flight instructors regularly practice this procedure and are less likely to cause problems.

3.3.2 In addition, engines must not be shutdown in flight when carrying passengers (except in an actual emergency), as emergency training is not permitted when transporting them. CASA also recommends that passengers not be carried on training flights as they can be a distraction and limit the type of training that may be conducted.

3.4 Multi-engine endorsement requirements

3.4.1 Pilots require an aircraft endorsement in their logbook before they are permitted to operate as pilot-in-command or co-pilot. An aircraft endorsement must be listed in the CAOs before it can be issued. In the case of multi-engine aircraft, there are type, class and special design feature endorsements. A type endorsement authorises a person to fly an aeroplane of the type specified in Appendix 1 to CAO 40.1.0 as pilot-in-command or as co-pilot. The aircraft is a unique type and examples of aeroplanes classified as a type are a Grumman G-21 (Goose) and Boeing 747-400 Series.

3.4.2 A class endorsement allows a pilot to fly an aeroplane in that class, as pilot-in-command or co-pilot. A class is comprised of a number of different aircraft that have similar design and flight characteristics. These aircraft are listed in Appendix IA and VI of the CAO and examples of some aeroplanes in a class are single-engine aeroplanes not exceeding 5700 kg maximum, Cessna 310/340 (which includes all models of Cessna 310, 320 and 340) and Boeing 737-100/200 (which includes Boeing 737-100 and 200 Series).

3.4.3 The third type of endorsement is a special design feature endorsement, which authorises a pilot to fly an aeroplane fitted with the design feature(s).

There are seven design features specified in the CAO and some examples of these are ‘manual propeller pitch control’ and ‘retractable undercarriage’. A pilot must hold the endorsement for all the design features fitted to the aircraft.

3.4.4 The training requirement for a command type endorsement is specified in the CAO and involves passing a theory examination detailed in Appendix II, and completing five hours of flight training to the approved syllabus at Appendix III. A co-pilot type endorsement involves passing a theory examination detailed in Appendix II of the CAO, and completing three hours of flight training to the approved syllabus at Appendix V.

3.4.5 The training requirement for a class endorsement is also specified in the CAO and the pilot must:

- Hold a pilot licence;
- Undertake training in the operating limitations, procedures and systems of the type of aeroplane for which the endorsement is being sought; and
- Satisfy the person giving the training that the pilot can safely fly that type of aeroplane.

3.4.6 To obtain a special design feature endorsement, a pilot must be trained and assessed as competent in the use of the design feature(s) on the aircraft for which the endorsement is sought. This endorsement applies to other types fitted with the same design features. However, it does not absolve the pilot of the responsibility of knowing how to operate the systems in each type. The person giving the training then enters the details in the pilot’s logbook and forwards the appropriate paperwork to CASA within five days.

3.5 Overseas endorsements

3.5.1 The procedure for the recognition of overseas endorsements is contained in the Flight Crew Licensing Procedures Manual and CAO 40.1.0 and is available at www.casa.gov.au.

3.5.2 When a pilot has a category rating such as Multi-engine Airplane Land that is issued by the FAA, CASA will only recognise those aircraft that are contained in the pilot’s logbook and have been operated by the pilot as pilot-in-command.

3.6 Certification of multi-engine aeroplanes

3.6.1 An understanding of the weight and performance limitations of multi-engine aeroplanes requires, firstly, an understanding of the performance of single-engine aeroplanes.

3.6.2 The Pilots Operating Handbook (POH) or Flight Manual for most single-engine aeroplanes provides for two requirements for climb capability:

> Note:
> FAR and equivalent regulations provide for requirements, POH or AFM present the climb capabilities of the airplane.

Take-off - the aeroplane in the take-off configuration at maximum weight with maximum power must have an adequate climb capability in standard atmospheric conditions. For most light aeroplane types, adequate climb capability is defined as ~~either 300 feet per minute (fpm) or~~ a gradient of 1:12 (8.3%) at sea level.

> Add (if feasible):
> with maximum continuous power, landing gear retracted, flaps in takeoff and an airspeed >= 1.2 Vs (AUW 6000 lb or less).

This definition is given in Part 23 of the US Federal Aviation Administration (FAA) regulations (see FAR 23.65). CAO 20.7.4 paragraph 7.1 specifies a minimum take-off gradient of 6%. CAO 20.7.4 is expected to be repealed when CASR Parts 91 and 135 commence.

Baulked Landing - the aeroplane in the landing configuration at maximum weight with maximum power must have an adequate climb capability in standard atmospheric conditions. For most light aeroplane types, adequate climb capability is defined as ~~either 200 fpm or~~ a gradient of 1:30 (3.3%) at sea level.

> Add (if feasible):
> with takeoff power on each engine, landing gear extended, flaps in landing position (may be retracted in 2 seconds or less without altitude loss and sudden changes of angle of attack), climb speed equal to Vref.

> Add:
> at an airspeed that must be the greater of 1.1 Vmca and 1.2 Vs.

This definition is given in Part 23 of the US Federal Aviation Regulations (see FAR 23.77). CAO 20.7.4 paragraph 9.1 specifies a landing climb gradient of 3.1%. CAO 20.7.4 is expected to be repealed when CASR Parts 91 and 135 commence.

3.6.3 Light multi-engine aeroplanes with all engines operating must possess the climb capabilities described above for single-engine aeroplanes. In addition, light multi-engine aeroplanes with one engine inoperative must have an adequate climb capability at 5000 feet pressure altitude. For most light aeroplane types, adequate climb capability with one engine inoperative is a positive rate of climb at 5000 feet pressure altitude.

> Add (important):
> The climb requirements can only be met when the bank angle is maintained that is presented in the legend of one engine climb performance charts in the POH or AFM, usually 3 degrees away from the inoperative engine.

This definition is given in Part 23 of the Federal Aviation Regulations (see FAR 23.67). CAO 20.7.4 subsection 8 specifies an enroute climb gradients of 0% and 1%. CAO 20.7.4 is expected to be repealed when CASR Parts 91 and 135 commence.

3.6.4 At practical operating weights, light multi-engine aeroplanes ~~do~~ not have climb capability with one engine inoperative after take-off. It is usually not until the propeller has been feathered, the aeroplane's undercarriage and wing flaps have been retracted and it's airspeed reaches the optimum speed (V_{YSE}) that light multi-engine aeroplanes have the capability to climb with one engine inoperative.

> Replace:
> might
>
> Why?
> The airplane weight for meeting the required climb performance is not presented in FAR's. Refer to performance data in AFM/ POH. Some airplanes still do climb immediately after liftoff while one engine inoperative (OEI).
> Would be good to demo during prof. checks (at a safe altitude).

> Insert:
> , a small bank angle (as specified in the legend of the one engine climb performance chart) is attained

3.6.5 This is most significant for pilots of light multi-engine aeroplanes. It means that if the aeroplane suffers an engine failure shortly after take-off it is unlikely to be able to climb. It is more likely that the aeroplane will descend and the pilot will have no alternative other than a forced landing.

3.6.6 Multi-engine aeroplanes with maximum take-off weight greater than 5700 kg have performance requirements that are significantly different to those of light multi-engine aeroplanes. Large multi-engine aeroplanes must have the capability to climb with one engine inoperative after take-off regardless of the configuration of the propeller, wing flaps and undercarriage. It is important that pilots of light multi-engine aeroplanes understand that their aeroplanes do not possess the same climb capability as large aeroplanes.

3.7 Recent experience

3.7.1 Paragraph 4.4 of CAO 40.1.0 also states that the pilot 'has sufficient recent experience or training on the aeroplane type, or in a comparable type, to safely complete the proposed flight'. Other recency requirements involving the number of take-offs and landings within the last 90 days, night flying and instrument flying are covered in other orders.

3.7.2 However, what is the aim of recency? The pilot should be familiar and competent to plan the flight and operate and control the aeroplane. Before getting airborne, pilots must ensure that all possible pre-flight contingency planning is completed and normal and emergency procedures can be confidently and competently managed.

Would you be able to?

- Load the aircraft to ensure adequate post take-off asymmetric performance on the day of the flight;
- Calculate single-engine climb performance;
- Manage a take-off or landing with a maximum permissible crosswind;
- Manage an engine failure after take-off;
- Confidently cross-feed and balance fuel during asymmetric flight;
- Manage fuel pump failures;
- Manage electrical/electronic malfunctions;
- Manage propeller malfunctions; or
- Manually lower the undercarriage?

Add:
- Manage an engine-out approach and landing
- Manage engine-out cruise flight
- Manage a proper lateral centre of gravity.

3.7.3 If the answer to any of the items listed above is 'No', then a review of the Pilot Operating Handbook, Operations Manual or some flight training is required. Recency may not be an issue for a pilot who is operating a multi-engine aeroplane on a regular basis and receives ongoing training, but could be a significant problem for a pilot who flies infrequently, or has not practiced asymmetric operations in recent times.

4. Multi-engine Training

4.1 The importance of receiving good multi-engine training

4.1.1 Good training for any aircraft type is extremely important. However, training is normally more involved in a multi-engine aircraft because of additional and complex systems and flight characteristics that require increased management and skills. The first multi-engine endorsement that a pilot receives is probably the most crucial.

During this training it is critical that aircraft systems and normal and asymmetric flight characteristics are well understood and practiced, and the pilot can comfortably maintain control of the aircraft under all circumstances. This can be achieved if the training is comprehensive and pilots apply themselves to attain these goals.

4.1.2 Professional organisations such as airlines, charter operators and defence forces acknowledge the importance of good flight training and dedicate considerable expenditure to this task. Safety does cost! Therefore, each pilot should carefully consider what training they require to operate a multi-engine aircraft safely. Appendices A and B contain the competency standards and syllabus of training required to operate a multi-engine aeroplane. Look at any course you are considering, measure it against the syllabus and final standard then ensure that the training provider can achieve those outcomes.

4.1.3 The standards included in this CAAP detail what you must be able to achieve at the end of your training, and provides advice for you to determine if you are competent to safely operate a multi-engine aeroplane weighing less than 5700 kg. However, also included in this CAAP is guidance on training techniques and practices that should lead to the development of a good level of competency and confidence.

4.2 Who is permitted to conduct multi-engine flight training?

4.2.1 A Flying Training Organisation (FTO) that has the multi-engine aircraft included in the Air Operator Certificate (AOC), and a multi-engine syllabus of training contained in the Company Operations Manual, is permitted to conduct multi-engine training.

Additionally, a flight instructor of any grade must hold a multi-engine training approval. Prior to undergoing training for addition of this privilege to their Flight Instructor Rating he/she must meet the minimum number of hours requirement specified in CAO 40.1.7 Subsection 9, Paragraph 9.7 (50 hours multi-engine) and pass a multi-engine flight test with an ATO or CASA Flight Operations Inspector (FOI). Before instructing on a particular type a pilot must have at least 10 hours on that type.

4.2.2 A flight instructor with a multi-engine training endorsement may conduct multi-engine conversion training as a private operation and this does not have to be conducted under an AOC. However, the training to become a multi-engine flight instructor is considered to be flying training and must be conducted under an AOC.

4.2.3 Instructors can only give other types of training such as night or instrument flying in a multi-engine aeroplane if they are qualified to conduct multi-engine training and the other activity.

4.2.4 A person may also be approved by CASA to conduct multi-engine conversion training under Civil Aviation Regulation (CAR) 5.21. Persons with this approval are normally associated with training and checking organisations under CAR 217 or have been individually approved because no qualified flight instructors are available or endorsed on the particular aircraft type.

4.3 What should I be looking for when choosing a Flying Training Organisation?

4.3.1 Many FTOs offer multi-engine training. This CAAP emphasises the importance of receiving good training, particularly for your first multi-engine endorsement, and the selection of a flight-training operator will be up to you. But it will be to your benefit if you are well informed.

4.3.2 A personal recommendation from another pilot is always helpful. However, a recommendation based on cost alone may be no recommendation at all. It is worthwhile researching a number of operators so that you get a feel for the market. The first item to examine is the syllabus of training that all FTOs must have in their operations manual. It should detail in a logical sequence all the theory and flight training exercises involved in the course. For guidance, refer to the recommended syllabus at Appendix B of this CAAP and map the course against this document. Ask how many flying hours will be involved. Experience has shown that it is unlikely that all the flight sequences for an initial multi-engine endorsement can be adequately taught in less than 5 to 7 hours of flight time.

The same time frame applies to the aeronautical knowledge training. A structured, well-run course should be your goal. If you choose a flying instructor to conduct your training, ensure that he or she has an appropriate written syllabus and training plan.

4.3.3 CASA requires training providers to supply adequate and appropriate training facilities before an Air Operators Certificate (AOC) is issued. However, examine the facilities yourself and look for:

- Briefing facilities (lecture rooms and training aids);
- Flight manuals and checklists;
- Training notes;
- Reference libraries;
- Comprehensive training records;
- Sufficient experienced instructors available at the time you require; and
- Flight testing capability close to the end of training.

4.3.4 Next, look at the aircraft. The aircraft should be well presented and clean. The interiors should be neat with no extraneous equipment or publications left inside. Windows should be clean and unscratched, and the condition of the paintwork is often an indicator of the care taken of the aircraft. Examine maintenance documents to ensure there are no long-standing unserviceabilities. Additionally, review the maintenance release to ensure that unserviceabilities are entered; sometimes this is not done. You do not want your training curtailed or delayed because the aircraft are continually unserviceable.

4.3.5 Finally-the flight instructor! The value of a flight instructor who helps you gain knowledge and skills and develop a positive and robust safety culture cannot be over emphasised. Make sure that you are satisfied with the instructor's performance and professional behaviour. Discuss your aims and any concerns you may have about the flight training and make sure you establish good communication. It is also important to determine that the instructor is available when you are. Some training operators will substitute flight instructors and this can cause time wasting while the new instructor re-assesses the student to establish what training is required. Remember you are the customer and you should not just accept an instructor that you feel uncomfortable with or have doubts about.

4.4 Knowledge training

4.4.1 Logical and comprehensive briefings by flight or specialist technical instructors are an essential component of your training. Ideally, the aeronautical knowledge briefings should be coordinated with your flight training so that maximum benefit can be gained.

'The relevant regulations and other references' section of this CAAP suggest some commercial publications which provide excellent guidance material for multi-engine pilots. CASA recommends use of these publications and any others that are equivalent. Obtain such documents well before you start your multi-engine training and study them. Good research and study can end up saving you money and time. It is also important to ensure that a flight manual or POH is readily available. Become very familiar with this document and make sure that you are comfortable using all the performance charts and tables. Familiarise yourself with the layout and table of contents of flight manuals, and know how to quickly look for any information you need.

4.4.2 The 'Syllabus of training for the initial issue of a multi-engine endorsement' at Appendix B of this CAAP has a training syllabus, which provides guidance for pilots to determine the suitability of a multi-engine training course. On completion of the course, pilots should finish the appropriate questionnaire provided at Appendices D and E. The questionnaires are designed to be completed by pilots using any suitable reference material and should be retained as a way to refresh your aircraft systems knowledge at any time. The questionnaire is based on the layout of a standard flight manual and is designed to give you practice in using a flight manual.

4.4.3 History has shown that one third of multi-engine accidents are caused by double engine failure, usually due to systems mis-management or poor planning. A good knowledge of the aircraft systems, performance planning and fuel management can reduce if not eliminate the chance of such accidents occurring. An important aspect of safe operations is the ability to apply knowledge in a practical sense. Being able to apply knowledge to analyse faults and make appropriate decisions can enhance safe operations. Too often pilots have only superficial knowledge that enables them to manage normal operations, but may limit their performance during abnormal situations. Therefore, pilots must apply themselves to understand and manage aircraft performance and systems confidently and competently.

4.5 Flight training

4.5.1 The purpose of flight training is to teach a pilot to control the aircraft, and to operate and manage all the aircraft systems in normal and abnormal flight. During training pilots should be shown all the flight characteristics of the aircraft, and be given adequate time and practice to consolidate their skills. Although no minimum flight time is specified for flight training, experience has shown that it is unlikely that a pilot can be given adequate training to proficiently operate a multi-engine aircraft, and to understand and manage asymmetric operations, in less than five to seven hours.

4.5.2 A good starting point would be to consult the flight standard at Appendix A of this CAAP and become familiar with what you must be able to do at the end of your training.

4.6 Understanding and operating the aircraft systems

4.6.1 Good training and conscientious application by a pilot can ensure confidence and competence when operating all the aircraft systems. Pilots can gain general knowledge of multi-engine aircraft from the references listed at the beginning of this CAAP (or from other similar publications). It is then important to refine this knowledge and apply it to the aircraft you are flying by reference to the approved flight manual. Pilots should not forget that hand-in-hand with competence, goes recency. If you do not fly regularly, review the flight manual to refresh your systems knowledge before leaping into the 'wild blue yonder'.

4.6.2 The following paragraphs offer advice that may help you, about issues, characteristics and some potential 'traps' of individual aircraft systems.

4.7 Fuel System

4.7.1 Mis-management of the fuel system has been the cause of many multi-engine accidents. These accidents included poor fuel planning leading to fuel exhaustion, inappropriate use of engine controls, cross-feed and fuel pump mis-management, incorrect tank selection and failure to visually inspect fuel contents.

Insert:
(lateral centre of gravity)

4.7.2 Fuel system configuration and operation vary from type to type and range from simple to complex. The simplest system may have one fuel tank in each wing with a cross-feed system to transfer fuel from one side to the engine on the opposite wing. More complex systems may have three fuel tanks on each side with multiple tank selections and cross-feed combinations, using auxiliary fuel pumps. Fuel systems may even be different in similar models.

Insert:
or the tank

Therefore, it is vitally important to understand the configuration and operation of the fuel system in the aircraft you are flying.

4.7.3 There is a lot of benefit in just sitting in an aircraft on the ground and using the fuel system (or any other systems) controls to accommodate various scenarios. This type of practice while not under pressure of actually flying the aircraft can be an effective learning experience.

4.7.4 Visual inspection of fuel contents applies to all aircraft types, but some larger multi-engine aircraft may have fuel tanks that are difficult to inspect. For example wing tip tanks are often hard to reach. It is particularly important to check the contents on the first flight of the day after the aircraft has been standing overnight. There have been numerous incidents of fuel being drained from the tanks of unguarded aircraft, in some cases with tragic results.

4.7.5 Fuel gauges in some aircraft can be inaccurate and must be used with a calibration card. Tanks should be dipped and the amounts compared to the fuel log and actual gauge indications.

4.7.6 Finally, pilots should know exactly how much fuel is in the aircraft on start, be familiar with the expected fuel flow rate of the aircraft and monitor these rates in flight to confirm normal engine performance.

Add:
Pilots should also be familiar with the maximum approved fuel asymmetry because of the effect of the lateral centre of gravity on the minimum control speed (a heavy wing requires larger aileron deflection).

4.8 Engines

4.8.1 Modern multi-engine aeroplanes can be fitted with a variety of engines including normally aspirated and turbo/supercharged piston engines and turboprops. Most pilots would be familiar with normally aspirated engines and should operate them within prescribed limitations. However supercharged or turbocharged engines require extra attention. Older supercharged engines are susceptible to over and under boosting which can cause significant damage to an engine. Pilots must carefully monitor engine performance at all times, but particularly when applying full power or descending rapidly so that manifold pressure limitations are not exceeded.

4.8.2 Modern turbocharged engines are generally fitted with an automatic waste gate and are simple to operate. However, it is important to use all the engine controls smoothly and not too rapidly, and in the correct sequence. If flying an aircraft with fixed or manual waste gates a little more attention needs to be paid to engine management, and the manifold pressure gauge may require more monitoring. Because turbochargers are driven by exhaust gas, they are subject to high temperatures.

Prior to shutdown, it is important to ensure that the temperature of the turbocharger has stabilised (comply with POH time limits), and if the cylinder head temperature is in the normal range this is also an indication that the turbocharger is within shutdown temperature limits.

4.8.3 Turbine propeller or turboprop engines are generally less difficult to manage than a piston engine. They are reliable and quite rugged. However, there has been cases of these engines compressor stalling when intakes are affected by ice build-up and care should be taken when operating in these conditions. However, pilots should also pay attention when starting turboprop engines. If excessive fuel gets to the combustion chambers, or the engine is slow to accelerate (possibly caused by low battery voltage), a 'hot start' can occur. This is likely to cause expensive damage and ground the aircraft. However, if the engine is operated within the prescribed limitations, it will provide reliable service.

4.8.4 On aeroplanes fitted with propellers, one engine has a greater yawing moment because of the effects of lift being produced by the down going propeller blade when the wing has an increased angle of attack. American built engines rotate clockwise when viewed from behind. Additionally, torque and slipstream effect add to the control difficulty. Therefore, the thrust of the down going blade of the right engine has a greater moment arm than the left engine, and consequently a greater yawing ~~force~~. Therefore, the loss of the left engine presents the pilot with a ~~greater control problem~~ than the loss of the right engine, so the left engine is called the critical engine. In some cases this problem is overcome by fitting counter-rotating propellers.

4.8.5 Pilots must always manage aircraft engines within the engine operating limitations, ensure that the specifications for fuel and oil are met and comply with maintenance requirements and they should enjoy trouble free operation of aero engines.

4.9 Propeller systems

4.9.1 Following an engine failure in multi-engine aeroplanes, a pilot needs to be able to feather the propeller to reduce ~~drag~~. The feathering function complicates the design of a basic constant speed unit as fitted to a single-engine aircraft. However, a good understanding of how such a system works will help you appreciate any limitations that the design can impose.

4.9.2 In most constant speed units, pressure is transmitted to the propeller through the engine oil and forces the propeller to move to the fine pitch stops.

Insert:
thrust of the down going blade of the

Replace:
moment
(= force x moment arm)

Note:
The thrust of the upgoing blades decreases with increasing airplane angle of attack. Better would be to talk about the shift of the thrust vectors of the whole propeller discs, the P-factor.

Replace:
Not really a control problem if the airspeed is higher than Vmca, as it should always be.
The Vmca resulting from the failure of the critical engine is a bit higher than the Vmca after failure of another engine. This higher Vmca is, as the worst case Vmca, red-lined on the airspeed indicator.
The actual Vmca after failure of the other, the non-critical engine, is lower than the red-lined Vmca, which is safer, less critical.
Pilots do not have to analyse the criticality of a failing engine. Only one Vmca applies, and only one emergency procedure for both engines.
Refer to the FAA and/ or EASA Flight Test Guides referenced on the downloads page of www.avioconsult.com.

Insert:
asymmetrical drag and therewith reduce actual Vmca.
(Yawing moment decreases).

Conversely, as the oil pressure is reduced, the propeller increases its blade angle to a coarser pitch by the action of spring and gas pressure contained in the propeller dome at the front of the propeller hub. The downside of this design is that, as the oil pressure reduces to zero when an engine is stopped on the ground, the propeller would feather. To overcome this, a centrifugal latch engages when the propeller speed decreases to between 700 to 1000 revolutions per minute (RPM), and this prevents the propeller from moving past the coarse pitch angle. Therefore, pilots should be aware that if an engine failure occurs in flight, the propeller must be feathered before the centrifugal latch engages if the RPM drops below 1000. Normally a windmilling propeller rotates at a speed well above this figure, but if a catastrophic failure occurs the engine may slow down rapidly and then it will not be possible to feather the propeller.

4.9.3 Restarting an engine that has been shutdown usually involves using the starter motor to turn the engine and feathered propeller until the increasing oil pressure moves the propeller towards fine pitch. However, before doing this the propeller pitch control lever must be moved to the fine pitch stops to allow the oil pressure to be directed to the propeller. As the blade angle decreases, aerodynamic forces help turn the propeller and with the addition of fuel and 'spark' (ignition) the engine starts. Alternatively, if an unfeathering accumulator is fitted, the action is initiated by moving the propeller pitch control lever forward to allow oil to flow under pressure from the accumulator to the propeller. This type of start is usually smoother and less stressful on the engine than a starter motor unfeathering procedure.

4.9.4 Pilots must analyse the situation they are faced with before restarting an engine that has been shutdown in flight. This action could lead to greater damage to an engine or cause an engine to windmill without starting, leading to a dangerous degradation of flight performance. This topic is discussed in more detail later in this CAAP.

Recommend to add a paragraph:

Vmca is determined using the propeller setting it achieves by itself/ automatically after engine failure, i.e. without pilot intervention. When an engine fails in-flight, controllability can be maintained (if the airspeed is higher than Vmca and a small bank angle away from the inoperative engine is being maintained), but drag will be higher if the propeller is not feathered by the pilot.
The red-lined Vmca is a worst case Vmca.
Best one engine performance can also be achieved by maintaining the small bank angle, as is listed in the legend of most one engine out performance charts.
Bank angle ties control and performance together (Dr. J. Roskam).

4.10 Electrical system

4.10.1 Multi-engine aircraft introduce pilots to electrical systems with multiple power sources and bus bars. Modern aircraft usually have two alternators (older aircraft may have generators) that provide electrical power to all the aircraft electrical equipment. Alternators have on-off switches, voltage regulators, over voltage protection, field switches and voltmeters. Pilots must understand the functions and application of these devices. The on-off switches isolate the alternators from the electrical system and should be turned off in the event of an alternator failure.

Voltage regulators maintain the voltage within the normal operating range, but if an over voltage occurs, relays will trip and take the alternator off-line. If an alternator is turned on and will not produce electrical power, it may require activation of the field switch to excite the alternator to produce electricity. The voltmeter shows the battery charge or discharge rate, the amount of current being delivered into or drawn from the electrical system (amperes) and the bus voltage, depending upon the mode selection, when fitted.

4.10.2 Pilots must be able to interpret the voltmeter reading to determine what is happening to the electrical system. Normally a switch connects the battery or individual alternators to the ammeter or voltmeter so that the pilot can monitor power or voltage of the electrical power delivery systems (alternator or battery). High amperage or low voltage can be an indicator of problems and remedial action may be required as detailed in the approved flight manual.

4.10.3 Bus bars are simply a metal bar connected to a power source (battery or alternator) to which all the aircraft electrical services are connected. Pilots should be familiar with what power sources the bus bars are connected to, and what services run off the bus bar. Some bus bars may be isolated to lighten the load on the electrical system during abnormal operations. For example, the battery bus would include all the services that are required to start an aircraft including the starter motors, radios, fuel pumps, avionics and lighting. These electrical services would also be required during flight if a double alternator failure occurred. After the engine is started and the alternator comes on-line more services may be added through other bus bars.

4.10.4 Flight instructors should ensure that trainees are able to interpret voltmeter readings, know the location and function of the circuit breakers, be able to identify and isolate services that demand high amperage (power) and demonstrate competency managing all electrical abnormal and emergency procedures.

4.11 Pressurisation system

4.11.1 Some multi-engine aircraft will introduce pilots to pressurisation. Because of the extra performance available, some multi-engine aircraft are able to operate at high altitude. Simply explained, engine driven pumps pressurise a sealed cabin. In the case of turbo-prop or turbine engines, bleed air is used. An automatic outflow valve regulates the pressure in the cabin. The pressurisation is normally turned on after engine start and is controlled automatically.

4.11.2 The pilot's primary role is to monitor the system and ensure that it works correctly. Therefore, the pilot must be familiar with all the pressurisation-warning devices, monitor the cabin altitude and differential and understand the implications of high altitude operations. They should be confident of manually operating the system if required and be able to identify and manage outflow valve problems if they arise. In addition, they should always recognise the symptoms of hypoxia and the action that should be taken to remedy this situation. It is important to be familiar with all the actions involved in an emergency descent following a pressurisation failure, including amended fuel usage, which should be addressed during pre-flight planning.

4.11.3 Pilots should never fly above a cabin altitude of 10000 ft without oxygen. There have been cases of fatal accidents caused by pressurisation failures that have gone undetected. Therefore, this system should not be treated lightly. Instructors must ensure that a new multi-engine pilot is competent to operate the system during normal and emergency operations, conducts regular checks of the system and is familiar with the physical hazards of high altitude flight.

4.12 Undercarriage system

4.12.1 "Gear goes up, gear goes down!…. This is the way an aircraft undercarriage normally works, and as a rule malfunctions are rare. However, when they do occur pilots must be familiar with all the actions that must be taken. On some aircraft, emergency lowering of the undercarriage is a simple process.

4.12.2 However, in other cases it may well be a long and involved procedure. It may require multiple actions with selectors, switches, valves and circuit breakers, as well as manual pumping or winding. Pumping or winding an undercarriage may entail a lot of physical effort and time. A pilot must also continue to stay in control of the aircraft, and maintain situation awareness; this could be a real problem in instrument conditions, at night or bad weather.

4.12.3 Therefore, a pilot must be familiar with limiting speeds and minimum speeds to reduce air loads, the normal and emergency undercarriage system, warning and undercarriage down indicators and the time frame required to complete the emergency lowering procedure. The best way of achieving these goals is to actually experience a practice emergency undercarriage lowering. It should be a standard part of endorsement training and never overlooked.

In some cases, manual undercarriage lowering requires significant maintenance action to return the aircraft to operation condition. In these circumstances, it may be preferable to simulate the manual undercarriage extension procedure while an aircraft is on jacks (during maintenance).

4.12.4 It is also important to discuss action in the event of a main wheel or nose gear failing to lower. Include in the discussions fuel burn-off to reduce the fuel load on landing, when to turn the fuel off during the landing roll, type of runway and advantageous use of crosswind. Finally, consider the evacuation and where to exit the aircraft.

Replace:
Vmca

(On page 101 below, Vmca is used!)

4.12.5 Flight instructors must give guidance to trainees on the considerations that should be included in the planning. Night, minimum control speed (V_{MC}) or instrument meteorological conditions (IMC), traffic, air traffic control (ATC) requirements, turbulence, timeframe, emergency services, passenger briefings and evacuation and flying techniques are just some of the issues that should be taken into account. For example, there may be a need to yaw the aircraft to lock the undercarriage down. This exercise is often overlooked by flight instructors, possibly because it can be time consuming and can require ground servicing to allow the undercarriage to be retracted, but the demonstration should be done at least once during endorsement training.

Insert:
or perform a max. g turn or pull up

4.13 Flight instruments

4.13.1 Because of the redundancy built into multi-engine aircraft systems it is unlikely that a vacuum pump failure would affect an attitude indicator, because each engine has a vacuum pump fitted. However, because of the complexity of the system it is remotely possible that a component failure could lead to an attitude failure. For example if a vacuum pump or an engine failed and the shuttle valve that diverts the suction to the other pump failed (stuck), then there may be a need to control the aircraft using -limited instrument panel techniques in IMC. The procedure for checking the system on start-up and/or shutdown should be well understood.

4.13.2 If the pilot is likely to operate in instrument conditions, the instructor should take the time to address this possibility.

4.14 Autopilot and electric trimming systems

4.14.1 The autopilot and trimming systems are a great aid to flight management and aircraft control during both normal and abnormal flight. It is vital that pilots use the systems to relieve workload and assist accuracy.

These systems have been linked together because both have influence on the pitch or roll control of the aircraft. Malfunctions of either system can lead to loss of control of the aeroplane.

4.14.2 Pilots must be familiar with the normal operation of the autopilot and trim systems, but it is critical to understand the abnormal actions contained in the flight manual that apply. Experience has shown that reaction time can be a vital factor in regaining or maintaining control of an aeroplane following an autopilot or pitch trim malfunction. Therefore, pilots must be sure of their actions to manage these malfunctions.

4.14.3 If a fault exists in an autopilot it will often manifest itself when the autopilot is first engaged. Therefore, pilots should monitor the aircraft attitude when engaging the autopilot and be prepared to disengage it immediately any abnormal attitude changes occur. During normal operations, the autopilot should automatically disengage if excessive roll or pitch deviations occur. Overpowering the autopilot will also normally disengage the autopilot. This instinctive reaction is probably the first action a pilot will take and the problem should disappear. If not, the autopilot disengage switch should be activated. As a last resort, the autopilot circuit breaker or the avionics master switch could be used. The primary concern is to regain control of the aircraft and the pilot must monitor the autopilot and be confident about disengaging it.

4.14.4 Runaway electric trim can be a serious problem in an aircraft, and it is not an uncommon problem. Depending upon the aircraft’s airspeed, it is possible that full travel of the trim may cause control column loads that a pilot will not be strong enough to manage. An electrical fault or a sticking trim switch could cause this condition. Normally the electronic trim is disengaged when the autopilot is engaged, so the most likely occasion for trim problems is when the pilot is hand flying the aircraft. In the first instance, the aircraft should be controlled using the control column and the trim disengage switch should be activated. There have been cases where this has not worked and pilots have repositioned the manual trim to override the system, or pulled the electric trim circuit breaker. Using the manual trim wheel to override the electric trim should pop the trim circuit breaker, but there have been examples where this has not happened, and when the trim wheel has been released, the loads have re-occurred. In addition the pilot should consider reducing airspeed to lower the aerodynamic loads on the flight controls.

4.14.5 Flight instructors should pay more than superficial attention to the autopilot and trim systems during multi-engine training. Control malfunctions are serious problems and pilots should be competent and quick to remedy them. Ensure that they understand the different methods of disengaging these aids, and are able locate the appropriate circuit breakers without having to look too hard.

4.15 Very Light Jets

4.15.1 Very Light Jets (VLJ) introduces new performance, technology and physiological aspects into multi-engine operations and training. Flight at transonic speeds and high altitude with unique weather and physiological conditions, new systems and avionics/glass cockpit will change the knowledge and skills required by flight instructors and pilots seeking endorsements on these aircraft.

4.15.2 Flight instructors who conduct training on these aircraft will be required to be familiar with technology and operational conditions that they may never have previously experienced. This will require good training and the development of teaching techniques to accommodate the technology and associated human factors.

4.16 Assessing the risks

4.16.1 Before undertaking a flight it is important to assess any associated risks and then implement procedures and practices that mitigate the identified risks. Flight training is no exception. This process is called risk management, and should be done before any flight to determine whether the flight should be undertaken and what modifications need to be made to reduce identified risks. The question that risk management addresses is whether the level of risk is acceptable or, if not, can it be managed to make it acceptable?

4.17 What are some of the risks associated with multi-engine training?

4.17.1 There are many identifiable risks associated with multi-engine training. Some of the risks are common to all types of flying while others are unique to multi-engine operations. Examples of risks associated with flight training in general are:

- Weather;
- Environmental conditions;
- Traffic;
- Task saturation; and
- Fatigue.

4.17.2 These risks can be countered by: planning for and avoiding adverse weather; being familiar with the operating environment and avoiding associated hazards; maintaining a lookout and traffic listening watch; prioritising tasks and following fatigue risk management procedures.

4.17.3 Identifying the risks specific to multi-engine training is probably more important because this form of training is potentially dangerous if not well managed.

4.17.4 Risks associated with multi-engine training are:

- Inappropriate management of complex aircraft systems;
- Conducting flight operations at low level (engine failures after take-off);
- Conducting operations at or near V_{MCA} or V_{SO} with an engine inoperative;
- Errors; and
- Asymmetric operations including:
  - Inadequate pre-take-off planning and briefing;
  - Decision making;
  - Aircraft control;
  - Performance awareness and management;
  - Operations with feathered propellers;
  - Missed approaches and go-arounds;
  - Final approach and landing; and
  - Stalling.

4.17.5 To mitigate these risks, robust defences must be put into place. Because multi-engine aircraft systems are often complex, it is important for pilots to be familiar with the systems operations. It is also important to be current on the aircraft though this may not always be possible for private operators, who may not have easy access to the full range of training. Certainly, self-study by the private pilot to regularly familiarise themselves with the aircraft systems, as an alternative form of recurrent training in the absence of actual flight training or comprehensive training facilities, will help. Therefore the pilot should undertake regular reviews of the flight manual or revision of the questionnaire that is available at Appendices D and E of this CAAP (this should be completed and retained by the pilot for each aircraft type flown).

4.17.6 Any flight operation at low altitude has potential dangers. Trainers have debated over the decades on the value of practicing engine failures after an actual take-off, that is, near the ground. The general consensus is that despite the risks, pilots must be trained to manage these situations in multi-engine aircraft.

However, instructors should consider not simulating engine failures below 400 ft AGL to provide a reasonable safety margin. The use of simulators has reduced the perils of this activity. Other mitigating factors are:

- Well trained instructors;
- Complete knowledge of the theoretical factors involved during asymmetric operations;
- Proven procedures provided these are strictly adhered to;
- Comprehensive pre-flight and pre-take-off planning and briefings;
- Ongoing training;
- Situation awareness. and
- Flying competency.

4.17.7 Each take-off is unique and should be carefully planned. Even daily operations from an aerodrome like Sydney airport require each take-off to be planned. Variables such as weight, weather, runway length available, take-off direction, traffic, temperature, departure clearances, and runway conditions should be included in pre-take-off planning. Terrain and obstructions are very real threats and should also be accommodated in your planning. After the planning comes the briefing - either a self or crew brief. A thorough briefing will both help with, and minimise, the in-flight analysis required, especially if a critical decision has to be made following an engine failure after take-off. This action will also reduce the workload which may distract from the critical task of flying the aircraft. Statistics show that a multi-engine aircraft that suffers an engine failure after take-off has a higher probability of experiencing a fatality, than a single-engine aircraft. This may be due to a multi-engine aircraft that had suffered an engine failure, presenting a host of alternative options for the pilot seeking a remedy. That would make decision-making, as well as identifying the correct solution, far more complex. Therefore, if the plan is simple and well-understood the correct solution may be identified without doubtful hesitation and in a timely fashion.

Note:
After engine failure, the equilibrium of forces and moments acting on the airplane is disturbed. Balance of forces and moments needs to be restored by the pilot.

4.17.8 The primary action in any emergency must be to maintain control of the aircraft. If a multi-engine aircraft has an engine failure it is immediately ‘out of balance’. The ability to maintain control of the aircraft is paramount and is dependent on sound knowledge of the asymmetric characteristics of the aircraft.

Stay above V_{MCA} and adjust the aircraft attitude to achieve best single-engine angle of climb speed (V_{XSE}) or best single-engine rate of climb speed (V_{YSE}) so that optimum climb performance is attained for the flight situation you are faced with. A pilot must maintain control of the aircraft, then know what flight performance is required in the circumstances, and finally, must achieve that performance.

Recommended to add:
", including attaining the small bank angle away from the inoperative engine that is listed in the legend of the one engine operating climb performance chart in the POH/ AFM, usually 3 degrees"...

This in fact means that straight flight must be maintained until some altitude can be sacrificed for turning at less than maximum thrust, for control to be maintained (refer to next text block. Actual Vmca increases to a value higher than the red-lined value if the small bank angle is not being maintained while the asymmetrical thrust is maximum during banking away from the small bank angle. Refer to the papers for pilots and to the links of Flight Test Guides on the downloads page of www.avioconsult.com.

4.17.9 Engine failures may occur during any stage of flight and could require considerable time flying around with a propeller feathered. Therefore, a pilot must safely manage the aircraft when in this configuration. Propellers should never be feathered in flight during training below 3000 ft above ground level (AGL).

However, a pilot should practice flight with a feathered propeller, including climbs, descents and turns in both 'clean' and 'dirty' (undercarriage and flap extended) configuration. It is important to be reassured that the aircraft will still fly safely when in this situation and configuration. However, flying asymmetric with the undercarriage or flaps down should only be accepted in the early stages of a take-off or overshoot during a missed approach, and the aircraft should be 'cleaned' up as soon as it is safe to do so, to improve aircraft climb performance. Finally, CASA strongly recommends that, when practicing asymmetric flight, an aircraft should never be landed with the propeller of a serviceable engine feathered. The risk far outweighs the minimal benefits, with abundant examples of such unnecessary risks proving fatal. If a landing with a feathered propeller on a serviceable engine is contemplated, a comprehensive risk assessment should be made and a clear plan developed. The plan should include weather, traffic air traffic control and any other factors that could adversely affect the safety of the procedure.

Add:
while keeping in mind that the red-lined Vmca is valid only while maintaining straight flight and while banking 5 degrees away from the inoperative engine when and as long as the asymmetrical thrust is maximum. Before turning, actual Vmca needs to be reduced by temporarily reducing the thrust a little. If thrust is not reduced, actual Vmca might increase above the red-lined Vmca, after which control will be lost. Vmca with wings level of a small twin is usually 8 kt higher than the red-lined Vmca, for a Cessna Conquest even 34 kt as presented on page 46 below.
Refer to the paper for pilots on the downloads page of website www.avioconsult.com, to FAA or EASA Flight Test Guides, or to paragraph 5.12.7 on page 46 below.

4.17.10 Go-arounds are often mis-managed, resulting in many fatalities. Establish a visual committal height applicable to you and your aircraft type and do not attempt to initiate a go round below this height. When initiating a go-around prior to or at the committal height from an approach to land, ensure that you apply power smoothly and accelerate to and maintain V_{YSE} while ~~maintaining directional control~~. Remember that every change of power on the live engine affects the directional balance of the aircraft; so anticipate the required change of rudder input to maintain continuous directional control. Do not adjust the nose attitude until you are sure that you can achieve V_{YSE} before establishing the climb. When terrain or obstructions pose a hazard, it may be a safer option to initially climb at V_{XSE} until clear. Raise the undercarriage and flaps as soon as it is safe to do so.

Add:
because the airspeed is close to Vmca and a bank angle of 5 degrees is not attained and maintained before increasing the thrust to maximum. In addition, turns are initiated at too low an altitude, too low an airspeed and/or too high an asymmetrical thrust setting. Then actual Vmca increases easily to a value higher than Vyse and to the loss of control.
Refer to the papers on the downloads page of www.avioconsult.com.

Replace:
increasing the rudder to maintain the heading and the bank angle to the number of degrees away from the inoperative engine as specified in the one engine performance data graph, usually 3 degrees.

Add: Decide on a go-around early to be able to exchange altitude for airspeed.

It is important to understand the need to maintain ~~directional control of the aircraft~~ during a go-around. Continue to maintain situation awareness during the process – in this procedure the handling of the aircraft is challenged by its low speed and maximum power setting, which has the potential to bring about a directionally critical flight situation. This may be further aggravated by its proximity to the ground. Therefore all care must be taken.

4.17.11 Pilots must have a plan of action that ensures a safe result when making an asymmetric approach. The approach and landing speeds and configurations should be as for a normal approach unless there are well-documented reasons for not doing so. Operations manuals should detail the procedures and the recommended approach speed, visual committal heights, when to lower the undercarriage and flaps (if different from a normal approach) and speed control. If these procedures are not available in an operations manual, seek guidance and have these actions clear in your mind before you get airborne.

4.17.12 Finally - asymmetric stalling! Never ever practice stalls when under asymmetric power. This is an extremely dangerous manoeuvre and ~~autorotation~~ and spinning are likely to occur. Experience has shown that the chances of recovery are poor. Pilots should also be aware that as altitude increases, stall speed and minimum control speed could coincide, so not only will you stall, but also you can almost be guaranteed to lose directional control. Pilots should also be aware that some aircraft have a V_{MCA} that is very close to the stall speed (for example-Partenavia PN-68) and care should be exercised when operating these aircraft near these speeds.

4.17.13 Although the risks associated with asymmetric operations are manifest, they can be mitigated. Robust procedures, adherence to standard operating procedures (SOPs), compliance with flight manual warnings, comprehensive and ongoing training and a willingness to learn about, and practice, asymmetric operations can ensure a safe outcome during multi-engine training.

4.18 Threat and Error Management (TEM)

4.18.1 Threat and error management (TEM) is an operational concept applied to the conduct of a flight that includes the traditional role of airmanship, but provides for a structured and pro-active approach for pilots to use in identifying and managing threats and errors (hazards) that may affect the safety of the flight.

Replace:
the heading using the rudder, and the small bank angle using the ailerons until reaching a safe altitude
(As a result, directional control will be maintained. This was determined during the flight and certification testing of the airplane).

Insert:
and/ or laterally...
(Some propeller airplanes require large aileron deflection to maintain lateral equilibrium.)

Insert:
The safest asymmetric approach is a long straight-in approach, because if during a turn in the circuit, especially the final turn for landing, thrust has to be increased to maximum, the actual Vmca might easily increase above the indicated airspeed after which control is lost.
This happened many times already. Banking has the greatest effect on Vmca. The red-lined Vmca is valid only during straight flight while banking 5 degrees away from the inoperative engine, as was also presented above. Refer to Flight Test Guides.

Replace:
a spiral dive

Note:
A Vmca close to or below the stall speed is considered safest (in flight-test). The airplane is said to be controllable down to the stall. But during turns, the actual Vmca might increase above the stall speed, and result in loss of control.

4.18.2 TEM uses many tools, including training, standard operating procedures (SOPs), checklists, briefings and crew resource management (CRM) principles to assist pilots to manage flight safely. It has been widely accepted in the airline industry as an effective method of improving flight safety, and is now required by the International Civil Aviation Organisation (ICAO) as an integral part of pilot training at all licence levels from student to airline transport pilot. It is also a useful concept for multi-engine pilots to apply to their operations.

4.18.3 There is some overlap between risk management, TEM and CRM, particularly at the stage of developing and implementing plans to mitigate risks and in reviewing the conduct of a flight. Generally risk management is the process of deciding whether or not operations can be conducted to an acceptable 'level' of risk (go or no-go) safely, whereas TEM is the concept applied to managing and maintaining the safety of a particular flight.

4.18.4 The following sections provide a brief introduction to TEM to assist multi-engine pilots and trainers who may wish to apply the principles to their own operations.

Add:
- Standard (Instrument) Departure Procedures.

Why?
Because if these procedures require a turn (shortly) after takeoff at low speed while an engine is inoperative and the power setting is high, actual Vmca increases.
Loss of control cannot be avoided if actual Vmca increases above indicated airspeed. This already happened many times.

4.19 Threats

4.19.1 In the TEM model, threats are events or hazards (e.g. meteorological conditions) whose occurrence is outside the control of the pilot(s) and which may threaten the safety of the flight. They may be anticipated or they may be unexpected, or they may be latent in the operational systems. Pilots need good situation awareness to anticipate, and to recognise, threats as they occur. Threats must be managed to maintain normal flight safety margins. Some typical threats/hazards to multi-engine operations might be:

- Weight;
- Density altitude;
- Runway length;
- Other traffic;
- High terrain or obstacles; or
- Condition of the aircraft.

Add:
- Deviation from the extended runway centerline after takeoff (and closing in on, or even crossing the extended centerline of a parallel runway).

Why?
If the small 3 - 5 degree bank angle is not maintained after engine failure, a sideslip cannot be avoided because of the side force due to rudder deflection. The sideslip angle depends on the airspeed.

Add:
- Inappropriate Vmca definition in Pilot Operating Handbook and/ or Airplane Flight Manual (and training/ text books).

Why?
The definition used is most often copied out of FAR/ CS 23 or equivalent, which are for designing, certification and experimental flight-testing the airplane, but definitely not for its operational use.
Example: The bank angle should not be "maximum 5 degrees", but exactly the same number of degrees that the design engineer used to size the vertical tail and the test pilot used to measure Vmca, most often 5 degrees away from the inoperative engine.

4.20 Errors

4.20.1 The TEM model accepts that it is unavoidable that pilots, as human beings, will make errors. Errors may be intended or unintended actions or inactions on the part of the pilot(s) and can be classified as handling errors, procedural errors or communications errors. External threats can also lead to errors on the part of the pilot(s).

4.20.2 While errors may be inevitable, safety of flight demands that errors that do occur are identified and managed before flight safety margins are compromised. Some typical errors in multi-engine flight might be:

- Incorrect performance calculations;
- Aircraft handling errors;
- Incorrect identification of failed engine;
- Incorrect systems operation or management; or
- Failure to recognise, achieve or manage optimum performance.

Add:
Failure to maintain fuel balance within limits (lateral centre of gravity).

Add:
- Turning at low speed and high thrust settings while an engine is inoperative (a catastrophic error).

Why?
In general, turning at low speed, while one engine is inoperative and the power setting on the opposite operative engine is maximum or is increased to maximum during the turn, might become a catastrophic error. The vertical tail is not designed large enough to generate the required side force during turns at low speed with maximum asymmetric thrust.

4.21 Undesired Aircraft State

4.21.1 Threats and errors that are not detected and managed correctly can lead to an undesired aircraft state, which could be a deviation from flight path or aircraft configuration that reduces normal safety margins. An undesired aircraft state can still be recovered to normal flight but, if not managed appropriately, may lead to an outcome such as an accident or an incident. Multi-engine flight requires recognition and recovery from undesired aircraft state in a very short timeframe before an outcome, such as loss of directional control, failure to achieve optimum climb performance or uncontrolled flight into terrain occurs. Examples of an undesired aircraft states in multi-engines might be:

- Mis-management of aircraft systems;
- Loss of ~~directional~~ control following engine failure (flight below V_{MCA});
- Flight below V_{YSE} or V_{XSE};
- Incorrect attitude recognised during manoeuvre; or
- Commencing a missed approach below visual committal height.

On some airplanes, propeller or swept wing, lateral control is lost before directional control.
(Max. aileron deflection reached before max. rudder while decreasing airspeed).

Add:
- Increasing asymmetric thrust to maximum before attaining and maintaining a 5 degree bank angle away from the inoperative engine, when the airspeed is low.

4.21.2 Good TEM requires the pilot to plan and use appropriate countermeasures to prevent threats and errors leading to an undesired aircraft state. Countermeasures used in TEM include many standard aviation practices and may be categorised as follows:

- Planning countermeasures–including flight planning, briefing, and contingency planning;
- Execution countermeasures–including monitoring, cross-checking, workload and automation management; and
- Review countermeasures–including evaluating and modifying plans as the flight proceeds, and inquiry and assertiveness to identify and address issues in a timely way.

Replace:
, rudder and/or ailerons

Add to end of this sentence:
and rolling

Not always, is not sure. This might happen following an increasing sideslip because of the rudder deflection to counteract asymmetrical thrust and an uncontrollable roll, after which weathercock points the nose down.

This is definitely not correct! Vmca is not only a specific speed for certification. Vmca is a worst case minimum control speed to be used and observed by all pilots, which is the reason it is published in the AFM and red-lined on the ASI. Vmca is determined with the airplane in the worst case configuration during experimental flight-testing (low weight, aft cg, small bank angle, etc.). Any configuration other than worst case, for instance a higher weight, less thrust or forward cg, results in a lower, safer actual Vmca. But a bank angle other than the bank angle used to design the vertical tail, and to determine Vmca during flight-testing results in an unexpected yet definite increase of Vmca when pilots accept this line.

This is confusing, and wrong. A sea level Vmca does not become a Vmc at higher altitude but then still is a Vmca; the airplane is still in the air. Vmca decreases with altitude, because engine thrust decreases. Only one Vmca is determined, although some manufacturers present tables or charts with 'calculated/ extrapolated' Vmca's for enabling operations at higher altitudes and temperatures. Some manufacturers call Vmca Vmc though.
Vmc refers to all Vmc's, like Vmca, Vmca1, Vmca2, Vmcl, Vmcl1, Vmcl2 and Vmcg.
Don't use Vmc, but only the Vmcx that is meant.

4.21.3 Once an undesired aircraft state is recognised, it is important to manage the undesired state through the correct remedial solution and prioritise aircraft control for return to normal flight, rather than to fixate on the error that may have initiated the event.

4.22 TEM Application

4.22.1 Threats and errors occur during every flight as demonstrated by the considerable database that has been built up in observing threats and errors in flight operations worldwide. One interesting fact revealed by this programme is that around 50% of crew errors go undetected.

4.22.2 TEM should be integral to every flight, including anticipation of potential threats and errors, and planning of countermeasures. Include potential threats, errors and countermeasures in the self-briefing process at each stage of flight, and avoid becoming complacent about threats that are commonly encountered.

4.22.3 Minimum control speed, often referred to as 'V_{MC}' is a speed that is associated with the maintenance of ~~directional~~ ***control*** during asymmetric flight. If you fly below this speed the tail fin ~~and rudder~~ are unable to generate enough lift to prevent the aircraft from yawing. If uncorrected, the yaw causes roll, ~~the nose drops~~, the aircraft rapidly assumes a spiral descent or even dive, and if you are at low altitude, the aircraft impacts steeply into the ground. Although a dramatic description, this type of accident is not uncommon in a multi-engine aircraft during training or actual engine failure. ~~V_{MCA} is a specific speed that is established for aircraft certification requirements.~~

~~*NOTE: With regard to a particular aircraft V_{MCA} is a specific, published speed, V_{MC} can be a range of speeds dependant on altitude, power setting, aircraft configuration etc!*~~

4.22.4 The following summary is intended to assist pilots to apply TEM to multi-engine operations:

- Try to anticipate possible threats and errors associated with each flight, and plan countermeasures;
- Brief (self-brief) planned procedures before take-off and prior to commencing each significant multi-engine sequence;
- Include anticipated threats and countermeasures in briefings;
- Continuously monitor and cross-check visual and instrument indications and energy state to maintain situation awareness;

Another note: If the bank angle is not the 5 degrees favorable bank angle and the rudder is not deflected to maintain the heading while the thrust is maximal, the actual Vmca is higher than the published and indicated Vmca, but still is a Vmca. Should not be called Vmc, but actual Vmca.

- Prioritise tasks and manage workload so as not to be overloaded but to maintain situation awareness;
- Identify and manage threats and errors;
- Maintain control of the aircraft and flight path;
- Monitor the progress of the sequence and abort if necessary;
- Maintain aircraft control and optimum performance;
- Do not fixate on error management;
- Identify and manage undesired aircraft state; and;
- Recover to planned flight and normal safety margins rather than dealing with other problems.

4.23 Pre-flight planning and briefing

4.23.1 A multi-engine pilot should never take-off without knowing how the aircraft is capable of performing during all phases of flight, and what options are available should an engine fail. The performance data in the flight manual will provide this information.

Recommend to add a paragraph on Vmcg (Runway excursion).

4.23.2 To begin with, the accelerate-stop distance will tell you how much runway length you require to accelerate to take-off speed, suffer an engine failure and be able to stop. If the available runway is less than this figure, you should reduce the take-off weight to meet the physical constraint of the available runway length. Otherwise you may possibly run off the runway end should an engine fail during the take-off run – so include this in your plan.

4.23.3 Next, calculate the single-engine best rate of climb for the prevailing atmospheric conditions. As an example, a 1978 Cessna 404 at all up weight (AUW) with one engine inoperative, will climb at 220 ft/min on a standard day or 140 ft/min at a temperature of 36°C from a sea level aerodrome. This information should be included in your Engine Failure After Take-off (EFATO) plan. Does the terrain require a steeper angle of climb? If so, consider V_{XSE} and look closely at where you should fly to avoid obstacles to return for a landing on the airfield. The aircraft is 20 years old; will it perform according to flight manual figures? Familiarity with the aircraft will help you here, and this should be included when considering your options.

Does the manual not present (a note for) the required bank angle for which the one engine climb performance data is valid?

4.23.4 Finally, calculate the single-engine service ceiling for various weights and terrain at different stages of the flight, and formulate a plan that will keep the aircraft clear of high ground and allow a safe diversion to a suitable aerodrome.

4.23.5 The pre-take-off briefing should at least explain your actions and plans in the event of an engine failure after take-off. The plan should also include a decision speed or point, at which the take-off will be abandoned or continued. Consideration should be given to the conditions in the over-run area of the runway. Having a plan reduces the chances of making a bad decision under the pressure of an emergency. Experience has shown that by verbalising (saying the plan out loud), whether with another crewmember or alone, helps to clarify and reinforce the plan for the pilot-in-command.

4.24 Understanding the important velocity (V) speeds

Insert:
... and the conditions that apply with the speeds ...

4.24.1 Power loss in a light multi-engine aircraft is a problem that requires good management. The asymmetric climb performance in such aircraft is not guaranteed as it is in the case of larger multi-engine aeroplanes such as a Boeing-737. At high-density altitudes, a heavily laden aeroplane may not even be able to climb following an engine failure after take-off. During multi-engine operations there are a number of airspeeds that a pilot will use. Some of these speeds are defined at the abbreviations section on page three of this CAAP. However, just being able to recall these speeds is not enough. You should understand the reasons for the speeds, the conditions that affect them and how the speeds are applied. When referring to these speeds, they can be categorized as relating to aircraft control or performance.

and/

4.24.2 The first speed to look at is V_{SSE} or safe single-engine speed. The speed is determined by the aircraft manufacturer and is greater than V_{S1} and minimum control airspeed airborne (V_{MCA}), factored to provide a safety margin for intentional asymmetric training operations. In other words, practice engine failures should never be simulated below this speed, and if you are in an aircraft where this occurs, you should question the pilot-in-command about his or her actions.

Note:
See remarks next to paragraph 4.22 above.

4.24.3 Minimum control speed, often referred to as 'V_{MC}' is a speed that is associated with the maintenance of ~~directional~~ ***control*** during asymmetric flight. If you fly below this speed the tail fin and rudder are unable to generate enough lift to prevent the aircraft from yawing. If uncorrected, the yaw causes roll, ~~the nose drops~~, the aircraft rapidly assumes a spiral descent or even dive, and if you are at low altitude, the aircraft impacts steeply into the ground. Although a dramatic description, this type of accident is not uncommon in a multi-engine aircraft during training or actual engine failure. V_{MCA} is a specific speed required for aircraft certification requirements.

See note next to paragraph 4.22.3.

~~*NOTE: With regard to a particular aircraft V_{MCA} is a specific, published speed, V_{MC} can be a range of speeds dependant on altitude, power setting, aircraft configuration etc!*~~

Insert:
provided a small bank angle of 3 to 5 degrees is maintained away from the inoperative engine. This bank angle is usually specified in the legend of one engine climb performance data graphs in the POH/ AFM.

4.24.4 The critical speed associated with asymmetric *performance* is best single-engine rate of climb speed (V_{YSE}). This speed is typically less than the all engine best rate of climb speed (V_Y) and allows a pilot to attain the best rate of climb under asymmetric conditions. This ensures that a safe height is achieved expeditiously so as to avoid all obstacles and be able to manoeuvre the aircraft for a safe landing. If an engine failure occurs below V_{YSE}, the nose attitude should be adjusted and maintained to allow the aircraft to accelerate to the optimum speed and then readjusted to maintain the best rate of climb. Pilots should also be aware that V_{YSE} varies with aircraft weight and airspeed differences can be significant. If, because of inadequate performance the aircraft does not climb, V_{YSE} should be maintained even during a descent. This speed is colloquially referred to as the 'blue line speed' and is marked by a blue line on the lower speed end of an airspeed indicator (ASI).

Is there a chart Vyse vs weight in the POH/ AFM?
What (weight) case does the blue line on the ASI represent?

4.24.5 In summary, to optimise your chances of survival in a multi-engine aircraft weighing less than 5700 kg, that is used for asymmetric training or suffers an engine failure:

- Never simulate a failure below V_{SSE} (may be unavoidable with an actual failure);
- Control the aircraft by preventing yaw, pitch and roll; and
- Achieve best performance by adjusting the nose attitude to maintain or attain V_{YSE}.

Add:
... and maintain straight flight while banking 3 degrees away from the inoperative engine (as specified in the one engine performance data graph), until reaching a safe altitude.

5. Flight Instructor Training

5.1 The multi-engine flight instructor

5.1.1 The multi-engine flight instructor employs the same teaching techniques as any other form of flight training, but the pilot is operating in a regime that is potentially more dangerous than most other flight training. Threat and error management should become an integral part of the instructor's flight training technique. Not only must the instructor follow the practices, but just as importantly, must also teach students the TEM principles and show them how to apply TEM to all their flying operations.

5.1.2 Because multi-engine aeroplanes generally have higher performance and greater mass than singles, students must be taught until they are familiar with the handling characteristics of the aircraft. As multi-engine aircraft systems are more complex, the instructor requires more than a superficial knowledge of the aircraft systems on which they are training students. The same applies to asymmetric operations. This is a critical area of training which needs both detailed briefings on the factors that apply to this type of flying as well as comprehensive airborne training.

5.1.3 The important role that the flight instructor plays in the development and training of pilots in general and multi-engine pilots in particular cannot be over emphasised.

Their ability to correctly teach, influence and direct pilots can help prepare them for a safe and effective flying career.

5.2 Instructor training

5.2.1 The greatest mitigators of fatal multi-engine aeroplane accidents are pilots that are well trained, assessed as competent and who have recent experience. The key to achieving this result is to make sure that the flight instructors who deliver the endorsement training are themselves well trained and competent. Not only must flight instructors have the knowledge, skills and behaviour to safely operate an aircraft during all phases of flight, but also, they must be capable of transferring their knowledge and skills to the pilots that they teach.

5.2.2 Traditionally flight instructors have conducted training in the same manner as they were taught themselves. However, under a competency-based training (CBT) system students should be trained to meet a clearly defined standard. The standard for a multi-engine pilot is at Appendix A of this CAAP, which forms the basis for designing a training plan that ensures a pilot can achieve the standard at the end of their training. The syllabus at Appendix B provides a means of achieving this goal.

5.2.3 Flight instructor training should involve all the sequences that the instructor will be required to teach a student. These include actually explaining and assessing the use of all systems during both normal and abnormal operations. Instructors should dedicate considerable effort into developing teaching techniques that ensure students are confident and competent operating all the aircraft systems by the end of their training. For example, students should be shown the emergency undercarriage lowering sequence. In some aircraft this is a straightforward operation, but in others it can be complicated.

5.2.4 A pilot should never be placed in a position where an actual emergency is the first exposure to a manual landing gear extension. Pilots should be aware of the:

- Time involved;
- Difficulties in controlling the aircraft while maintaining situation awareness; and
- Physical effort that may be required to wind an undercarriage down.

For a pilot flying in instrument flight conditions the problem becomes even more complicated. As discussed in paragraph 4.12.3, it may be necessary to devise an alternative method to teach this sequence if manual undercarriage lowering requires maintenance action to return the aircraft to a serviceable state.

5.2.5 The increased flying performance of the aircraft such as speed and inertia has to be well managed and thus well taught. Runway performance and safety considerations demand additional attention by the instructor, and asymmetric operations require a high degree of situation awareness and adherence to standard operating procedures. It is also important that students thoroughly understand the implications of control and performance and apply all the techniques to ensure a positive result.

5.2.6 The cabin of a multi-engine aircraft is often larger than a single-engine aeroplane, and is capable of carrying more passengers. This requires sound passenger management technique and thorough briefings. Flight instructors should highlight these considerations during a pilot's training.

5.2.7 Flight instructors must guide trainees on how to formulate valid plans and ensure that during their training they follow the plans when practicing engine failures. Most importantly, emphasise the requirement to have a plan for every take-off.

5.2.8 Before commencing after take-off asymmetric training which should not be started until the trainee is competent with general aircraft handling, the instructor should clarify:

- The trainee is competent at general aircraft handling;
- How engine failures will be simulated;
- The trainees actions in the event of a simulated engine failure;
- The threats and countermeasures applicable during asymmetric training; and
- Actions in the event of an actual engine failure.

5.2.9 To be an effective multi-engine flight instructor it is essential that all sequences be taught in a logical and comprehensive manner. This involves a good training plan, high-quality technical and flight briefings and continuous threat and error management. A suggested course for FTOs that conduct multi-engine flight instructor training, and may be adapted to suit individual training needs, is at Appendix C of this CAAP.

5.3 Behaviour and responsibility

5.3.1 Flight instructor's behaviour must be impeccable. Not only do they need to have knowledge and skills, but also they must set an example of good planning, compliance with standard operating procedures and regulations, professionalism and self-discipline. Deviations from these principles will be observed, and in some cases copied by trainees. Therefore, hand in hand with good behaviour comes responsibility. The responsibility is for the good or bad influence that an instructor can have on the future safety and professional approach of those pilots that they train throughout their aviation career. This is a great responsibility that should never be compromised or forgotten.

5.3.2 ATSB statistics indicate that 16% of multi-engine aeroplane accidents occur during training or assessment. Unfortunately a number of these accidents where caused by unsatisfactory behaviour by instructors or ATOs. This behaviour has ranged from disregard of regulations or best advice to failure to comply with standard operating procedures or loss of situational awareness. In this CAAP, the term 'behaviour' is used rather than 'attitude', as behaviour is something that is observable, measurable and assessable.

5.3.3 One of the hallmarks of a good pilot or instructor is their ability to maintain situation awareness. This is particularly important during multi-engine asymmetric training at low altitude. Instructors must be able to think ahead and anticipate. At critical stages of flight such as engine failures after take off, the instructor must constantly monitor the trainee's performance and be ready to take over and rectify any dangerous event. It does not pay to be a 'Joe cool' looking out the side window when a single-engine overshoot is being performed. Be prepared to react quickly at any time. Additionally, an instructor must not only maintain situation awareness, but should also teach it to the trainee.

5.4 Engine shutdown and restart

5.4.1 During multi-engine training, engine shutdown and restart is an exercise that the trainee will be required to practice throughout their course. However, it is more than just a training exercise, and pilots must be aware of the serious implications of shutting down and re-starting an engine.

5.4.2 In a section, which follows later in this document, titled 'About engine failures' the symptoms of engine failures are discussed. Pilots should consider this guidance when making the decision to shutdown an engine. It is likely that a partial engine failure could occur, and it may be advantageous to delay shutting down an engine until more suitable conditions exist, unless of course a greater risk exists in not shutting the engine down immediately, such as mechanical damage, oil/fuel leak or fire in the affected engine. For example, it may be better to use a partially failed engine to help position the aircraft clear of inhospitable terrain before securing the engine. On the other hand, as mentioned, if the engine is 'beating itself to death' it may require an immediate shutdown. Once the decision has been made, ensure the aircraft and serviceable engine are set up to achieve optimum performance. Advise ATC of your actions and intentions. Ensure that all actions are conducted in accordance with the approved flight manual and navigate to the nearest suitable landing area.

5.4.3 In the unlikely event that an engine is to be restarted after shutdown, considerable thought should be given to your actions. Firstly, will a re-start cause more damage to the engine, and is there a likelihood that the propeller may not unfeather? Worse still, after the propeller has come out of feather, the engine may fail to start, but the propeller cannot be re-feathered and thus continues to windmill. This would create significant drag that may seriously impair the aircraft's performance in maintaining altitude. This situation is not unusual and has caused a number of fatal and non-fatal accidents. When re-starting an engine, pilots should refer to a checklist or the flight manual in order to avoid mis-management (errors).

5.4.4 Flight instructors must give clear guidance on shutting down and re-starting engines. Discuss the implications, options and hazards associated with these activities. When conducting the procedure as a training exercise, it is a good opportunity to use a scenario that mimics actual situations.

5.4.5 The exercise should be thoroughly briefed, covering both the trainee and instructor's activities, and clearly state what you expect the student to demonstrate when the propeller is feathered. Throughout the exercise, emphasise the need to maintain control of the aircraft at all times and to strictly follow checklist procedures.

5.5 Simulating engine failures

5.5.1 Before simulating engine failures in multi-engine aircraft, instructors must be aware of the implications and be sure of their actions. Consult the aircraft flight manual or pilot operating handbook for the manufacturer's recommended method of simulating an engine failure. Prior to undertaking the task, make sure that the aircraft is not in a dangerous situation to start with……too slow, too low, in an unsuitable configuration or hazardous weather (wind, ice or visibility). There is no benefit introducing more risks than the emergency being trained for. Avoid loading the student up with multiple emergencies, and remember that more will be learned by concentrating on one aspect at a time. Do not simulate an engine failure using procedures that may jeopardise the restoration of power. It would be folly to simulate an engine failure at low level by selecting the mixture to idle cut-off or turning the fuel selector off. These procedures would be more appropriate at higher altitude

5.5.2 Instructors must emphasise that during a practice engine failure, when the throttle is closed and the propeller is windmilling this replicates the situation of high propeller drag that exists until the propeller is 'simulated feathered', when zero thrust is set. Slowly closing the throttle is probably one of the methods used to simulate an engine failure. Although selecting idle cut-off may be kinder to an engine, the engine or aircraft manufacturer may not permit it, so slowly closing the throttle to idle or zero thrust is unlikely to harm the engine and allows for immediate restoration of power. When setting zero thrust (only after the student has completed the simulated feathering), throttle movements should not be rapid, and of course the student should have been briefed about your actions. As a rule, unless a catastrophic engine failure occurs, an engine does not just fail without warning. During an actual failure pilots should also take the time to determine whether a total failure has transpired or if the engine is still delivering some power. If it is delivering power, use the thrust to get to a safe height before shutting the engine down to avoid further damage, unless a greater risk exists in continuing to operate the engine such as fire, oil/fuel leaks or significant mechanical damage.

5.5.3 Students must be shown how to identify and confirm that an engine has failed. For initial identification, an oldie but goodie is 'Dead leg, dead engine'. When controlling yaw the leg that is not exerting pressure to the rudder pedal is the 'dead leg' and is on the same side as the 'dead' or failed engine.

This is probably the most used method as it is a direct function of maintaining control of the aircraft, thus offering a true indication of which engine has failed. But appropriate engine instruments and thrust gauges may be judiciously used to confirm the failure. It should be noted that the RPM and manifold pressure gauges of a piston engine are not reliable means of identifying a failed engine, as the instrument indications may appear normal. After identifying the failed engine through, for example, the 'dead leg, dead engine' method, the pilot should confirm that his/her identification has been correct. This is done by closing the throttle of the failed engine - if no yaw develops as the throttle is eased back, and the serviceable engine operates normally it confirms the identification of the faulty engine. It is not uncommon for pilots to shutdown the wrong engine in haste or panic, so train yourself to calm down and take the time to accurately confirm the problem. Although time can be critical in some situations, 'sitting on your hands and taking the time to properly identify and confirm the failed engine' can reduce the chances of an error.

5.5.4 Trainees should be made to verbalise their actions when practicing asymmetric procedures. They should verbally identify controls and switches and touch them at 90 degrees to the direction of operation to avoid inadvertent activation during turbulence. Flight instructors should guard controls, particularly during initial training, in order to prevent incorrect selections.

5.6 Simulating turboprop engine failures

5.6.1 Because turboprop aircraft are fitted with auto-feather, when simulating engine failures after take-off, power only need be reduced to zero thrust. The propeller of a failed turboprop engine does not windmill, but automatically feathers. If a negative torque sensing system (NTS) is fitted, negative torque is sensed in the gear train between the propeller and the aircraft engine when a failure occurs. When the reverse torque exceeds a selected threshold, hydraulic valves are actuated which remove oil pressure from the pitch control mechanism of the propeller. This loss of oil pressure causes the propeller to set a pitch that ensures minimal drag. Therefore, to properly replicate the conditions that apply to an actual failure, instructors should ensure that zero thrust is set whenever simulating an engine failure on a turboprop. Some typical zero thrust settings for individual aircraft types are detailed in the next section.

5.6.2 To avoid inadvertent feathering of a propeller, before simulating an engine failure, instructors must turn the auto-feather off if this is recommended in the flight manual, as is the case with the DHC-4 (Caribou).

5.6.3 Identification of a failed turboprop is less complicated than a piston engine. Like all multi-engine aircraft with wing-mounted engines, “Dead leg, dead engine” still applies but the torque gauge is an accurate indicator of the condition of the engine. This instrument immediately measures loss of power and is an almost foolproof way of confirming a failed engine. If the power loss is caused by a compressor surge or stall there will be an accompanying rapid increase in turbine temperature.

5.6.4 When performing an actual shutdown and restart of a turboprop, instructors must ensure that the checklist procedures are followed religiously. Feathering a propeller is normally straightforward, but if the re-start is mishandled, the propeller can go into flight idle or even the beta range. Should this occur, the aircraft performance might be so adversely affected that a return to the departure point may not be possible if unsuitable terrain exists. Therefore, before shutting down an engine, pilots should make sure that if the engine will not re-start, it would still be possible to return to the airfield of departure.

5.7 Setting zero thrust

5.7.1 Reports from Australia and overseas have repeatedly shown that fatal accidents have occurred following practice engine failures because instructors have failed to set zero thrust on a windmilling engine to simulate a feathered propeller. A windmilling propeller causes the largest component of drag on an aircraft that suffers an engine failure. If the propeller is not feathered following an actual failure, or in the case of a practice failure zero thrust is not set to simulate a feathered propeller, the aircraft’s climb performance cannot be guaranteed. In many cases it is likely that the aeroplane will only be able to maintain a descent. Therefore, any pilot giving multi-engine asymmetric training must know how to set zero thrust on the propeller aircraft type that they are flying.

5.7.2 The zero thrust setting depends on the engine type and aircraft’s airspeed, altitude and temperature. In a piston engine aircraft zero thrust is normally achieved by setting a manifold pressure that causes a specified RPM; and a turbine propeller engine by a torque and in some cases RPM for a particular airspeed. Unless stated otherwise in the flight manual, CASA recommends that V_{YSE} be used for setting zero thrust. Remember that if zero thrust is set and the airspeed increases above V_{YSE}, there will be a corresponding increase in propeller drag from the windmilling ~~engine~~.

This propeller drag increases the total yawing moment, increasing the requirement for additional rudder. If the rudder is already maximal, the airspeed needs to be increased to generate the proper yawing moment to counteract the total thrust yawing moment: Vmca is higher.

5.7.3 Before conducting asymmetric flight training it is important for an instructor to determine an accurate zero thrust power setting for the aircraft type being flown. If a zero thrust power setting is not specified in the aircraft's flight manual, a method of doing this would be to climb to a minimum of 3000 ft AGL, feather a propeller, shutdown an engine, and find what power setting will allow the aircraft to fly, trimmed at V_{YSE}. Restart the engine and adjust the RPM and manifold air pressure (MAP) combination on the restarted engine to re-establish the airspeed at V_{YSE}, and return the aircraft to the previously trimmed state. This procedure may take some time and could involve manipulation of the engine controls to determine a reliable power setting. The RPM to indicated air speed (IAS) relationship could vary significantly between aircraft and engine types.

5.7.4 Some typical zero thrust power settings for turbine propeller engine aeroplanes are:

- Beech C90 Kingair: 100 ft pounds of torque at 1800 RPM at V_{YSE};
- Beech 1900D Airliner: 200 pounds of torque at or above V_{SSE};
- de Havilland DHC-6: 5 psi;
- de Havilland DHC-8: 14% torque;
- Embraer EMB-110 Bandierante: 150 ft pounds of torque at 2200 RPM;
- Fairchild Metro III: 10% to 12% of indicated torque; and
- SAAB SF340: 10% to 20% torque below 120 kts.

5.7.5 With respect to setting zero thrust a company or FTO operations manual should at least state for each aircraft type being operated:

- The procedure for setting zero thrust;
- The power setting that represents zero thrust; and
- That engine failures should be simulated by setting zero thrust on aircraft fitted with negative torque sensing (NTS) or auto feather

5.7.6 Failure by an instructor to set an accurate zero thrust to simulate a feathered propeller will result in unrealistic asymmetric climb performance that may give the trainee an over optimistic or pessimistic impression of what performance the aircraft is capable of achieving on one engine. Therefore, multi-engine flight instructors must know how and when to set zero thrust before commencing any asymmetric flight training.

5.8 About engine failures

5.8.1 Flight instructors often simulate an engine failure by rapidly closing the throttle or moving the mixture control to idle cut-off. The latter method should never be used at low altitude. However, the majority of engine failures are not instantaneous. If an engine failure is caused by fuel starvation or low fuel pressure the engine will usually cough and splutter before stopping; this may take time and gives a pilot some space to react. When an engine suffers damage such as a broken valve rocker arm, valve stem or pushrod, the engine is likely to run roughly, but still deliver power. It may be possible to reduce power and still develop some useful thrust. However, a precautionary shutdown is probably inevitable.

5.8.2 Low oil pressure coupled with increasing oil temperature indicates that a failure is imminent, with a possible engine seizure and rapid decrease in RPM. The engine should be shutdown before the centrifugal latches engage and lock the propeller in coarse pitch. Electrical malfunctions usually result in rough running, misfiring and a reduction in power. It may be possible to rectify the problem by isolating a faulty magneto.

5.8.3 Probably the worst type of engine failure is a catastrophic failure caused by a fractured crankshaft or connecting rod. Such a failure can be indicated by a loud bang, vibration and a very quick reduction in RPM. In some cases it may not be possible to feather the propeller. This could be a very serious problem if it occurred shortly after take-off, and quick but precise action needs to be taken to feather the propeller.

5.8.4 Part of managing an engine failure is to recognise the type of problem and then decide the appropriate action. It is very unlikely that an engine failure will be instantaneous, and instructors should give trainees advice about what action to take to manage partial engine failures and attempt to restore power when possible. Consideration should also be given to looking after the serviceable engine. In some circumstance there may be no alternative other than to apply full power. However, pilots should be aware of engine limitations and time limits for the application of full power and plan actions accordingly. During training, learn how an aircraft performs with less than full power

5.9 Engine failure after take-off

5.9.1 Management of an engine failure starts with a clear and well thought-out plan. Firstly, the pilot should have an unambiguous plan of what to do during various phases of take-off:

Insert:
tab and dot

Engine failure before the decision speed/point prior to lift-off;

- Engine failure before the decision speed/point after take-off; and
- Engine failure after the decision speed/point.

5.9.2 Pilots may note that the term 'decision point' is used as well as decision speed. This is another concept to aid decision-making. From the list above, the first two situations will require an aborted take-off, using procedures specified in the flight manual. A decision point can be a predetermined point, on the runway or an action. For example, by adjusting the pilot's grip on the throttle, or retracting the undercarriage, these actions could represent the point at which the pilot has made the decision to continue the take-off and keep on flying if an engine failure occurs. A further example would be a take-off from a 13000 ft runway like Sydney airport, where the decision point may be when the aircraft passes 200 ft and the undercarriage is selected up. Flight instructors should give clear guidance on how to apply the principles of determining and using the decision point or decision speed.

Insert:
, attain a bank angle of 5 degrees (or as specified by the manufacturer) away from the inoperative engine, i.e. to the same side as the foot pressure and aileron (on prop airplanes),

This is definitely required to maintain control.

5.9.3 If a pilot experiences an engine failure after the decision speed/point, actions must be prompt and correct. In this section engine failures are addressed in a general sense, and pilots must understand that the procedures in the approved flight manual must be followed.

5.9.4 The first action is to control the aeroplane. Prevent yaw with the rudder and adjust the nose attitude to a position where the aircraft is able to maintain or accelerate to V_{YSE}. The wing may also be required to be lowered towards the serviceable engine.

These steps come too late when the failure occurs at low altitude. The drag has increased already due to increased sideslip because of not attaining the small bank angle while the rudder is deflected to counteract the thrust yawing moment. Furthermore, actual Vmca increased (at least 8 kt) if the wings are kept level to this point.

5.9.5 Next ensure that full power is applied to the good engine and the gear and flap are selected up. ***'Pitch up, mixture up, throttle(s) up, gear up, flap up'.***

5.9.6 Identify the failed engine (dead leg, dead engine), but maintain control of the aircraft during this process.

5.9.7 Confirm the failed engine. Close the throttle of the failed engine and confirm that the engine noise does not change or no yaw occurs towards the live engine. Visually identify the failed engine propeller level before activation.

5.10 Feather the propeller.

5.10.1 Up to this point a lot has been done in a short time and there is no room for error.

Here, Vmca is used. Finally!

Insert:
It is even more vital to maintain a bank angle of 3 to 5 degrees away from the inoperative engine (as is "prescribed" in the legend of one engine climb performance data graphs), therefore ensure ...

Bank angle ties control and performance together (Dr. Jan Roskam, University of Kansas).

Add:
, which is usually a half ball width to the 'good engine' side.

5.10.2 Now, it is time to ensure that the aircraft is achieving best performance. Ideally the aircraft should be at V_{YSE}, but depending on the terrain it may be necessary to climb initially at V_{XSE}. It is vital to maintain the appropriate nose attitude while conducting all other procedures. If the nose attitude is too high, speed can decay towards V_{MCA} very rapidly, and cause serious control problems. ~~Ensure~~ that the wing is lowered towards the serviceable engine with the balance ball appropriately positioned to attain optimum performance.

5.10.3 Finally, perform clean up actions in accordance with the flight manual and trim appropriately.

5.10.4 As previously stated there is a lot to do in a short time. Actions must be precise and the pilot must maintain situation awareness. Maintenance of situation awareness involves a lot of factors. Control of the aircraft, engine identification, feathering, performance, terrain, traffic, weather and ATC are just some of the factors. It seems a daunting task, but good management comes with knowledge and practice.

5.10.5 Management is defined as planning, directing and controlling a manoeuvre or operation. Have a good plan, do the actions and monitor and modify the progress of the procedure.

5.10.6 In summary, it is important to have a logical and systematic approach to an engine failure after take-off:

- I have to maintain control of myself and the aircraft and keep it airborne;
- I must make sure the maximum power is set, gear is up, flaps are up (or in the position required by performance considerations);
- I must correctly identify the failed engine;
- I must feather the appropriate propeller to reduce drag;
- I must achieve optimum performance;
- I must monitor the situation and revise plans if required; and
- I must communicate my situation.

5.11 Checklist Aide-Memoire

5.11.1 A good recall-checklist for an engine failure in a multi-engine aircraft, especially after takeoff, is "CONTROL - IDENTIFY – CONFIRM – FEATHER – CLEAN UP"

Insert:
and lateral control

5.11.2 The item CONTROL includes not only directional but attitudinal control (speed) and maximum power is applied. CLEAN UP calls for undercarriage and flaps to be retracted but only when it is safe to do so, and to trim the aircraft correctly. Once flight has been brought under control, follow up the recall emergency drills by going through the hardcopy checklist to ensure that nothing has been left out, and to manage the remaining systems (e.g. switching off non-essential busbars and electrical services).

5.12 Minimum control speed demonstration

Note:
Of all Vmc's, only Vmca is usually subject of training, therefore it is recommended to use Vmca here rather than minimum control speed or Vmc. It is way too dangerous to demo Vmcg.

5.12.1 The minimum control speed sequence is one of the more important in asymmetric training. Before commencing flying training, instructors need to ensure that the trainee fully understands the theory and application of minimum control speed. The student should receive a good explanation of minimum control speed and what leads to loss of control, and the quickest method of regaining control. Also point out all the potential dangers of both practice and actual loss of control. During the first pre-flight briefing question the student to determine his or her level of understanding of the topic. It is imperative that the student understands how V_{MCA} is derived from minimum control speed (V_{MC}) principles and the relevance of each!

Refer to the note next to paragraph 4.22.

5.12.2 Before getting airborne, adjust and lock the control seats so that both the instructor and trainee are able to apply full rudder in both directions. This simple check may appear deceivingly mundane but is absolutely vital if an engine fails after take-off, and could mean the difference between a safe flyaway or a fatal crash. Double check that the seats are locked on the adjusting rails and seat belts are tight, as there may be a need to apply up to 150 lbs (60 kg) of pressure to the rudder pedals to maintain control of an aircraft with a failed engine. This is the seating position that should be used for every take-off.

spiral dive

5.12.3 The demonstration should be given at a height that permits the engines to develop full power or as much power as possible but is safe for the proposed exercise. Be aware that the engine may not be developing full power at this height because of the reduced density altitude and minimum control speed may be lower than V_{MCA} published in the flight manual. In fact, there is a critical altitude where the minimum control speed will reduce to where it will coincide with the stall speed (which does not reduce). This is a dangerous area as auto-rotation and a spin could occur. Generally, multi-engine aircraft are not certified to recover from spins.

Add:
, but intentional spins are usually prohibited.

(Spin recovery procedures are developed during experimental flight-testing and presented in the emergency sections of POH's or AFM's.)

Replace:
increase actual Vmca

Similarly, some aircraft have a minimum control speed that is close to the stall. In such cases, the instructor can restrict the application of full rudder in order to avoid auto-rotation, but still demonstrate how directional control is lost. V_{MCA} demonstrations should be terminated when yaw is recognised by the trainee.

Replace:
rudder to maintain heading and banking 5 degrees away from the inoperative engine to both reduce actual Vmca and the drag. This is provided the airspeed was higher than Vmca. Adjust pitch control to maintain Vyse or Vxse.
There is no optimum choice; the design philosophy of multi-engine airplanes requires both rudder and a bank angle to be applied. The vertical tail is simply not large enough to maintain control while 'waiting' for a speed increase.
As long as the airspeed is equal to or higher than Vmca, and rudder is applied to maintain heading, and a bank angle of 5 degrees (as determined by the manufacturer) away from the inoperative engine is being maintained, control can be maintained when the asymmetrical thrust is maximal. This is the real value of Vmca; it is a worst case Vmca. In addition, the drag is minimal too and hence, climb performance maximal.
Refer to the papers on the downloads page of www.avioconsult.com.

5.12.4 During the minimum control speed demonstration point out the yaw, wing drop and change to attitude. Show that the recovery technique depends on two factors, increase in airspeed or/and reduction of power on the live engine. The optimum choice, especially in a take-off climb, should only be to increase airspeed firstly to regain control, and finally to achieve V_{YSE}. However, when very close to the ground, this may not be practical where reduction of power on the live engine remains the only option.

Insert:
control will be restored and

Insert:
and temporary

Insert:
and when maximum rudder and/ or ailerons are applied,

5.12.5 In a critical situation, with low speed near the ground, and possibly with an engine windmilling, the pilot may have to maintain directional control by a combination of a slight lowering of attitude (not below the straight and level for the speed) and very small incremental reduction in power changes, until the airspeed may be coaxed up by feathering of the failed engine and cleaning up the aircraft. Obviously the power reduction should be dictated by how much control has been lost. Recovery may only require a small reduction in power to stop yaw and roll, and power re-introduced immediately after speed has been gained through feathering and clean up action. On the other hand a major loss of control may require large power changes, but any power changes should be deliberate and measured, even if the throttle needs to be closed completely. Show how power should be re-applied and any yaw prevented. Mention the height loss in the exercise and relate this to the dangers of an engine failure at low altitude. Instructors should also highlight that when the exercise is done during straight and level flight, the airspeed might drop off slowly. However, in a situation such as an engine failure shortly after take-off, the nose attitude will be higher and speed will reduce towards minimum control speed more rapidly. Allow the student to experience this situation, and observe how important it is to adjust the nose attitude to maintain or regain airspeed after an engine failure.

Add somewhere:
If near maximum rudder and/ or aileron is required to maintain heading and attitude, the airspeed is very close the (actual) Vmca. Loss of control is imminent if airspeed is reduced or a turn is initiated.

If yawing or rolling motions cannot be prevented with the respective controls, the airspeed is below (actual) Vmca. The only remedy is to temporarily reduce asymmetrical thrust a little.

5.12.6 When students are conducting the minimum control speed exercise, ask them to tell you when the aircraft starts to yaw and roll so that you can determine if they are recognizing these conditions early enough. Also ask the student to state how much height was lost during the recovery phase of each demonstration.

Note:
The effect of bank angle finally presented. Why not in the paragraphs above?

Insert:
(actual)

Insert:
(actual)

Insert:
Also note the sideslip angle and the rate of climb/ descend with wings level and with the small bank angle applied.

Replace:
Any other bank angle increases (actual) Vmca. Increasing the bank angle greater than 5 degrees might reduce Vmca further, but side slip increases. Since the rudder is deflected, a fin stall might occur already when the bank angle is larger than 8 degrees.

Therefore it is recommended to climb during straight flight using rudder to maintain heading and bank to reduce the drag until the altitude is high enough. Before turning, reduce asymmetrical thrust a bit, therewith sacrificing some altitude for a controlled turn. Following the turn, bank again a few degrees while increasing the thrust to maximum again. The required bank angle for Vyse is usually presented in the legend of the one engine climb performance data graphs.

Insert:
, bank angle increased up to 5 degrees

5.12.7 It is also important to demonstrate the effect of lowering the wing up to 5° towards the live engine and keep the balance ball half a ball width from the centre towards the lowered wing. Failure to perform this procedure increases ~~the~~ minimum control speed of the aircraft. Flight tests in an instrumented Cessna Conquest showed that with a published VMCA of 91 kts, if the aircraft was flown in asymmetric flight with full power applied and the wings held level with the rudder balancing the aircraft, minimum control speed increased to 115 kts; that is a 24 kt increase[1]! Conversely, lowering the wing towards the failed engine, minimum control speed increases by about 3 kts per degree of bank. Therefore, the lesson is obvious: make sure you lower the wing 5° towards the serviceable engine. ~~Pilots should also consider the direction of turn in order to optimise performance.~~

5.12.8 This manoeuvre is difficult to perform, particularly in the early stages of the training or when using flight instruments. A lot of concentration is required to maintain the low angle of bank towards the serviceable engine, and to keep the ball ½ to ¾ outside the 'cage', towards the lower wing.

5.13 Single-engine go-around

5.13.1 A single-engine go-around in a multi-engine aircraft weighing less that 5700 kg must be well managed. Recently there have been a number of accidents involving this procedure, particularly during training. Pilots must be aware of the implications of a single-engine go-around and be prepared to lose height in the process. It is important to have a good understanding of what a visual committal height, is and how to apply this concept

5.13.2 Visual committal height is a nominated height at or above which a safe asymmetric go-around can be initiated, or below which the aircraft is committed to land. It is used for visual flight operations and is to accommodate the performance of the aircraft being flown. It should not be confused with minimum descent altitude (MDA) or decision altitude (DA) that applies to IFR operations.

5.13.3 Ideally, an asymmetric approach should be flown in the normal configuration (undercarriage, flap and airspeed), at least until the visual committal height is reached and a landing assured. However, if the aircraft has to go round, positive and precise action must be taken if a successful single-engine go-around is to be completed. Full power should be applied smoothly and the yaw controlled and the aircraft accelerated to $V_{YSE.}$ If full flap has been selected, pilots must anticipate a tendency for the aircraft to roll soundly and full aileron may be insufficient to maintain wings level.

1. USN Approach magazine April 1981 Article by Mr. R. A. Eldridge

Insert:
and bank angle

Replace:
airspeed

Insert:
while also increasing the rudder deflection as well as the bank angle away from the inoperative engine. Keep in mind that not increasing the bank angle increases actual Vmca (on a Cessna Conquest 24 kt, see paragraph 5.12.7 above).

Insert:
and roll due to increased propulsive lift of the wing behind the operative engine.

Insert:
while banking the small (3 degree) bank angle away from the inoperative engine. Refer to the one engine performance data in POH or AFM.

Replace:
commenced

Insert:
while maintaining the favorable bank angle presented in the legend of the performance data graphs.

Insert:
at a safe altitude

Insert:
and lowest drag (bank angle)

Correct anticipation ~~of the rudder trim~~ change with power change is the fundamental key to smooth and effective handling technique, ensuring confident and safe asymmetric operations.

5.13.4 It is unlikely that the ~~aircraft~~ would be less than minimum control speed during an approach so full power should be applied smoothly. If for some obscure reason the ~~aircraft speed~~ happens to be below minimum control speed, advancing power to maximum even with full rudder applied will cause the aircraft to yaw. Should this happen, do not increase the power any further until the yaw is controlled before further increasing power.

5.13.5 Where necessary, the go-around may be ~~conducted~~ in a smooth continuous descent, while the aircraft is cleaned up and V_{YSE} achieved. The committal height is precisely for this manoeuvre where height is traded for speed. Once V_{YSE} has been attained, the nose attitude should be readjusted to maintain V_{YSE}, or when appropriate V_{XSE}, during the climb.

5.13.6 The visual committal height should be designed to accommodate a worst-case scenario (as described above) and a height between 200 - 500 ft AGL is commonly used

5.13.7 MDAs and decision altitude (DA) pose another problem. As an MDA is usually at a considerable altitude, a single-engine missed approach should not be a big predicament. However, the case of a DA is different. Because a DA is quite low it may be below the pilot's visual committal height. This means that once below this height the aircraft is committed to land and if the weather is below minima the aircraft is in an emergency situation and must continue. If the weather minima are known to be below committal height, then the approach should not have been commenced except in an emergency The information on how to consider this type of situation should be included in the company operations manual as an operating policy.

5.13.8 During training, flight instructors must emphasise the potential dangers of mis-managing a single-engine go-around. Give trainees ample opportunity to practice this procedure and ensure the trainee is able to maintain both directional and attitudinal (for speed) control with varying power and/or speed changes. As the student's skill level increases in his control of the aircraft even with significant changes in power and airspeed, his/her conduct of a safe, smooth and effective go-around would be assured. However, remind the trainee that if recency is not maintained, the level of skill may reduce.

5.14 Stall training

5.14.1 It is important to be able to recognise and avoid the stall in any aircraft. Instructors must conduct this exercise in multi-engine aircraft. Stress the characteristics and devices that warn the pilot of the stall. Of course the stall warning is the primary device. However, airspeed indications, nose attitude, buffet, and reduced control response rate are all indicators of impending stall. Allow the student to experiment with these characteristics and practice them in different configurations and flight situations. Show the pilot a stall while simulating a turn from base leg to final approach. Of course a pilot should commence recovery action well before a stall occurs.

Replace:
a spiral dive

5.14.2 To recover from a stall in a multi-engine aircraft, the procedure is no different to any other aircraft. Unstall the wing by adjusting the stick position to reduce the angle of attack releasing the backpressure on the control column and simultaneously applying full power while keeping the aircraft balanced.

5.14.3 Stall training should never be done with asymmetric power. This is a very dangerous exercise and numerous aircraft in Australia and overseas have fatally crashed after entering ~~autorotation~~ and spinning.

5.15 Asymmetric Training at Night

5.15.1 Engine failures after take-off must never be practiced at night. History has repeatedly shown that a disproportionate number of fatal accidents have occurred while conducting this exercise. The main danger is the loss of visual cues that alert the pilot to the fact that the aircraft performance is inadequate to avoid terrain or obstacles. When operating at night or in poor visibility it is likely that a pilot will be slow to interpret instrument readings that show the aircraft is not climbing or has drifted off track. Therefore, asymmetric training should not be practiced in these conditions. When conducting simulated instrument training, the flight instructor should still be able to see the terrain or obstacles and terminate the exercise immediately a dangerous situation is recognised.

5.15.2 Aeronautical Information Publication – En-route (AIP ENR) 1.1 Paragraph 81.3 states that simulated asymmetric flight at night must not be conducted below 1500 ft AGL.

5.16 Touch and go landings during asymmetric training

5.16.1 Experience has shown that it is inadvisable to perform touch and go procedures when conducting asymmetric circuits and landings. There would be increased likelihood for confusion and errors with engine controls and possibly offset elevator, aileron and rudder trim settings that may be fairly different from normal takeoff trim settings. Coming to a full stop on each landing and taxiing back to the threshold provides the instructor with the opportunity to perform a good debrief, as well as allowing engine temperatures to stabilise.

5.17 Summary

5.17.1 This CAAP was written following a number of multi-engine aeroplane accidents caused by aircraft systems mis-management and loss of control by pilots, flight instructors and persons approved to conduct multi-engine training. The CAAP also addresses threats and errors associated multi-engine operations and provides advice about multi-engine training.

- Aircraft system mis-management and loss of directional control are the main cause of multi-engine accidents;
- Pilots and operators have a joint responsibility for ensuring the competency and recency of pilots operating multi-engine aeroplanes;
- Good training is one of the cornerstones of the safe operation of a multi-engine aeroplane;
- Select a comprehensive course of multi-engine training and have a clear understanding of the standard required;
- Strive to understand and competently operate all the aircraft systems and do not aim for mediocrity;
- Establish a thorough understanding of the theoretical aspects associated with asymmetric flight;
- Instructors and pilots should know and apply TEM practices;
- Flight instructors have an important role to play in teaching, influencing and developing a robust safety culture;
- Ensure comprehensive pre-flight planning and briefings applicable to the flight situations on the day are conducted before each departure;

Insert:
laterally (attain and maintain a small 5 degree bank angle away from the inoperative engine, to the same side as foot pressure), and

Insert:
and maintain the bank angle that is presented with the one engine performance data (usually 3 degrees)

- Engine shutdowns and restarts require deliberation, planning and strict adherence to flight manual/checklist procedures;
- Instructors must plan safe simulated engine failures, conduct thorough briefings and monitor trainee's actions;
- Understand the symptoms of partial and complete engine failure;
- Instructors must set zero thrust to replicate a feathered propeller;
- The general procedures following an engine failure are:
  - ***Control*** the aircraft directionally, attitudinally for speed to be at or above minimum control speed;
  - Power up, gear up, flaps up, identify and confirm the failed engine;
  - ~~*Feather the propeller or rectify engine problems;*~~
  - Achieve optimum ***performance***; V_{YSE} or V_{XSE}; and
  - Complete shutdown procedures in accordance with flight manual.
- Understand and respect minimum control speed;
- Plan, practice and be patient when conducting single-engine overshoots;
- Comply with visual committal height procedures when overshooting; and
- Never practice engine failure after take-off (EFATO) at night or in poor visibility.

5.17.2 Pilots must develop and possess the correct knowledge, skills and behaviour to be able to operate a multi-engine aircraft safely in every phase of flight.

APPENDIX A TO CAAP 5.23-2(0)

GENERIC RANGE OF VARIABLES

Table 1: Generic Range of Variables

Range of Variables
• Performance standards are to be demonstrated, in flight, in an aircraft of the appropriate category equipped with dual flight controls and electronic intercommunication between the trainee and the instructor or examiner. • Consistency of performance is achieved when competency is demonstrated on more than one flight. • Flight accuracy tolerances specified in the standards apply under flight conditions from smooth air up to, and including, light turbulence. • Where flight conditions exceed light turbulence appropriate allowances as determined by the assessor may be applied to the tolerances specified. • Infrequent temporary divergence from specified tolerances is acceptable if the pilot applies controlled corrective action. • Units and elements may be assessed separately or in combination with other units and elements that form part of the job function. • Assessment of an aircraft-operating standard also includes assessment of the threat and error management and human factors standards applicable to the unit or element. • Standards are to be demonstrated while complying with approved checklists, placards, aircraft flight manuals, operations manuals, standard operating procedures and applicable aviation regulations. • Performance of emergency procedures is demonstrated in flight following simulation of the emergency by the instructor or examiner, except where simulation of the emergency cannot be conducted safely or is impractical. • Assessment should not involve simulation of more than one emergency at a time. • Recreational and private pilots should demonstrate that control of the aircraft or procedure is maintained at all times but, if the successful outcome is in doubt corrective action is taken promptly to recover to safe flight. • Commercial and airline transport pilots should demonstrate that control of the aircraft or procedure is maintained at all times so that the successful outcome is assured. • The following evidence is used to make the assessment: – The trainee's licence and medical certificate as evidence of identity and authorisation to pilot the aircraft; – For all standards, the essential evidence for assessment of a standard is direct observation by an instructor or examiner of the trainee's performance in the specified units and elements, including aircraft operation and threat and error management (TEM); – Oral and written questioning of underpinning knowledge standards; – Completed flight plan, aircraft airworthiness documentation, appropriate maps and charts and aeronautical information; – Aircraft operator's completed flight records to support records of direct observation; – Completed achievement records for evidence of consistent achievement of all specified units and elements of competency; – The trainee's flight training records, including details of training flights and instructors comments, to support assessment of consistent achievement; and – The trainee's logbook for evidence of flight training completed.

Range of Variables
For licence and rating issue: – Completed application form, including, licence or rating sought, aeronautical experience, Chief Flying Instructor (CFI) recommendation and the result of the flight test; – Completed flight test report indicating units and elements completed; and – Examination results and completed knowledge deficiency reports.

Unit: Multi-Engine Aeroplane (Land) – Flight Standard

Unit Description: Skills, knowledge and behaviour to extract and interpret required performance information to calculate aeroplane weight and balance; to calculate take-off, climb, cruise, descent, landing and emergency flight performance; and to control a multi-engine aeroplane and operate all aeroplane systems in normal and abnormal flight in accordance with Flight Manual/pilot operating handbook (POH).

Insert: longitudinal and lateral

Element	Performance Criteria
1.1 Extract, interpret, calculate and apply normal and abnormal flight performance information.	• Extracts approved flight performance information from Flight Manual/POH, interprets and applies the information to calculate aircraft take-off and landing weight, centre of gravity and take-off and landing performance. • Extracts flight performance information from Flight Manual/POH, interprets and applies the information to the phase of flight and calculates aircraft performance during normal flight operations. • Applies performance information to calculate fuel requirements. • Extracts flight performance information from Flight Manual/POH, interprets and applies the information to failed engine(s) operations during any phase of flight.
1.2 Plan for asymmetric operations after take-off, during cruise and approach phases of flight.	*Engine failure after take-off* • Assesses weather and traffic conditions and terrain and formulates a plan that can be implemented following an engine failure after take-off to achieve the safest outcome. *Engine failure during cruise* • Determines asymmetric performance for the cruise phase of flight, analyses weather and terrain conditions, and formulates a plan that can be implemented following and engine failure during any stage of cruise flight to achieve the safest outcome. *Engine failure during visual and instrument approach* • Maintains situation awareness of aircraft position, altitude, configuration and weather during approach, and formulates a plan that includes actions before and after visual committal height that can be implemented following and engine failure on approach to achieve the safest outcome.
1.3 Operate multi-engine aeroplane (land) in all phases of flight.	• Controls multi-engine aircraft in all phases of normal flight to the appropriate standards specified for a private or commercial aeroplane pilot in the Day Visual Flight Rules (VFR) (Aeroplane) Syllabus. • Operates all aircraft systems, equipment and engines in accordance with Flight Manual/POH.
1.4 Manage abnormal or emergency situations in multi-engine aeroplane (land).	• Controls aeroplane. • Identifies and confirms abnormal or emergency situation. • Performs appropriate abnormal or emergency procedures in accordance with Flight Manual/POH and published procedures. • Advises Air Traffic Service (ATS) or another agency capable of assistance of situation and intentions.

1.5 Manage engine failure in multi-engine aeroplane (land).	• Self-briefs or briefs crew members, stating a plan of action that will ensure the <u>safest outcome</u> in the event of an engine failure. • Maintains control of aeroplane, identifies and confirms failed engine(s) and shuts down failed engine(s) following engine failure during any phase of flight, in accordance with Flight Manual/POH. • Operates aircraft in accordance with Flight Manual/POH during flight with failed engine(s). *Engine failure in flight (sequence of actions may be varied)* • ~~Controls aircraft~~. • Sets power on serviceable engine(s) to ensure desired aircraft performance. • Shuts down failed engine(s) in accordance with Flight Manual/POH. • Configures aircraft to achieve minimum drag. • Controls aircraft without sideslip (1/2 ball out towards the lowered wing) or <u>balances aircraft</u> when applicable. • Maintains indicated airspeed at or above minimum control speed. • Climbs aircraft at V_{YSE} (+5-0kts) if applicable. • Lands aircraft at nearest appropriate landing area. *Rejected take-off* • Recognises and identifies cause for rejecting take-off. • Decides to reject take-off. • Controls aircraft and maintains aircraft on runway. • Closes throttle(s) on all engine(s). • Applies braking and other fitted retardation devices and stops aircraft in runway distance available. • Performs engine shutdown or abnormal procedures in accordance with Flight Manual/POH or Company Operations Manual. *Engine failure after take-off (EFATO)* • ~~Controls aircraft~~. • Ensures maximum take-off power is applied to serviceable engine(s). • Identifies failed engines and confirms failure. • Feathers propeller (as applicable) and shuts down failed engine(s) in accordance with Flight Manual/POH. • Configures aircraft to achieve minimum drag. • Controls aircraft without sideslip (1/2 ball out towards the lowered wing) or <u>balances aircraft</u> when applicable. • Maintains aircraft at or above minimum control speed. • Climbs aircraft at V_{YSE} (+5-0 kts). • Lands aircraft at nearest appropriate landing area. *Manage engine failure after take-off below take of safety speed (V_{TOSS}) – aircraft will not accelerate or climb* • Sets power as required to manoeuvre aircraft to most suitable area to land.

Replace:
Applies rudder to maintain heading and 5 degrees of bank to the same side to be able to maintain control and reduce the drag

Insert:
- Maintains straight flight until reaching a safe altitude.
- Avoids max. power settings during turns at low speeds.

Note:
Same as above

Insert:
- Maintains straight flight until reaching a safe altitude.
- Avoids max. power settings during turns at low speeds.

Replace:
go-around

Perform ~~overshoot~~ from visual committal height

- Determines <u>visual committal height</u> (consider 300 ft above ground level (AGL).
- Initiates go-around at or above <u>visual committal height</u>.
- Controls aircraft.
- Applies maximum take-off power.
- Configures aircraft to achieve minimum drag.
- Maintains V_{YSE} (+5-0 kts).
- Climbs to circuit height.
- Reassesses situation for landing.

Insert:
and simultaneous and proportionate rudder to maintain heading and applies 5 degrees of bank to the same side to be able to maintain control and reduce the drag

Manage engine failure below <u>visual committal height</u>

- Controls aircraft.
- Lands aircraft.

Insert:
- Committed to land.

Range of Variables

- Day VFR. or IFR
- Approved multi-engine aeroplane with dual controls, electronic intercom and dual control brakes.
- Aerodromes.
- Sealed, gravel or grass surfaces.
- Simulated emergencies.
- Simulated hazardous weather.

Note: Much of the data listed is not required to be memorized, because these vary with every flight.
It is unrealistic to require to be able to recall all of the data, that's too easy a requirement, and prone to failures. Require a few " Bold face" items.

Underpinning Knowledge

General aircraft data

- Recall make, type and model of aircraft, designation of engines, take-off and rated power.
- Explain the relationship between take-off distance available and aircraft weight to accelerate stop distance.

Airspeed and load limitations

- Recall and apply all stated airspeed limitations including: V_{NO}, V_{A}, V_X and V_Y, V_{NE}, V_{FE}, V_{LO}, V_{LE}, V_{LO2} (landing gear operations down), maximum crosswind, turbulence penetration speed and maximum load factor.
- Determine and apply accelerate/stop distance.

Insert:
- Know the bank angle conditions for both Vmca and Vyse to be valid (often 5 resp. 3 degrees away inop. engine).

Emergency procedures

- Recall from memory and apply all stated emergency airspeeds including: V_{MCA}, V_{SSE}, engine(s) inoperative climb, approach and final speed, emergency descent and best glide range speeds.
- List applicable emergency procedures for: engine failure after take-off, engine fire on the ground and airborne, engine failure in the cruise, electrical fire on the ground and airborne, cabin fire in flight, rapid depressurisation, waste gate failure (if applicable) and propeller over-speed.
- Recall from memory all warnings stated in the Flight Manual.

Add:
Vxse, Vyse, although Vyse and Vmca are indicated on the airspeed indicator with blue resp. red radial lines.

Normal procedures

<u>Fuel system</u>

- Use a schematic diagram of the fuel system to explain layout and normal operating procedures
  - Explain operation of fuel selector panel;
  - Explain use of cross-feed;
  - Explain fuel-dumping procedures if applicable;
  - Recall full fuel capacity and fuel grade; and
  - State normal, minimum and maximum fuel pressures.

Add:
- Know max. approved fuel imbalance (might affect Vmca)

Hydraulic system

- Use a schematic diagram of the hydraulic system to explain layout and normal operating procedures:
  - Explain likely faults that may affect hydraulic system;
  - Explain emergency operating procedures;
  - Detail units or services operated by hydraulics; and
  - Recall type of hydraulic fluid, operating pressure and capacity of reservoir.

Add: - Know whether pressure drop (due to gear retraction) affects the boosting of controls. if applicable (affects Vmca)

Electrical system

- Use a schematic diagram of the electrical system to:
  - Explain type(s) of electrical system alternating current/direct current (AC/DC);
  - State voltage and amperage of battery;
  - State number and output of generators;
  - Explain methods of circuit protection;
  - Locate fuses and circuit breakers;
  - Specify precautions to be taken when operating electrical service; and
  - Specify instruments operated by electrics.

Oil system

- Use a schematic diagram of the oil system to:
  - Explain function of the oil system;
  - State number of tanks, capacity and oil grade;
  - State oil source of constant speed unit (CSU) and propeller feathering;
  - State normal, minimum and maximum oil pressure and temperature; and
  - Explain operation of oil cooler shutters.

Autopilot

- Explain the principles of operation.
- Identify power sources, voltage or pressure.
- Explain procedure to determine gyros are operating normally.
- Explain procedure to engage autopilot.
- Explain normal and emergency procedure to disengage autopilot.
- Explain the conditions that will automatically disengage the autopilot.
- State the limits of gyro units.
- Explain pre-flight serviceability checks for autopilot.

Add:
- State limitations of the autopilot during engine-out ops.

Anti-icing and de-icing systems

- Explain method of de-icing aerofoils, propeller and carburettor.
- Explain heat or power source of de-icing/anti-icing equipment.
- Explain any system limitations.
- Explain operation and control of systems.

Heating, ventilation and pressurisation systems

- Explain normal procedures to operate and control system.
- Explain emergency operation of system.
- Recall all precautions to be complied with.

Pitot/static system

- Use a schematic diagram of the pitot/static system to:
  - Explain heating source of pitot system if applicable;
  - Explain operating procedure for pitot/static system;
  - Explain methods of detecting pitot/static system problems;
  - Explain procedures to rectify static system problems;
  - Identify location of pitot and static pressure source;
  - Locate alternate static source; and
  - Locate static drain points if applicable.

Gyro suction pressure system

- Use a schematic diagram of the suction system to:
  - Explain the function of the suction pressure system;
  - Identify source of suction or pressure;
  - State normal operating pressure;
  - List instruments operated by suction or pressure; and
  - Explain warning system to indicate suction pump failure.

Oxygen system

- Use a schematic diagram of the oxygen system to:
  - Explain type and principles of operation of system; and
  - Explain method of operation, flow and warning indicators, and characteristics of system.

Fire extinguisher system

- Use a schematic diagram of the fire extinguishing system to:
  - Explain what areas of aircraft are serviced by extinguishers;
  - Explain method of activation of fire extinguishers;
  - Explain method of cross-selection of fire bottles if applicable;
  - Explain fire warning indications;
  - State number of fire bottles fitted and identify contents;
  - Detail position, number and type of hand-held extinguishers; and
  - Explain precautions for the operation of fire extinguishers.

Engines

- Explain starting order and any starter limitations.
- State normal, minimum and maximum engine and oil temperatures and pressures.
- State all power limitations.
- State power combinations for take-off, climb, cruise and descent.
- Explain the use of supercharger on the ground and airborne.
- State all supercharger limitations.
- Interpret all engine instrument readings.
- Interpret and apply fuel flow indications.
- State revolutions per minute (RPM) settings for approach and landing.
- State maximum permitted RPM drop on magneto test.
- State engine idling speed.
- Explain precautions to be observed when unfeathering propeller on cold engines.
- State any appropriate engine limitations.

Add:
- Explain propeller feathering system, arming, feathering, unfeathering and the limits

Weight, balance and performance

- Calculate take-off weight.
- State maximum take-off weight.
- State maximum take-off weight, landing weight, ramp weight and zero fuel weight.
- Demonstrate use of the Approved Loading System.
- Apply calculated centre of gravity position and confirm it is within limits.
- Relate mean aerodynamic chord to loading, fuel used and retraction or extension of undercarriage, reference point and turning moment in mm/kg.
- Calculate take-off distance for any specified conditions.
- Calculate landing distance for any specified conditions.
- Explain the procedures for landing on a wet or contaminated runway.

Failed engine operations - Multi-engine aeroplane less than 5700 kg

- Define V_{MCA}.
- Explain ~~the relationship between minimum control speed (V_{MC}) and V_{MCA}~~ and describe potential hazards with operation at low airspeeds with one engine failed ~~or at low~~ power.
  at high
- State the minimum control speed airborne (V_{MCA}) for the aircraft type flown.
- Explain the safety implications of asymmetric flight below minimum control speed.
- Explain the power, flight and configuration ~~requirements that apply to V_{MCA}.~~
  and bank angle
- Identify the critical engine (if there is one).
- Explain the methods of regaining control of an aircraft with a failed engine that is flying at a speed less than minimum control speed.
  ?? only controllable at less than max. power.
- Explain the relationship between minimum control speed at altitude and V_{S1} (clean stall speed), ~~and the potential dangers of this condition of flight~~.
  ?? Is stall speed a potential danger?
- Explain why asymmetric stalling and asymmetric stall recoveries should never be practiced.
- Explain the primary reason for V_{YSE}.
  and the associated - required bank angle.
- Explain the performance implications of flying below or above V_{YSE} following an engine failure.
- Explain the parameters that apply to V_{SSE} and the factors that are taken into account in calculating this speed.
  Is this really required?
- Explain why ~~simulated~~ engine failures after take-off are not ~~conducted~~ below V_{SSE}
  initiated
- Calculate initial rate of climb and climb gradient for one engine inoperative after take-off for specified conditions.
- Explain markings on the airspeed indicator that appli~~es~~ to asymmetric engine operations.
  y
  and the conditions that apply for these airspeeds to be valid.
- Calculate fuel flow and true airspeed during cruise with one engine inoperative.
- Determine if the range of the aircraft increases or decreases following an engine failure.
- Calculate point of no return (PNR) for one engine inoperative with maximum fuel (Commercial Transport Pilot Licence [CPL] and Airline Transport Pilot Licence [ATPL]).
- Calculate equi time point (ETP) for one engine inoperative with maximum fuel (CPL and ATPL).

Multi-engine aeroplane with Large Aeroplane Performance

- Calculate V_1 for any specified take-off conditions.
- State the conditions that would increase V_1.
- Explain the function of V_2.
  and the limitations that apply after engine failure.
- Explain what performance the aircraft can achieve after reaching V_2 during asymmetric flight.

MULTI-ENGINE AEROPLANE (LAND) – ACHIEVEMENT RECORD

NAME:.. ARN:............

The standard for certification of each element is that all performance criteria for that element are met.

Unit	Element	Instructor/ARN /Date	Student/Date
1.1 Multi-engine aeroplane (land)	• Extract, interpret, calculate and apply normal and abnormal flight performance information		
	• Plan for asymmetric operations after take-off, during cruise and approach phases of flight		
	• Operate multi-engine aeroplane (land) in all phases of flight		
	• Manage abnormal or emergency situations in multi-engine aeroplane (land)		
	• Manage engine failure in multi-engine aeroplane (land)		

I have completed the training specified in the elements, which have been certified on this achievement record.

....(Signature) Date ....

Attach this achievement record to the candidate's training records to be retained at the office of the flight training organisation. (FTO).

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APPENDIX B TO CAAP 5.23-2(0)

MULTI-ENGINE AEROPLANE GROUND AND FLIGHT TRAINING SYLLABUS

AIM

The aim of this document is to describe in detail the course of ground and flight training that candidates seeking their first multi-engine endorsement (rating) should undertake. The syllabus is also applicable to subsequent endorsements.

COURSE OBJECTIVE

The objective of the course is to give the candidate a sound theoretical knowledge of multi-engine aircraft operation on which to base endorsements, and to teach the piloting skills necessary for the safe and competent operation of such aircraft.

COURSE STRUCTURE

The course will comprise 7 hours of ground training in the form of lectures or briefings, and 7 hours of flight training. The content of the ground training starts at page 63 of this CAAP; and the content of the flight training, which should include 3½ hours of asymmetric training and 1 hour of instrument flying (for instrument rated pilots), starts at page 73. The ground and flight training should be integrated and coordinated so that the candidate gains the maximum benefit from time spent in the air. During the course of the endorsement (rating) the 'endorser' should certify, on the assessment form, the successful completion of each required sequence. On completion of this training, the Chief Flying Instructor/Chief Pilot (CFI/CP) of the training organisation concerned should certify that the candidate has completed the course satisfactorily. All requirements stated in this syllabus are to be regarded as minimum.

CONVERSION TRAINING FOR OTHER THAN INITIAL MULTI-ENGINE ENDORSEMENT

Candidates for subsequent endorsements, on aircraft specified in part 2, 3, 4 or part 5 of Appendix I of Civil Aviation Order (CAO) 40.1.0 or a class endorsement specified in part 3, 4, 5 or 6 of Appendix IA of CAO 40.1.0 are required to complete the flight training as detailed therein. Candidates for all other multi-engine endorsements are not required to complete the syllabus as detailed, however all applicable items on the endorsement application form should be satisfactorily completed. The candidate may be subject to an assessment flight covering but not limited to the heavily boxed items.

TURBO-JET AIRCRAFT

An applicant who wishes to add a turbo-jet aircraft, as the first multi-engine aircraft in their licence should undergo the same course as described above, except that jet-engine theory and handling is substituted for the piston engine teaching. If, however, the applicant already has a multi-engine propeller aircraft on their licence, the course may be reduced to 4 hours of ground, and 3 hours of flight (5 hours for those aircraft affected by Appendices III and V of CAO 40.1.0), integrated training. The flight training may be carried out either in an aeroplane or in an approved flight simulator under the supervision of a person approved by the Civil Aviation Safety Authority (CASA) to give such instruction. The content of this abridged turbo-jet course is given at page 81 of this CAAP.

TURBO-PROP AIRCRAFT

An applicant wishing to add a turbo-prop aircraft as the first multi-engine aircraft in his/her licence should undergo the same course as described above, except that jet engine theory and practice is substituted for that of piston engines.

INSTRUCTION

A flight instructor or other approved person shall conduct flight instruction for multi-engine aeroplanes. The ground instruction is most desirably given in the form of long briefings by the same flying instructor, but may take the form of lectures by a competent ground school instructor.

FINAL FLIGHT ASSESSMENT

On completion of the course for the endorsement of the first multi-engine aeroplane in their license, the candidate may be required to undertake an assessment flight either with a CASA Flying Operations Inspector (FOI) or with a suitably approved person. For each additional multi-engine category i.e. turbo propeller or turbo-jet, an assessment flight may be required.

Candidates seeking an additional endorsement but in the same category as their initial endorsement, e.g. another multi-engine piston type, are not required to undergo the full syllabus of training but may be required to demonstrate their ability at all appropriate sequences on the flight assessment form.

NIGHT FLYING

Flying instructors conducting the course should note that the full flight assessment includes a night element. If a candidate has limited night experience, an additional flight is advised to familiarise them with normal night circuits. However, flight with an engine simulated inoperative and engine failures after take-off must not be practiced (conditions in Aviation Information Publication En-route (AIP ENR) 1.1 Paragraph 81.3 to apply). This flight is included in the detailed syllabus at page 82 of this CAAP.

Note 1: If the candidate does not hold an instrument rating or a Night Visual Flight Rules (NVFR) rating, the night element should be incorporated in the day element such that the overall 'hours' requirement remains unchanged.

Note 2: If an approved type simulator is available, then the night sequences should be conducted in the simulator notwithstanding Note 1 above.

DOCUMENT STATUS

This Civil Aviation Advisory Publication (CAAP) 5.23-2 (0)) provides a training syllabus for use by approved organisations or persons offering courses for the initial issue of a multi-engine aircraft type endorsement (rating). It amplifies the requirements of CAO 40.1.0, in particular the requirements of subsection 4 Notes 1 and 2 and it represents industry 'best practice' with regard to the minimum acceptable level of training.

SOURCE MATERIAL

A list of source material for use on the course is at page 1, of this CAAP, however the recommended reference is 'FLYING TRAINING Multi-engine Rating' by R.D. Campbell. This reference was written to complement the United Kingdom Civil Aviation Authority (UK CAA) syllabus on which this CAAP is based.

GROUND TRAINING

The training for the multi-engine course comprises a total of 7 hours of ground lectures/long briefings on subjects associated with the operation of multi-engine propeller or turbo-jet aircraft. It includes elements which are related to the type of aeroplane to be used on the course. The training should be integrated with the flight training so that the maximum benefit is gained from time spent in the air.

The outline syllabus is as follows:

Long Briefing (LB)	*Subject Duration*	
LB1	Aircraft Systems	1½ hrs
LB2 (P)	Variable Pitch (VP) Propellers and Feathering	1 hr
LB3	Principle of Multi-Engine Flight	1 hr
LB4	Minimum Control & Safety Speed	1 hr
LB5	Weight & Balance	½ hr
LB6	Effect of Engine Failure on Systems & Performance	1 hr
LB7	Weight & Performance	1 hr

If the rating required is for a turbo-jet aeroplane, Long Briefing 2 changed to:

LB2 (TJ)	Turbo-Jet Engine Theory & Handling	1 hr

If the rating required is for a turbo-prop aeroplane, an additional briefing is to be given in conjunction with LB2 (P):

LB2 (TP)	Turbo-Prop Engine Theory & Handling	1 hr

The flying instructor conducting the course should give the long briefings; however, a suitably qualified ground instructor may give them in the form of lectures. Before commencing flying training the candidates should have satisfactorily completed the Engineering Data and Performance questionnaire (see Appendices D and E of this CAAP), and in the case of a turbo-jet or turbo-prop, Basic Gas Turbine theory. Knowledge level should be a minimum of Commercial Pilot Licence (CPL) ground examination standard.

The detailed content of each Long Briefing as set out in the following pages should be used as a guide. The Bibliography at page 1 should provide the reference material for general theory and principles; the Flight Manual should be used for type specific data.

LONG BRIEFING: LB1 – AEROPLANES AND ENGINE SYSTEMS

Duration: 1½ hours

Aim: To give the candidate a thorough understanding of all systems relevant to the aeroplane type.

Briefing content:

- Aeroplane systems (normal operation):
  - Fuel;
  - Electrical;
  - Flight control (primary and secondary);
  - Hydraulic;
  - Flight instruments;
  - Avionics;
  - Braking;
  - De-icing;
  - Oxygen;
  - Cabin air conditioning and pressurisation; and
  - Others.
- Engine systems (normal operation):
  - Fuel;
  - Oil;
  - Starter (including air start for turbo-jets);
  - Ignition;
  - Propeller – piston engine only;
  - Mixture – piston engine only; and
  - Turbochargers.
- Limitations:
  - Airframe:
    - Load factors; and
    - Speeds.
  - Engine:
    - Revolutions per minute (RPM), temperatures and pressures.
- Emergency Procedures:
  - Refer to the flight manual for the specific aeroplane type

Knowledge Standard: The candidate should have a sound knowledge of airframe and engine systems and their operation in normal and emergency conditions at a standard to pass the Engineering Data and Performance Type Endorsement written questionnaire.

LONG BRIEFING: LB2 (P) – VARIABLE PITCH PROPELLERS

Duration: 1 hour

Aim: To revise the principles of variable pitch propellers and propeller feathering mechanisms.

Briefing Content:

- Variable pitch propellers:
  - Principles;
  - Constant speed units;
  - Synchronisation;
  - Full authority digital engine control (FADEC) and
  - Handling (type related).
- Feathering:
  - Principles and purpose;
  - Feathering mechanisms; and
  - Handling and limitations (type related).

Knowledge Standard: The candidate should have sound understanding of variable pitch (VP) propellers feathering systems, and know the handling and feathering limitations for the aeroplane type.

LONG BRIEFING: LB2 (TJ) – TURBO-JET ENGINES – THEORY AND HANDLING

Duration: 1 hour

Aim: To give the candidate a sound theoretical knowledge of the principles of the turbo-jet engine, and the handling procedures and techniques relevant to the aeroplane type.

Briefing Content:

- Turbo-jet engine theory:
  - General principles;
  - Factors affecting thrust;
    - Altitude;
    - True air speed (TAS);
    - Density;
    - Spool-up time;
    - Temperature; and
    - Pressure.
  - Performance factors:
    - Rate of climb – best climb speed;
    - Specific fuel consumption;
    - Range speed (including effect of altitude etc.); and
    - Endurance speed (including effect of altitude etc.).
  - Twin spool engines.
- Theory of high speed flight:
  - Compressibility effects; and
  - Swept wing;
    - Effect on handling.

Knowledge Standard: The candidate should gain a sound (commercial pilot license (CPL) equivalent) knowledge of turbo-jet engine principles and handling related to the aeroplane type, including the difference between piston and turbo-jet engines in performance considerations

LONG BRIEFING: LB2 (TP) – TURBO-PROP ENGINES – THEORY AND HANDLING

Duration: 1 hour

Aim: To teach the candidate a sound theoretical knowledge of the principles of the turbo-propeller jet engines and the handling procedures and the techniques relevant to the engine/propeller/aeroplane type.

Briefing Content:

- Variable pitch propeller:
  - Principles;
  - Constant speed units;
  - Feathering and reversing/braking propellers;
  - Synchronisation; and
  - Pilot handling (type related).

Insert:
, arming, disarming

- Engine theory:
  - General principles;
  - Factors affecting thrust:
    - Altitude;
    - True Air Speed (TAS);
    - Density;
    - Spool-up time;
    - Temperature; and
    - Pressure.
  - Performance factors:
    - Rate of Climb – best climb speed;
    - Specific fuel consumption;
    - Range speed; and
    - Endurance speed.
- Engine Handling:
  - Thrust indicator (torque, RPM, interstage turbine temperature [ITT] and gas generator speed [N_1%)]);
  - Limitations (type related);
  - Reaction (spool up) time;
  - Emergencies (type related); and
  - Air start systems (windmill/starter assist) type related;
- Theory of high altitude flight:
  - Performance Limitations.

Knowledge Standard: The candidate should gain knowledge (CPL equivalent) of propeller systems together with jet engine principles and handling including performance considerations of aeroplane type.

LONG BRIEFING: LB3 – PRINCIPLES OF MULTI-ENGINE FLIGHT

Duration: 1 hour

Aim: To give to the candidate a sound knowledge of the aerodynamic principles involved in multi-engine flight in normal and asymmetric conditions.

Briefing Contents:

- The multi-engine environment:
  - Rationale for 2 or more engines; and
  - Configurations of multi-engine aeroplanes.
- The multi-engine problem:
  - Engine failure situation, leading to:
    - Asymmetry;
    - Control capability reduction; and
    - Performance reduction – LB7.
  - Aerodynamics of asymmetry:
  - Thrust:
    - Offset thrust line; and
    - Asymmetric blade effect.
  - Drag:
    - Offset drag line;
    - Failed engine drag; and
    - Total drag.
  - Lift:
    - Asymmetry; and
    - Slipstream effect.
  - Unbalanced flight:
    - Effect of yaw; and
    - Sideslip/side forces.
  - Thrust/drag, side force couples.
- Controllability in asymmetric flight:
  - Rudder, Aileron and Elevator:
    - Effectiveness; and
    - Limitations.
  - Balanced/unbalanced flight;
  - Effect of bank/sideslip:
    - Fin strength, and stall;
    - Residual unbalance – effect on controls;
    - Out of balance control loads; and
    - Trimming.
  - IAS/thrust relationship.

Knowledge Standard: CPL equivalent.

LONG BRIEFING: LB4 – MINIMUM CONTROL AND SAFETY SPEEDS

Duration: 1 hour

Aim: To ensure the candidate has a full understanding of the principles involved in, and the factors affecting, critical/minimum control and safety speeds.

Insert:
longitudinal and lateral
Why?
Max. approved fuel imbalance.

Briefing Content:

Replace:
Vmca

- Minimum control speed (V_{MC}):
  - Definition;
  - Derivation; and
  - Factors affecting:
    - Power;
    - Weight/centre of gravity (CG);
    - Altitude;
    - Drag (e.g. undercarriage, flaps, etc.; feathering);
    - Turbulence; and
    - ~~Critical engine (if applicable.)~~
  - Pilot handling:
    - Skill/strength;
    - Reaction time; and
    - Effect of bank.
- Take-off safety speed (V_{TOSS}) (V_2):
  - Definition; and
  - Derivation.
- ~~V_{MC};~~ V_2 and other V coded speeds (type related).

Insert:
Bank angle;

Why delete here under Vmca?
Is not really required, but sounds mighty interesting. Vmca is determined while the critical engine is inoperative, the cg is aft, the weight is as low as possible, the bank angle is 5 degrees away from the inoperative engine during straight flight, while the power setting is maximum. A few more configuration factors might apply. This results in the worst case Vmca which is then published in the airplane manual and indicated on the airspeed indicator. Failure of any other engine results in a lower, safer Vmca. Manuals publish only one Vmca, one Vyse and one engine emergency procedure.
A bank angle other than the favorable 5 degrees bank angle has a much greater effect on Vmca than the critical engine.
Refer to papers presented on the downloads page of www.avioconsult.com or to the referenced FAA and EASA Flight Test Guides on that page.
Performance is a bit better if a not-critical engine fails, rudder is little less deflected.

Knowledge Standard: The candidate should show a complete understanding of the principles and factors affecting minimum control and safety speeds, and should know the value of these and other V speeds for the aeroplane type.

Replace:
Vmcg, (Vmcl?), V1

?? Like an experimental test pilot, and/
or an airplane design engineer?

LONG BRIEFING: LB5 – WEIGHT AND BALANCE

Duration: ½ hour

Aim: To familiarise the candidate with the weight and balance calculations for the aeroplane type.

Briefing Content:

- Revision of weight and balance principles
- Application of principles to aeroplane type calculation
- Practice sample calculations using Flight Manual data; and
- Use of the aircraft's Load Data Sheet and Approved Loading System.

Knowledge Standard: The candidate should be able to perform correctly weight and balance calculations for the aeroplane type.

LONG BRIEFING: LB6 – EFFECTS OF ENGINE FAILURE ON SYSTEMS AND PERFORMANCE

Duration: 1 hour

Aim: To give the candidate a sound knowledge of the effects on performance in flight caused by one inoperative engine.

Briefing Content:

- Effect on Systems:
  - Electrics;
  - Hydraulic;
  - Fuel;
  - Air conditioning and pressurisation; and
  - Others (type related).
- Effect on ~~power:~~

  > Replace:
  > performance

  - Excess power available; and
  - Optimum speeds.
- Effect on cruise:

  > Add:
  > and altitude (drift down).

  - Range; and
  - Endurance.

  > Add:
  > - Drift down altitude
  > - Bank angle (drag)
  > - Speeds (Vxse, Vyse).

- Acceleration/deceleration; and
- Zero thrust:
  - Definition;
  - Purpose; and
  - Determination.

Note: This content should be varied appropriately for relevance to the turbo-jet and turbo-prop aeroplane.

Knowledge Standard: The candidate should demonstrate a sound theoretical knowledge (CPL equivalent) of the effects on performance of one engine inoperative.

LONG BRIEFING: LB7 – WEIGHT AND PERFORMANCE

Duration: 1 hour

Aim: To familiarise the candidate with weight and performance calculations.

Briefing Content:

- Revision of Civil Aviation Regulations and Orders.
- Revision of principles of weight and performance calculations, use of graphs and tables.
- Practice calculations for the aeroplane type, using Flight Manual Data:
  - Weight at take-off (WAT);
  - Take-off;
  - Accelerate/stop;
  - Climb out – flight paths;
  - En-route ceiling, range, endurance;
  - Descent; and
  - Landing.

To include, as appropriate, the one engine inoperative case.

Knowledge Standard: The candidate should be able to perform correctly all weight and performance calculations relevant to the aeroplane type.

Flight training

The Flight Training element of the Initial Multi Engine course consists of 7 hours of dual instruction that should include 3½ hours of asymmetric training and a one-hour flight covering instrument flying (where the candidate holds an instrument rating), particularly the asymmetric flight condition. The syllabus also covers type conversion training for the aeroplane used on the course.

The outline syllabus is as follows:

Flight Number	*Description Duration*	
F1	Initial Type Conversion	1 hr
F2	General Handling & Circuits	1 hr
F3	Introduction to Asymmetric flight	1 hr
F4	Critical & Safety Speeds	1 hr
F5	Asymmetric Circuits	1 hr
F6	Asymmetric Performance & Circuits	1 hr
F7	Instrument Flying	1 hr

Details of each flight exercise are given starting on page 74 of this CAAP. Asterisked items refer to piston-engine aircraft; the equivalent item should be substituted for turbo-jet or turbo-prop aircraft.

On satisfactory completion of the flight training set out above, the candidate should satisfactorily complete the final assessment flight with an approved person or a CASA Flying Operations Inspector. This assessment includes a night element and it is recommended that a candidate with limited night flying experience should be given a further dual flight at night.

If the candidate does not hold an instrument rating, F7 should be omitted; however the balance of flight hours should remain unchanged. In the event that the candidate does not hold a night visual flight rules (NVFR) rating, then night elements should be treated in a similar manner.

Guidance on asymmetric flight training is available in the reference texts at page 77 of this CAAP .

When the full course is to be conducted on a turbo-jet aeroplane, the same flight training should be followed, except that engine shut-down and air start drills should be substituted for feathering and unfeathering exercises. Items that are applicable to piston engine aeroplanes only are indicated in the Flight Number briefs by an asterisk; the alternative turbo-jet exercise is shown in brackets where appropriate.

On completion of the training, the candidate should be capable of handling the aeroplane safely and confidently under both the normal and asymmetric condition.

FLIGHT NUMBER F1 – INITIAL TYPE CONVERSION

Duration: 1 hour

Aim: To familiarise the candidate with the handling characteristics of the aeroplane in normal flight.

Air Exercise:

- Pre-flight preparation and aircraft inspection.
- Start-up and taxiing:
  - Cockpit familiarisation;
  - Checklist procedures;
  - Engine start;
  - Engine fire on the ground;
  - Taxiing:
    - Use of brakes; and
    - Use of throttles.
- Take-off and climb:
  - Check list procedures;
  - Normal take-off/cross-wind take-off;
  - After take-off checks;
  - Normal climb, climbing turns;
  - Throttle and VP propeller (engine limitations)*; and
  - Pressurisation (as appropriate).
- Cruise:
  - Level off;
  - Use of trim;
  - Effect of flaps, undercarriage;
  - Normal turns; and
  - Cruise checks.
- Engine handling:
  - Engine temperatures and pressures; and
  - Use of:
    - Mixture control*; and
    - Carburettor de-icing and engine anti-icing (as appropriate)*.
- In flight emergencies (other than engine fire/failure):
  - Hydraulic;
  - Electric;
  - Airframe and engine icing;
  - Pressurisation; and
  - Others as per Flight Manual.
- Steep turns:

- Descending:
  - Descent checks;
  - Normal descent and descending turns;
  - Mixture control; and
  - Carburettor de-icing (as appropriate)*.
- Demonstration normal circuit:
  - Checklist procedures;
  - Approach; and
  - Normal landing.

Skill Standard: The candidate should know the normal and emergency checklist procedures, and be able to handle the aeroplane competently.

FLIGHT NUMBER F2 – GENERAL HANDLING AND CIRCUITS

Duration: 1 hour

Aim: To revise aeroplane and engine handling, and practice circuit procedures.

Air Exercise:

- Start-up and Taxi;
- Normal Take-off and Climb;
- Stalling:
  - Checks;
  - Clean configuration – power off;
  - Approach configuration – power off;
  - Approach configuration – power on; and
  - Landing configuration – power on and power off.
- Circuit Procedures – Both Engines Operative:
  - Normal configuration;
  - Flapless approach and landing;
  - Performance landing; and
  - Go-around.
- Undercarriage Emergency Procedures.

Skill Standard: The candidate should demonstrate his/her ability to handle all aspects of aeroplane operation with all engines operative.

FLIGHT NUMBER F3 – INTRODUCTION TO ASYMMETRIC FLIGHT

Duration: 1 hour

Aim: To teach the candidate basic aeroplane handling in the event of engine failure.

Air Exercise:

- Normal Take-Off and Climb;
- Single-Engine Flight:
  - Demonstrate full feathering drill* (engine shut-down):
    - Checklist procedures.
  - Aeroplane handling with one engine inoperative:
    - Power required;
    - Trim position for balanced flight; and
    - Flight controls positions for balanced flight.
  - Demonstrate fuel cross-feed;
  - Demonstrate unfeather drill* (air start):
    - Checklist procedures.
  - Demonstrate zero thrust condition:
    - Determination of 'zero thrust' settings.
- Simulated Engine Failure:
  - Effect of engine failure:
    - Visual;
    - Instrument; and
    - Performance.
  - Control after engine failure:
    - Yaw;
    - Roll; and
    - Pitch.
  - Identification of failed engine:
    - Dead leg, dead engine; and
    - Instrument indications.
  - Engine failure in turns:
    - Identification; and
    - Control.
  - Alternative method of control.
- Airspeed/power relationship:
  - Effect on control of:
    - Varying speed at constant power; and
    - Varying power at constant speed.
  - Practice handling in asymmetric flight.

Skill Standard: The candidate should be able to handle the aeroplane confidently in asymmetric flight, and to understand engine failure, feathering and unfeathering drills* (engine shut down and air start drills).

FLIGHT NUMBER F4 – CRITICAL AND SAFETY SPEEDS

Duration: 1 hour

Aim: To investigate the significance of critical speeds and take-off safety speed (V_{TOSS}).

Air Exercise:

- Revise engine failure: control and identification.
- Critical Speeds:
  - Critical speeds – wings level – windmilling engine;
  - Critical speeds – wings 5° bank – windmilling engine; and
  - Critical speeds – wings 5° bank – zero thrust.
- Engine failure during take-off:
  - Engine failure below V_{TOSS};
  - Engine failure at or above V_{TOSS};
  - Full engine failure at take-off (EFATO) drill; and
  - Single engine climb.
- Practice feathering and unfeathering drill* (engine shut-down and air start).
- Aeroplane handling: (turbo-jet and turbo-prop only):
  - High speed; and
  - High altitude.
- Demonstrate asymmetric circuit, go-around and landing.

Replace critical speeds with Minimum Control Speeds Airborne, resp. Vmca:

Why?
Critical speeds are not defined, these speeds are in fact "actual" Vmca's.

Recommend to add:
- wings level - zero thrust.

Why?
Keeping the wings level and max. thrust on the operating opposite engine might increase actual Vmca above the red-lined Vmca.

It is strongly recommended to repeat the first 2 steps with less than max. power to show the effect on actual Vmca (for making safe turns).

Skill Standard: The candidate should understand the significance of critical speeds and take-off safety speeds, should be able to handle an engine failure correctly in flight or during take-off, and should be able to carry out the feathering and unfeathering drills (shutdown and air start) correctly.

It is recommended to also demo the remaining climb performance. Write this down, as well as the sideslip angle (refer to page 9 above).

Warning.

Initiate each demo at a safe altitude (5000 ft).

Every time the configuration is changed, reduce speed slowly from Vsse while increasing rudder and aileron until heading or bank angle can no longer be maintained. The speed at which this occurs is the actual Vmca. The actual Vmca's with the wings level and with a windmilling propeller might be higher than the red-lined Vmca.
This shows that the actual Vmca during any flight is under control of the pilot with thrust, rudder and aileron deflection, and bank angle.

If control is lost, close all throttles, rudder normal and recover. Only then re-apply the power required. Never release the rudder abruptly. The sideslip will increase rapidly with a resulting roll into the dead engine. This can produce a spin! See also page 80 below.

FLIGHT NUMBER F5 – ASYMMETRIC CIRCUITS

Duration: 1 hour

Aim: To teach the candidate to handle an engine failure after take-off, and to carry out an asymmetric circuit, go-around and landing.

Air Exercise:

- Take-off brief;
- Engine failure after take-off;
- Asymmetric circuit:
  - Power settings and speeds; and
  - Use of flap.
  - Undercarriage and flap operation:
    - Normal; and
    - Emergency.
  - Visual committal height:
    - Consideration.
  - Go-around:
    - Decision; and
    - Actions.
  - Landing:
    - Use of flap;
    - Foot load; and
    - Taxiing.

Skill Standard: The candidate should be able to demonstrate an ability to handle an engine failure after take-off and an asymmetric circuit and land safely and competently at the flight test standard, i.e. maintain selected speeds within ±5 knots and headings within 10° during simulated engine failure operations.

Warning: Circuits, like all engine-out demo's, should be practised first at a safe altitude, 5000 ft AGL.

Warning: Increasing thrust during a turn in the circuit (at low speed) is very dangerous. Increase speed first, or reduce power temporarily during the turn to be able to maintain control. Maintaining control while the power setting is increased requires straight flight while banking away from the inoperative engine. The vertical tail is not large enough to maintain control during turns at high power settings.

FLIGHT NUMBER F6 – ASYMMETRIC PERFORMANCE AND CIRCUIT

Duration: 1 hour

Aim: To revise the effects of asymmetric operation on aeroplane systems and performance, and to practice asymmetric circuits.

Air Exercise:

- Effect On Aircraft Systems:
  - Engine parameters;
  - Electrical system operation;
  - Hydraulic system operation;
  - Fuel system:
    - Cross feed; and
    - Fuel consumption.
  - Other systems – type related.
- Effect on aeroplane's performance of:
  - Feathering;
  - Configuration (e.g. flaps, undercarriage); and
  - Departure from scheduled speeds.
- Effect on climb/cruise performance:
  - Climb;
  - Range;
  - Endurance; and
  - Descent.
- Asymmetric circuits.

Skill Standard: The candidate should have a thorough understanding of systems operation and aeroplane performance with one engine inoperative.

Note: the case of aircraft meeting the performance requirements of CAO 20.7.1B, or if this sequence is conducted in an approved simulator, the aircraft should be loaded to approximately 90% maximum all up weight (MAUW). If loading the aircraft is not practicable, then the use of a properly developed Training Power setting that approximates the performance of the aircraft at MAUW may be utilised.

***Warning**: Where a training power setting is used, the pilot-in-command (PIC) should not hesitate to resume full power immediately should an actual emergency occur during training.*

Note:
Resuming power, that is increasing power on the previously 'inoperative' engine, is dangerous, because the rudder and ailerons are still deflected near maximum. It is safer to close all throttles, set rudder normal and recover after which both throttles are advanced simultaneously. See also the warning on page 78.

FLIGHT NUMBER F7 – INSTRUMENT FLYING

Duration: 1 hour

Aim: To teach the candidate instrument flight on a multi-engine aeroplane in normal and asymmetric conditions.

Air Exercise:

- Normal Flight (all engines operative):
  - Straight and level;
  - Climbing and descending;
  - Turning; and
  - Recovery from unusual attitudes.
- Asymmetric Flight (one engine inoperative):
  - Engine failure: identification and control;
  - Straight and level;
  - Climbing and descending;
  - Turning; and
  - Effect of flap and/or undercarriage.
- Visual asymmetric circuit and landing (or asymmetric instrument approach and circle to landing).

Skill Standard: The candidate should be able to control the aeroplane and its systems in instrument flight conditions with one engine inoperative.

Abridged Turbo-jet Course

When a candidate who already has a multi-engine propeller aeroplane on his/her licence wishes to add a first turbo-jet multi-engine aeroplane to it, the full course is reduced to a minimum of 4 hours ground school and 3 hours (5 hours in the case of aircraft affected by CAO 40.1.0, Appendices III and V) of flight training. The ground school should normally be conducted by the person giving the flight instruction, but may be given by a suitably qualified ground instructor.

The flight instruction may be given in the aeroplane or in a flight simulator approved for this purpose. In the latter case the training should be given by a person authorised by CASA to give such instruction.

The ground element of the course consists of 5 long briefings which are the same long briefings used on the full course for turbo-jet engine candidates. In view of the candidate's previous multi-engine experience, two of these are reduced in duration as indicated below:

Long Briefing	*Subject Duration*	
LB1	Aircraft Systems	1 hr
LB2 (TJ)	Turbo-jet Engine Theory & Handling	1 hr
LB5	Weight & Balance	½ hr
LB6	Effect of Engine Failure on Systems & Performance	½ hr
LB7	Weight & Performance	1 hr

The content of these long briefings are as given starting at page 64 of this CAAP.

The flight instruction, given in the aeroplane or an approved simulator, shall consist of 3 flights as given below. The exercise content of each flight is shown in detail at the end of this chapter; flights do not correspond with the full course flights, because the candidate is assumed to be competent in handling a multi-engine piston aeroplane.

Flight Number	*Description Duration*	
F1 (TJ)	Type Conversion	1 hr
F2 (TJ)	Critical & Safety Speed	1 hr
F3 (TJ)	Instrument Flying	1 hr

If required an additional flight to give the candidate night circuit experience may be added; the flight content is to be as at Flight Number F8 on page 83 in the flying training section of this CAAP.

On completion of the flight training, a flight assessment is required in accordance with normal practice.

FLIGHT NUMBER F1 (TJ) – TYPE CONVERSION

Duration: 1 hour

Aim: To familiarise the candidate with the handling characteristics of the aeroplane and its systems in normal flight.

Air Exercise:

- Pre-flight Preparation and aircraft inspection.
- Start-up and taxiing:
  - Normal procedures; and
  - Starting emergencies.
- Take-off and climb:
  - Normal procedures.
- Aeroplane handling:
  - High altitude;
  - High speed;
  - Stalling;
  - Steep turns; and
  - Engine handling.
- In Flight Emergencies (other than engine):
  - Hydraulic;
  - Electric;
  - Cabin conditioning and pressurisation;
  - Undercarriage;
  - Others as per flight manual; and
  - Emergency descent.
- Normal Circuits:
  - Circuit procedures;
  - Normal and flapless approaches;
  - Go-around; and
  - Landings and performance landings.

Skill Standard: The candidate should know the normal and emergency procedures and be able to handle the aeroplane safely and competently.

FLIGHT NUMBER F2 (TJ) – CRITICAL AND SAFETY SPEEDS

Duration: 1 hour

Aim: To introduce the candidate to asymmetric flying, critical and safety speeds, and asymmetric circuits.

Air Exercise:

Same as before (page 78 above).

- Normal take-off and climb.
- Asymmetric flight:
  - Engine fire/failure drills;
  - Engine shutdown and air start drills;
  - Fuel cross feed; and
  - Aeroplane handling with one engine inoperative.
- Critical Speeds:
  - Critical speeds – wings level, engine windmilling; and
  - Critical speeds – wings 5° bank, engine windmilling.
- Safety Speeds:
  - Engine failure during take-off:
    - Below decision speed; and
    - Above decision speed.
- Asymmetric Circuits:
  - Power settings and speeds;
  - Use of flap, and undercarriage operation;
  - Visual committal height;
  - Go-around; and
  - Landing.

Skill Standard: The candidate should be able to carry out correctly engine failure drills and to handle the aeroplane competently in the asymmetric configuration.

FLIGHT NUMBER F3 (TJ) – INSTRUMENT FLYING

Duration: 1 hour

Aim: To practice instruments flying in the normal and asymmetric configuration, and to revise asymmetric circuits.

Air Exercise:

- Take-off brief.
- Engine failure after take-off.
- Instrument flying:
  - Normal configuration:
    - Full panel;
    - Limited panel; and
    - Unusual attitudes.
- Asymmetric Instrument approach, go-around and visual landing.

Skill Standard: The candidate should be able to handle the aeroplanes competently under instrument flight conditions, and to fly the aeroplane competently and safely to a standard to pass the final flight assessment.

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APPENDIX C TO CAAP 5.23-2(0)

MULTI-ENGINE FLIGHT INSTRUCTOR TRAINING

Course Duration

	Training Hours	Equipment Type
Ground School	16.5 (Lesson Briefings)	N/A
Synthetic Trainer	1.0	Appropriate STD or aeroplane on the ground
Flight Training	9.5	Multi-engine aeroplane <5700 kg

Course Aim:

The aim of this course is to train the holder of a flight instructor rating to be proficient in multi-engine operations and to gain the skills, knowledge and behaviour to conduct multi-engine flight training.

Prior to the commencement of this course candidates must hold an appropriate grade of instructor rating.

Phase Objectives:

1. To refresh and confirm the candidates multi-engine aircraft systems and asymmetric principles knowledge.
2. To become proficient in the delivery of instructional lesson briefings applicable to an initial multi-engine type rating training course.
3. To ensure proficiency in multi-engine aircraft handling.
4. To develop and refine multi-engine instructional techniques.

Instructional Aids Required:

- Briefing Room
- Over-head Projector (OHP)
- Whiteboard
- Multi-Engine Aeroplane <5700 kg
- Aircraft and/or Synthetic Training Device (STD)

MULTI-ENGINE FLIGHT INSTRUCTOR TRAINING

Ground School

There is no pre-set ground school for this course. Ground instruction in the form of long (tutorial) and short (pre-flight) briefings are included in the flight training details. The contents of the long briefings are explained from pages 96 to 116 of this CAAP.

Ground Training (GT)

Exercise		Brief Time	Progressive
GT 1	Aircraft Systems	1.0	1.0
GT 2	Aircraft Systems	1.0	2.0
GT 3	Aircraft Systems	1.0	3.0
GT 4	Asymmetric Refresher	1.0	4.0
GT 5	Demonstration Briefing- Differences	1.5	5.5
GT 6	Demonstration Briefing- Asymmetric. Principles	1.5	7.0
GT 7	Demonstration Briefing- Asymmetric Flight Procedures	1.5	8.5
GT 8	Demonstration Briefing- Introductory Flight	1.5	10.0
GT 9	Student Brief - Differences	1.5	11.5
GT 10	Student Brief - Asymmetric Principles	1.5	13.0
GT 11	Student Brief - Asymmetric Flight Procedures	1.5	14.5
GT 12	Student Brief - Short Notice	1.0	15.5
GT 13	Simulator Practice - Mutual	1.0	16.5
GT 14	The Twin Instructor- Instructional Technique	1.0	17.5

Total Briefing **17.5 Hours**

Flight Training

Flight training involves multi-engine familiarisation and practical demonstrations and assessment of instructional technique. The flight simulator time may be conducted in an aircraft on the ground when a synthetic training device is not available.

The flight training course is comprised of five sorties which are explained in the six tables starting on page 90 of this CAAP. Each sortie is made up of a pre-flight briefing and the airborne exercise. The first sortie is a familiarisation and consolidation flight involving general and asymmetric flying. On the second sortie the flight instructor demonstrates or 'gives' the instructional techniques for stalling, asymmetric flight and circuits. The third sortie requires the trainee flight instructor to 'give back' or repeat the previous sortie acting as a flight instructor. The fourth sortie is a consolidation flight where the trainee instructor refines and reinforces his or her instructional techniques. The final sortie involves a flight test with an approved training officer (ATO) or other approved person.

Trainee multi-engine flight instructor assessment

In the tables which start on page 90 of this CAAP, there are columns used to record assessments, titled ‘student preparation’ and ‘student technique’. These tables are generic and each flying training organisation may use its own system of recording a student’s competence. On the example form in this appendix a scale of one to five is used, but this could be adapted to ‘C’ for competent or ‘NYC’ for not yet competent. Flying training organisations should use a system of recording assessment that suits their individual needs.

The sorties and flying hours breakdown for the multi-engine instructor course are specified in the table that follows.

Exercise		**Flight Time**	**Progressive**
ME 1	Multi-engine (ME) Rating or re-familiarisation	1.5	1.5
ME 2	Right-hand Seat Familiarisation -Airborne Sequences Demonstrated	2.0	3.5
ME 3	Right-hand Seat Instruction	2.0	5.5
ME 4	Consolidation	2.0	7.5
ME 5	Test	2.0	9.5

Total Flight **9.5 Hours**

MULTI-ENGINE FLIGHT INSTRUCTOR TRAINING SEQUENCES

ME 1 (Page 1)	**Instructor:**						**Student:**				
Date:	**Duration**	**Student Preparation**					**Student Technique**				
		1	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
Pre-Flight Brief											
Stalling - clean and approach configuration											
V_{MC} - entry and recovery											
Medium level turns 45/60° angle of bank											
Emergency undercarriage lowering											
High speed handling characteristics											
Normal Circuits - standard circuit/power settings											
Flapless and asymmetric circuits											
Pre-brief on simulated and real emergencies - action and responsibilities											
Use of touch drills, for simulated emergencies											
Management of engine and flight controls during normal											
At the Aircraft											
Aircraft familiarisation											
Cockpit familiarisation											
Systems familiarisation - normal operation and											
Protection of systems where provided											
Pre-start checks and precautions											
Start up - pre-taxi checks and ground manoeuvreing											
Run- up - Normal take off and climb											
Comments:											
Instructors Signature:											

ME 1 (Page 2)	**Instructor:**					**Student:**					
Date:	**Duration**	**Student Preparation**					**Student Technique**				
		1	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
Flight - Refamiliarisation											
Medium level steep turns - note performance detriment Effect of controls - flaps, landing gear, etc											
Stalls in clean, approach and landing configuration V_{MC} demonstration and recovery											
Engine failure with touch drills											
Single-engine handling and demonstration of go-around											
Circuits - normal, flapless and asymmetric approaches											
Comments:											
Instructors Signature:											

ME 2	**Instructor:**						**Student:**				
Date:	**Duration**	**Student Preparation**					**Student Technique**				
		1	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
Pre-Flight Brief											
Engine feather and unfeathering drills											
Flight - Give											
Patter stalling and recovery											
Patter initial asymmetric (emphasis on control)											
Patter engine failures in various configurations (emphasis on accuracy of drills)											
Patter V_{MC} demonstration and recovery											
Patter engine failure drills with full feathering											
Patter unfeathering drills											
Patter single engine go-around at altitude											
Patter normal, flapless and asymmetric circuits											

Comments:

Instructors Signature:

ME 3	**Instructor:**					**Student:**					
Date:	**Duration**	**Student Preparation**					**Student Technique**				
		1	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
Pre-Flight Brief											
Discuss the importance of passing on the essential information only											
Emphasise that the patter should not be rushed and has a logical flow											
Flight - Give Back											
Give back stalling and recovery											
Give back initial asymmetric (emphasis on control)											
Give back engine failures in various configurations (emphasis on accuracy of drills)											
Give back V_{MC} demonstration and recovery											
Give back engine failure drills with full feathering											
Give back unfeathering drills											
Give back single engine go-around at altitude											
Give back normal, flapless and asymmetric circuits											
Comments:											
Instructors Signature:											

ME 4	**Instructor:**		**Student:**							
Date:	**Duration**	**Student Preparation**					**Student Technique**			
		1	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
Pre-Flight Brief											
Discuss sequences to revise											
Flight may start with an hour of mutual if there are two trainees											
Flight - Consolidation											
Revise sequences as discussed											
Ensure all flight sequences a have logical flow											
Trainee is aware of all safety aspects											
Comments:											
Instructors Signature:											

ME 5		**Instructor:**					**Student:**				
Date: **Sim 1 or 2**	**Duration**	**Student Preparation**					**Student Technique**				
		1	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
Pre-Flight Brief											
Quiz based on questions listed on CASA Instructor Rating Test Form											
Discuss profile of test											
Instructor Brief											
Briefing as requested by ATO											
As per CASA Test Form											
Flight											
Sequences as requested by ATO											
Comments:											
Instructors Signature:											

MULTI-ENGINE FLIGHT INSTRUCTOR TRAINING

Ground training 1 - Aeroplanes and Engine Systems

Duration: 1.0 hour

Aim: To ensure a thorough understanding of all systems relevant to the aeroplane type.

Briefing Content:

- Airframe:
  - Construction;
  - Aerodynamic features;
  - Flight controls (primary and secondary);
  - Flaps- type, operation, selection, limitations and common problems;
  - Hatches/Harnesses; and
  - Pre-flight checks.
- Engine:
  - Type;
  - Power ratings;
  - Fuel types;
  - Oil type, cooling and quantities;
  - Starter operation and limitations;
  - Priming;
  - Ground starting;
  - In-flight restart; and
  - Pre-flight checks.
- Propeller:
  - Type and Dimensions;
  - General Variable Pitch Propeller/Constant Speed Unit Principles;
  - General Feathering Principles and Mechanisms;
  - Construction;
  - Operation- fine, coarse, constant speeding, feathering and un-feathering;
  - Ground and in-flight un-feathering;
  - Normal handling and synchronising; and
  - Pre-flight checks.
- Electrics:
  - Alternator types, voltage and capacities;
  - Alternator control system. Activation, indication, over/under voltage control and resetting;
  - Buses;
  - Battery - Type, capacity, physical location and drainage details;
  - Aircraft electrical systems;
  - Starting procedures when using external power sources; and
  - Pre-flight checks.

MULTI-ENGINE FLIGHT INSTRUCTOR TRAINING

Ground Training 2 - Aeroplanes and Engine Systems (Continued)

Duration: 1.0 hour

Aim: To give the candidate a thorough understanding of all systems relevant to the aeroplane type.

Briefing Content:

- Hydraulic:
  - Systems/Operation; and
  - Location and top up details.
- Undercarriage:
  - Type;
  - Normal operation and operating limits (speeds/times);
  - Up-locks;
  - Down-locks;
  - Indications;
  - Abnormal operation;
  - Emergency selection; and
  - Struts.
- Brakes:
  - Type, operation and refill details.
- Fuel:
  - Type;
  - Tank locations and types;
  - Capacity, measurement and indication;
  - Boost pumps and locations;
  - Tank Selection and consumption requirements;
  - Fuel cross-feeding;
  - Fuel drain location;
  - Cabin heater use;
  - Minimum required fuel for flight;
  - Slipping or abnormal flight limitations; and
  - Flight planning.
- Instrumentation:
  - Power sources; and
- Electric Trim/Auto-pilot:
  - Type and power source;
  - Operation; and
  - Pre-flight checks.

- Cabin air Conditioning:
  - Venting;
  - Heater type, operation and selection; and
  - Abnormal operation.
- De-icing/Anti-Icing:
  - Pitot Heat; and
  - Pre-flight check (Amps/temperature).
- Avionics:
  - System provided/system operation:
    - Intercom and radio telephone/transmission (RT) and reception (Tx/Rx);
    - automatic direction finder (ADF);
    - Very high frequency omni-directional range (VOR);
    - Instrument landing system (ILS);
    - Markers (MKRS);
    - Distance measuring equipment (DME);
    - Global navigation satellite system (GNSS); and
    - Other.
  - Aerials and locations;
  - Pre-flight checks.

Insert:
longitudinally and/ or laterally

- Aircraft Weight and Balance:
  - Limitations;
  - System and load sheet;
  - Movement of centre of gravity (CG) with fuel burn-off; and
  - Instrument flight rules (IFR) and asymmetric restrictions (take-off, cruise, approach and landing).
- Flight Planning:
  - Fuel (normal, asymmetric, holding, approaches, alternates; endurance and range);
  - Speeds;
  - Climb, Cruise, instrument flight (IF) manoeuvring, normal descent, IF descent;
  - Take-off, accelerate/stop, climb, cruise, approach and landing;
  - Performance for normal and asymmetric; and
  - Max endurance, holding and maximum range configurations.

MULTI-ENGINE FLIGHT INSTRUCTOR TRAINING

Ground training 3 - Aeroplanes and engine systems

Duration: 1.0 hour

Aim: To give the candidate a thorough understanding of all systems relevant to the aeroplane type.

Briefing Content:

- Limitations:
  - Airframe;
  - Load factors;
  - Airspeeds; and
  - Engine/propeller:
    - Full power/revolutions per minute (RPM);
    - Max Continuous power/RPM;
    - Temperatures and pressures; and
    - Minimum fuel and oil quantities.
- Emergencies:
  - Engine;
  - Propeller- over/under speeding and feather on shutdown;
  - Undercarriage- lights, micro's, electrical, hydraulic, mechanical and partial;
  - Flap;
  - Flight controls (elevator, aileron, rudder and trims);
  - Electrical/Lighting;
  - Electric Trim/Auto-pilot;
  - Radio/Navigation-aid;
  - Fuel – leaks, fuel cap off, cross feeding and asymmetric;
  - Brakes;
  - Tyres;
  - Door open in-flight;
  - Fire - engine/wing, electrical, heater and cabin;
  - In-flight structural; and
  - Passengers.

MULTI-ENGINE FLIGHT INSTRUCTOR TRAINING

Ground training 4 - Asymmetric refresher part a

Duration: 1.5 hours

Aim: To refresh the candidates knowledge of piston engine asymmetric operations

Briefing Content:

Multi-engine problems:

- Engine failure situation, leading to asymmetric flight symptoms:
  - VFR;
  - Feel;
  - Yaw/Roll/Nose Drop - leading to spiral dive;
  - IFR;
  - Flight Instruments no yaw on AI, mainly see roll but yaw is what needs to be countered first;
  - Engine instruments – probably use EGT only;
  - Control capability reduction rudder;
  - Aileron – can often over power yaw;
  - Elevator; and
  - Minimum control airspeed (V_{MCA}).

Other writer?
Now Vmca used!

- Aerodynamics of asymmetry:
  - Thrust (Yaw);
  - Offset thrust line;
  - Asymmetric blade effect (P factor – good/bad); and
  - Asymmetric torque (good/bad).
- Drag (Yaw):
  - Offset drag line;
  - Failed engine drag; and
  - Total drag.
- Lift (Roll):
  - Asymmetry;
  - Slipstream effect;
  - Vertical stabiliser/rudder (good/bad); and
  - Flaps.
- Unbalanced flight:
  - Effect of yaw;
  - Side-slip/side-forces; and
  - Drag increase.

- Thrust/drag/side-force couples – aircraft cannot fly straight (side-slip) lift/weight force couple – nose drop;
- Controllability in asymmetric flight;
- Identification dead leg – dead engine (rudder force - not instruments – ball always shows rudder required);
- IAS/thrust relationship;
- Rudder, aileron and elevator:
  - Effectiveness;
  - Limitations;
  - Balanced/unbalanced flight;
  - Effect of bank/side-slip;
  - Fin: size; strength, and stall;
  - Residual unbalance-effect on controls;
  - Out of balance control loads;
  - Trimming- using rudder trim reduces rudder control effectiveness and can reduce your ability to correctly identify the failed engine; and
  - BUT YOU NEED TO USE RUDDER TRIM AFTER FEATHERING TO STAY ON HEADING.
- Controllability Methods:
  - Rudder only and aileron for wings level (side-slipping and less rudder available);
  - Aileron only and no rudder (full rudder available but less vertical lift and more drag); and
  - Combination 5° angle of bank and ½ rudder ball to live engine (least drag and reasonable rudder control available).
- Minimum air control Speed (V_{MCA}):
  - Definition;
  - Derivation;
  - Factors affecting V_{MCA};
  - Weight/centre of gravity (CG);
  - Drag (e.g. undercarriage, flaps and wind-milling propeller);
  - Turbulence;
  - Condition of airframe;
  - Critical engine (if applicable);
  - P Factor;
  - Slipstream; and
  - Torque.
- Power;
- Altitude;
- Pilot Handling;

Insert:
(longitudinal and lateral).

Refer to notes on page 69.

- Reaction time:
  - Minimal reaction time for test pilot expecting engine failure means lower V_{MCA} for him/her; and
  - Pilot currency – ability degrades with lack of practice.
- Skill/strength:
  - Greater skill of test pilot means lower V_{MCA} for him/her;
  - Some pilots not strong enough (use some rudder trim); and
  - Optimisation - not used initially due uncertainty of which engine has failed.
- Pilot seat position:
  - Must be seated so as to be able to command full control movement; and
  - Lap seatbelt tight to avoid slipping up in the seat due to Newton's third law reducing control deflection.
- Relationship of V_{MCA} to V_S:
  - Recovery from flight below $V_{MCA;}$
  - Power; and
  - Airspeed.
- Take-off Safety Speed (V_{TOSS}) (V_2):
  - Definition;
  - Derivation; and
  - V_{MC}, V_{SSE}, V_2 and other V coded (type related).

MULTI-ENGINE FLIGHT INSTRUCTOR TRAINING

Ground training 5 - Asymmetric refresher Part B

Duration: 1.5 hours

Aim: To refresh the candidates knowledge of piston engine asymmetric operations

Briefing Content:

Below 5700 kg aircraft design requirements compared to >5700 kg regular public transport (RPT) requirements:

- Instrument flight rules (IFR) requirements;
- Aircraft Performance:
  - Loss of horse power (HP);
  - Due loss of engine;
  - Due temperature above International Standard Atmosphere (ISA);
  - Due Altitude;
  - Due lack of going to full power;
  - Increase in HP required due increased drag (propeller and form [due side-slip] drag);
  - Rough handling in the recovery and climb increases control/trim drag;
  - Any turbulence increases drag (summer);
  - Leaving gear and flaps down;
  - Not feathering wind-milling propeller;
  - Reduction of excess horse-power (HP);
  - Climb performance reduction - 80% or more loss;
  - The aircraft's ability to out-climb obstacles after take-off is in no way guaranteed but continued climb may be possible under optimal conditions; and
  - As a product of excess HP - rate of climb will be optimum at one airspeed – $V_{YSE.}$
- V_{YSE} – Definition:
  - Blue line on air speed indicator (ASI).
- Single-engine ceiling:
  - Drift down;
  - If terrain is above single-engine ceiling or even if just close then only a controlled forced landing is available; and
  - V_{XSE} may be required to avoid close in obstacles but drag is increasing and the control margin is reducing. With passengers – do not take off unless obstacles can be out-climbed at V_{YSE}.
- Visual asymmetric committal height (decision height);
- Asymmetric instrument approach considerations;
- Asymmetric instrument meteorological conditions (IMC) committal height – missed approach considerations;
- Factors affecting single-engine performance:

  - Aircraft design requirements – minimal performance;
  - Airframe/engine condition;
  - Density altitude;
  - Turbulence;
  - Aircraft weight;
  - Engine power used;
  - Drag;
  - Pilot handling technique;
  - Reaction time;
  - Quick and accurate control and cleanup;
  - Accurate V_{YSE} maintenance and climb optimisation; and
  - Smooth handling.
- Introduction to asymmetric handling and engine failure checks:
  - Recognition;
  - Yaw primary - instruments secondary;
  - Aborting - immediate actions;
  - Throttles to idle;
  - Control - yaw/turn back to runway centreline/lower nose;
  - Gear down;
  - Full flap;
  - Land;
  - Full optimal braking;
  - Continuing - immediate actions;
  - Control - yaw/wings level/pitch/$V_{YSE;}$
  - Power - mixture/pitch/throttle;
  - Drag reduction - gear/flap;
  - Identify (dead leg dead engine;
  - Confirm with throttle (remember partial power case);
  - After take-off - feather dead engine/trim to hands off/cowls flaps open live – closed dead/check dead engine for visual signs of fire;
  - At a safe airspeed and height – trim to hands off/cowl flaps open on live – closed on dead/check dead engine for visual signs of fire;
  - Trouble checks, (remember to try throttle) if not fixed;
  - Feather dead engine;
  - Monitor climb-out path – Climb at V_{YSE}/lowest terrain/forced landing required;
  - Effect of bank;
  - Optimise performance by 5° to live engine/rudder ball ½ out to live;
  - If at a safe height/airspeed then fly ball middle and wings level for ease unless in drift-down situation;
  - Importance of balance;
  - Use of flight controls and trim - trim to hands off;
  - PLAN - then action it;
  - Radio - PAN call (to obtain priority and assistance);

  - Secondary actions if time permits (securing engine); and
  - Mixture idle cut-off, fuel cock off/boost pump off/magneto off/alternator off (reduces fire risk).
- Asymmetric Approach Considerations:
  - Live engine temps and pressure – Reduce to climb power if possible;
  - Fuel cross-feeding – on own tank for landing;
  - Delay gear and flap extension ; and
  - Possible increase to minimum descent altitude (MDA) for manifold air pressure (MAP) terrain clearance.
- Effects of engine failure on systems and performance:
  - Electrics;
  - Hydraulic;
  - Fuel;
  - Air-conditioning;
  - Other systems;
  - Excess power;
  - Optimum speeds;
  - Range;
  - Endurance;
  - Acceleration/Deceleration;
  - Overheating – live engine working harder – open cowl flap;
  - Ensure dead engine cowl flap closed in training particularly;
  - May have to slowly warm 'dead' engine before using high power; and
  - Use higher than zero thrust generally to reduce cooling.
- Zero thrust settings:
  - Definition;
  - Purpose; and
  - Determination.
- Discuss performance consideration:
  - Accelerate stop/go distances;
  - Take-off runway available and take-off distance available; accelerate stop distance available, clear-way and stop-way available;
  - Continued take-off climb gradient;
  - Decision point on take-off;
  - Why;
  - Determination;
  - Wind;
  - Aircraft weight;
  - Density Alt;
  - Runway surface condition;
  - Take-off path obstacles;
  - Turns towards failed engine unless terrain requirements;

– Touch drills for simulation after confirming;
– Climb out flight paths;
– En-route single engine ceiling/lowest safe altitude;
– Single-engine range/endurance;
– Asymmetric consideration during non-precision approach outside/inside final approach fix;
– Asymmetric consideration during precision approaches outside/inside FAF;
– Asymmetric landing considerations;
– Asymmetric taxiing considerations;
– Missed approach climb gradients; and
– Standard departure climb gradients.

MULTI-ENGINE FLIGHT INSTRUCTOR TRAINING

Ground training 6 - Demonstration briefing – differences

Duration: 1.0 hour

Aim: To give the candidate a demonstration briefing on multi-engine aircraft differences compared to single engine aircraft.

Briefing Content:

- As per Ground Training (GT) 4

This briefing should address all the items listed in GT4. However, trainee instructor may vary the order of delivery, style or teaching techniques to achieve the best learning outcome for the student.

MULTI-ENGINE FLIGHT INSTRUCTOR TRAINING

Ground training 7 - Demonstration briefing – asymmetric principles

Duration: 1.0 hour

Aim: To give the candidate a demonstration briefing on multi-engine aircraft asymmetric operation principles.

Briefing Content:

- As per Ground Training (GT) 4 and 5.

This briefing should address all the items listed in GT4 and 5. However, trainee instructor may vary the order of delivery, style or teaching techniques to achieve the best learning outcome for the student.

MULTI-ENGINE FLIGHT INSTRUCTOR TRAINING

Ground training 8 - Demonstration briefing – asymmetric flight procedures

Duration: 1.0 hour

Aim: To give the candidate a demonstration briefing on multi-engine aircraft asymmetric flight procedures.

Briefing Content:

- As per Ground Training (GT) 4 and 5.

This briefing should address all the items listed in GT 4 and 5. However, trainee instructor may vary the order of delivery, style or teaching techniques to achieve the best learning outcome for the student.

MULTI-ENGINE FLIGHT INSTRUCTOR TRAINING

Ground training 9 - Demonstration briefing – multi engine aircraft introduction flightt

Duration: 1.0 hour

Aim: To give the candidate a demonstration briefing on a multi-engine aircraft introduction flight

Briefing Content:

- Recap on effect of controls.
- Engine feather and un-feathering drills.
- Stalling - Clean and approach configuration.
- V_{MCA} - entry and recovery
- Medium level turns 45°/60° angle of bank.
- Emergency under carriage lowering.
- High Speed handling characteristics.
- Normal circuits - standard circuit/power settings.
- Pre-brief on simulated and real emergencies -action and responsibilities.
- Use of touch drills, for simulated emergencies.
- Management of engine and flight controls during normal two engine operations.

At the aircraft:

- Aircraft familiarisation – Pre-flight inspection.
- Cockpit familiarisation.
- Systems familiarisation - normal operation and remedial actions in case of malfunctions.
- Protection of systems where provided.
- Pre start checks and precautions.
- Start Up - Pre-taxi checks - ground manoeuvring.
- Run up - Normal take-off and climb.

MULTI-ENGINE FLIGHT INSTRUCTOR TRAINING

Ground training 10 - Student brief – differences

Duration: 1.5 hours

Aim: For the candidate to practice a briefing on the differences of multi-engine aircraft flight to single engine aircraft flight.

Briefing Content:

- As per Ground Training (GT) 6.

MULTI-ENGINE FLIGHT INSTRUCTOR TRAINING

Ground training 11 - Student brief – principles of asymmetric flight

Duration: 1.5 hours

Aim: For the candidate to practice a briefing on the principles of multi-engine aircraft flight.

Briefing Content:

- As per Ground Training (GT) 7.

MULTI-ENGINE FLIGHT INSTRUCTOR TRAINING

Ground training 12 - Student brief – asymmetric flight procedures

Duration: 1.5 hours

Aim: For the candidate to practice a briefing on asymmetric flight procedures

Briefing Content:

- As per Ground Training (GT) 8.

MULTI-ENGINE FLIGHT INSTRUCTOR TRAINING

Ground training 13 - Student brief – subject as required

Duration: 1.0 hour

Aim: For the candidate to give a briefing on a particular topic with short notice

Briefing Content:

- As required.

MULTI-ENGINE FLIGHT INSTRUCTOR TRAINING

Ground training 14 - Simulator practice – asymmetric flight procedures

Duration: 1.0 hour

Aim: For the candidate to practice his /her asymmetric flight procedures and then practice failing and restoring engines while a "student" is flying the aircraft.

Simulator practice or utilising an aircraft on the ground to practice the engine failure and power restoration procedures:

- Engine failures:
  - on take- off – abort/continue; and
  - In-flight –climbing/level/turning/descending/instrument approach.
- Change seats for a repeat of above.

MULTI-ENGINE FLIGHT INSTRUCTOR TRAINING

Ground training 15 - The twin instructor

Duration: 1.0 hour

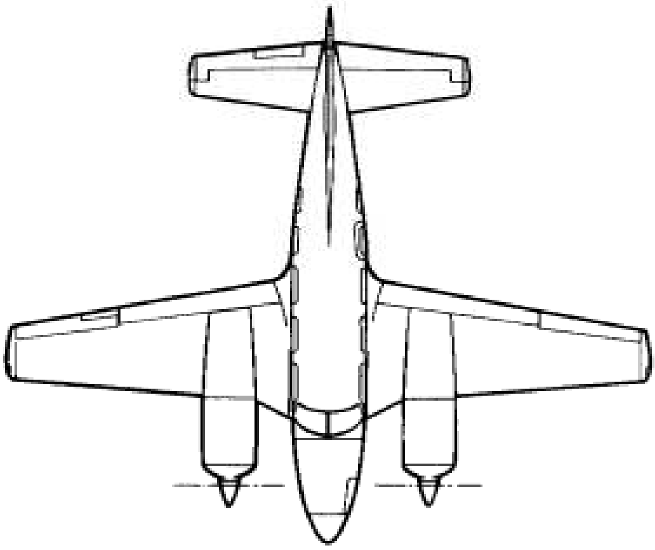
Aim: To give the candidate an appreciation of the factors involved in maintaining aircraft safety in-flight and particularly while close to the ground. To give the candidate guidelines for maintaining engine and system integrity in the short and long term.

Briefing Content:

- Instructional Technique with emphasis on instructor situation awareness.

APPENDIX D TO CAAP 5.23-2(0)

MULTI-ENGINE PISTON AEROPLANE ENDORSEMENT



ENGINEERING, DATA AND PERFORMANCE QUESTIONNAIRE

FOR____
(Aeroplane make and model)

Version 2 April 2007

Name:__________________________ **ARN:**___________

Endorsed:_______________________ **ARN:**___________

(Signature/Name)

The endorsement questionnaire

To qualify for an aeroplane endorsement you must be able to fly the aeroplane to an acceptable standard and demonstrate a level of knowledge which satisfies the Endorser that you have completed *'training in the operating limitations, procedures and systems of the type of aeroplane for which the endorsement is sought'* Civil Aviation Order (CAO) 40.1.0, paragraph 4.3 Note 1).

This questionnaire will assist you to fully satisfy these knowledge requirements, thereby enhancing safety and reducing industry costs.

The questionnaire will also be a useful ready reference for you in the future, particularly if you do not fly regularly.

In any case, the Civil Aviation Safety Authority (CASA) recommends that both you and your instructor retain a copy of the questionnaire for at least 12 months as proof of completion of training.

How to answer these questions

You should use references such as Flight Manuals, the Pilot Operating Handbook (POH) and theory texts, and make liberal use of notes and sketches on the applicable questionnaire page.

To assist you, the layout of the questionnaire corresponds to the sections of most POH.

Some of the questions may not apply to the aeroplane type on which you are being endorsed, you should mark these 'N/A' (not applicable).

The questionnaire at Appendix E is comprised of 16 pages and may be copied.

General Aircraft Data

1.
   (a) What is the make, type and model of the aeroplane?

   (b) In which category (categories) is the aeroplane permitted to fly?

Airspeed Limitation

2. List the applicable airspeed for the aeroplane type:

Format/ paragraph numbering errors?

(a) V_{NO} (normal operating)

(i) $V_{MAX\ X/WIND}$ (maximum crosswind)

(ii) V_A (design manoeuvre speed)

(iii) V_x (best climb angle)

(b) V_B Turbulence penetration speed:

(i) V_Y (best climb rate)

(iv) V_{FE} (flap extension)

(v) V_{LO} (landing gear operation up)

(vi) V_{LE} (landing gear extended)

(vii) V_{LO2} (landing gear operation down)

Add:
Vmca

(viii) V_{NE} (never exceed)

(c) Maximum landing light operating speed;

(d) Maximum load factor (flaps up) is + g and - g; and

(e) Maximum load factor (flaps down) is + g and - g.

Emergency Procedures

3. Detail the emergency procedures for the following situations, if applicable:

   (a) Engine fire on the ground;

   (b) Engine failure after take-off;

   (c) Engine fire airborne;

   (d) Engine failure in the cruise;

   (e) Electrical fire on the ground;

   (f) Electrical fire in flight;

   (g) Cabin fire in flight;

   (h) Rapid depressurisation;

   (i) Waste gate failure;

   (j) Emergency undercarriage extension procedure;

   (k) The optimum glide speed for the aeroplane is kts; and

   (l) Propeller over-speed.

Normal Procedures

4. State, describe or detail:
   (a) The start sequence for cold and hot starts;

   (b) The revolutions per minute (RPM) used for checking:
      (i) The feathering system (if applicable);

      (ii) Minimum RPM for feathering;

      (iii) The ignition system;

      (iv) The propeller governing system (if applicable); and

      (v) The carburettor heat.

   (c) The maximum RPM drop and RPM differential between magnetos when checking the ignition switches;

   (d) The use of cowl flaps (if fitted);

   (e) The climb power setting, IAS and fuel flow;

   (f) A typical 65% power setting, indicated air speed (IAS) and fuel flow at 5000 ft pressure height;

   (g) Using the aeroplane flight manual, calculate the endurance for the aeroplane at 5000 ft above mean sea level (amsl) international standard atmospheres.(ISA) with 65% power set; and

(h) How the mixtures are leaned in the cruise.

Weight and Balance and Performance

5. Specify the correct values of:

(a) The maximum ramp weight;

(b) The maximum take-off weight (MTOW);

(c) The maximum landing weight;

(d) The maximum zero fuel weight;

(e) The maximum number of adult persons on board (POB);

(f) The maximum baggage weight; and

(g) The maximum fuel which can be carried with a full load of adult passengers (80 kg/person) and maximum baggage weight.

(h) Do any of the weight limitations in (a) to (g) vary between categories?

(i) If so, what are the weight limitations of each category?

(i) Using the aeroplane flight manual, and a typical loading problem posed by the endorser, determine the take-off weight and balance solution (MTOW and CG position), the amount of fuel that can be carried and the endurance;

(j) Calculate the take-off distance required at maximum take-off weight, 2500 ft amsl and, outside air temperature (OAT) 30° C, and the minimum landing distance at maximum landing weight;

Fuel System, Fuel and Fluids

6. State, sketch or show on the aircraft diagram:
   (a) The correct grade of fuel;

   (b) Any approved alternate fuel;

   (c) The location of fuel tanks and drain points;

   (d) The total and usable fuel in each tank;

   (e) The position of the fuel tank vents;

   (f) Whether the engines have a carburettor or fuel injection system;

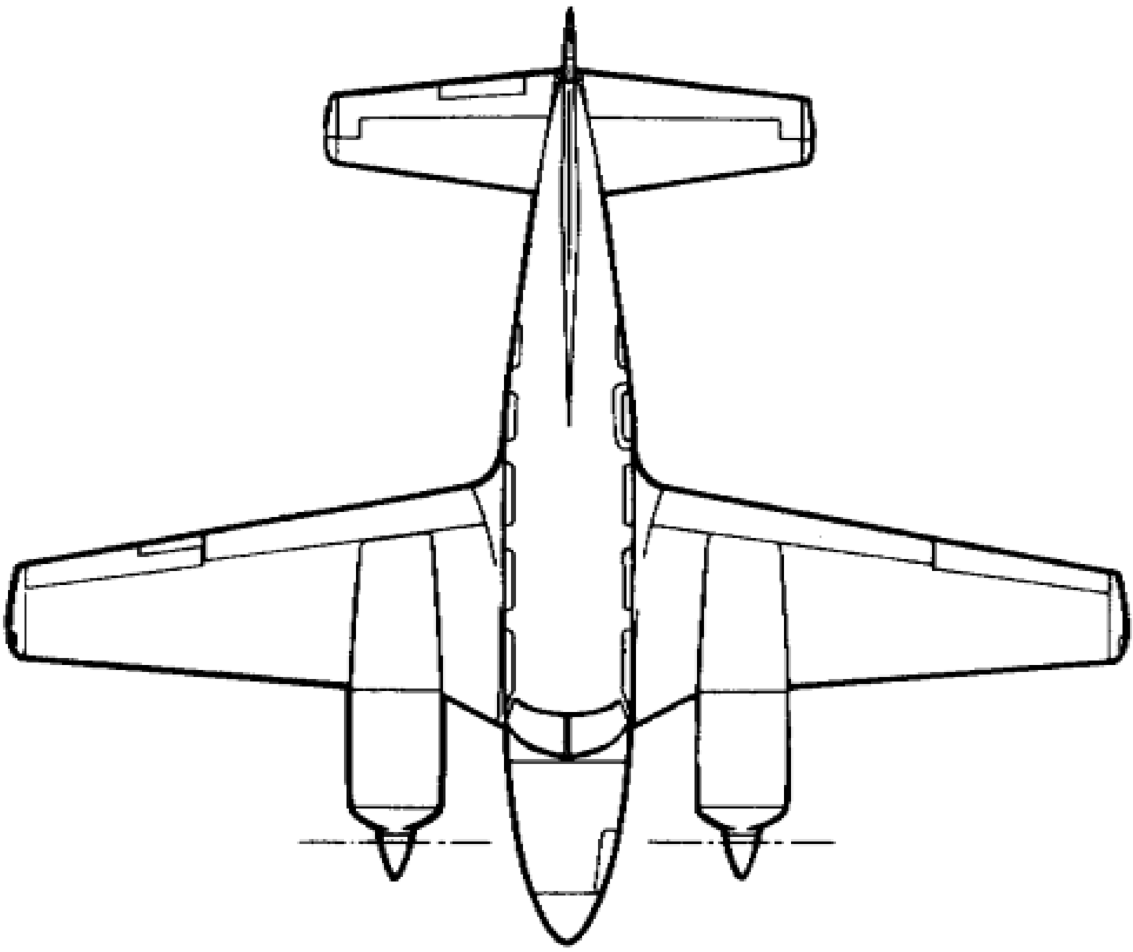
   (g) If applicable, describe the priming system and its use; and

   (h) Where the fuel boost/auxiliary pumps are located:
      (i) Are these electrical or mechanical?

      (ii) Maximum and minimum operating pressure; and

      (iii) When pumps should be used;

   (i) If applicable, the fuel tank change procedure;



(j) What conditions apply to tank selection for take-off and landing?

(k) When refuelling, to less than full tanks, what restrictions apply, and how is the fuel quantity checked?

(l) If applicable, describe the cross feed system;

(m) If applicable, the minimum and normal hydraulic fluid capacity;

(n) The correct grade of oil for the aeroplane;

(o) The minimum oil quantity before flight;

(p) The maximum quantity of oil;

(q) The maximum, minimum and normal engine oil pressures; and

(r) The maximum, minimum and normal engine oil temperatures.

Add:
(s) Max. approved fuel asymmetry / lateral cg.

Why?
A wing heavier than the other wing causes a lateral imbalance. A heavy wing (dead engine) increases actual Vmca, because it requires a larger aileron deflection. Actual Vmca decreases if fuel is transferred to the wing tanks of the operative engine, which is safer.

This effect can also be achieved by positioning passenger(s) on the side of the good engine, time permitting and if applicable.

Asymmetric Performance

7. Answer the following questions:

   (a) What indicated air speed (IAS) is V_{MCA} in the take-off configuration?

   (b) What effect will full flap have on V_{MCA}?

   (c) What speed is V_{SSE}?

   (d) What is the fuel flow rate with one engine shut down at 1000 ft amsl on an ISA day?

   (e) What is the rate of climb with one engine shutdown, propeller feathered maximum AUW, 1000 ft amsl, take-off power, undercarriage and flap retracted, on an ISA day?

      (i) On an International Standard Atmosphere (ISA) +20 day?

   Note:
   Effect of critical engine is included in Vmca.
   The effects of variables that are under control of the pilot are not included in Vmca. Ask about these.
   Refer to the note on page 69.

   (f) Which engine is the critical engine?

   Replace:
   What is the effect on Vmca of bank angle, weight, cg, engine power.

   (g) What is the single engine rate of climb speed (V_{YSE})?

   (h) How does single engine flight affect the range of the aeroplane?

   Insert:
   altitude and

Engines and Propeller

8. Answer the following:
   (a) What is the make/model of the engines?

   (b) What is the power output, and number of cylinders?

   (c) What is the take-off power setting and time limit?

   (d) What is the maximum continuous power?

   (e) Are the engines supercharged of turbo-charged?

   (f) What is the maximum manifold air pressure (MAP) permitted?

   (g) If turbo-charged, what:
      (i) Is the type of waste gate fitted (Fixed, Manual or Automatic)?

      (ii) Is the procedure for operating the waste gate?

      (iii) Prevents the engine from being over-boosted?

   (h) If supercharged, what:
      (i) Prevents the engine from being over-boosted?

      (ii) Controls the MAP in the climb/descent?

   (i) Describe the propeller governing system; and

   (j) If the oil pressure to the propeller dome is lost, does the propeller go into coarse or fine pitch?

Airframe

9. Answer the following:

   (a) What type is the undercarriage system (fixed/retractable/tricycle/conventional)?

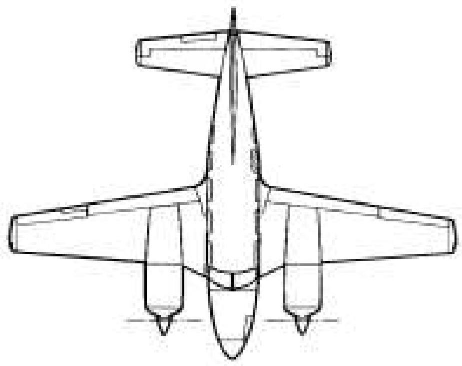
   (b) Which control surfaces can be trimmed?

   (c) Describe the flap actuating system;

   d) Describe the flap indicating system;

   (e) What is the flap operating range?

   (f) Sketch the location of all exits;



   (g) Describe/sketch the location of:

      (i) Landing/taxi lights;

      (ii) Fresh air intakes; and

      (iii) Fuel caps;

   (h) What is the wingspan of the aeroplane?

Ancillary Systems

10. Answer the following questions:

(a) What systems are hydraulically operated?

(b) What procedures are followed when a hydraulic system failure is suspected?

(c) How many brake applications would be expected from a fully pressurised brake accumulator (if applicable)?

(d) What are the sources of electrical power?

(e) What is the DC system voltage?

(f) Can an external power source be used?

(i) If so, what is the procedure?

(g) Where are the battery and external power receptacle located?

(h) How long can the battery supply emergency power?

(i) Following an alternator/generator failure in flight, which non-essential electrical services should be switched off?

(j) Which, if any, ancillary system(s) would be lost if the left engine is shut down and the propeller feathered?

(k) Which, if any, ancillary system(s) would be lost if the right engine is shut down and the propeller feathered?

(l) If a stall-warning device is fitted, is it electrical or mechanical?

(m) How is the cockpit ventilated?

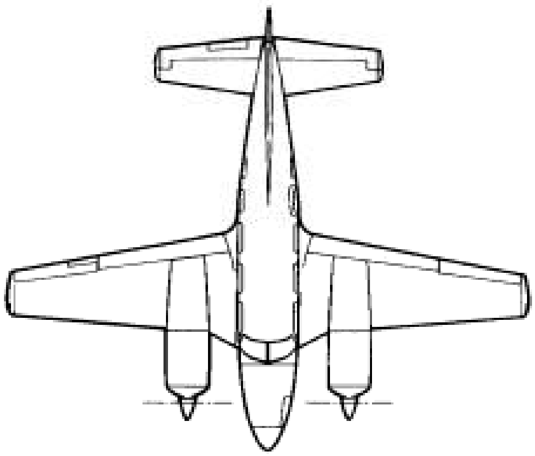
(n) How is the cockpit heated?

(o) If a fuel-burning heater is installed, describe the method used to turn the heater on and off, and detail any limitations;

(p) What is the fuel consumption of the heater?

(q) Describe the pressurisation system (if applicable);

(r) Show the location of the following safety equipment:
 (i) fire extinguisher;
 (ii) Emergency locator transmitter (ELT);
 (iii) Torches;
 (iv) Survival equipment; and
 (v) First aid kit.



(s) Explain all the methods of disengaging the autopilot;

(t) Under what conditions will the autopilot automatically disengage? and

(u) Explain how an electrical trim can be over-ridden if it runs away.

Flight Instruments

1. Answer the following questions:

   (a) Where are the pitot head(s), static vent(s) and any water drain points for the pitot/static system located?

   (b) Is there a pitot heat system fitted?

   (c) Is there an alternate static source fitted? - if so:

      (i) Where is this located?

      (ii) What is the purpose of this system?

      (iii) If used, what effect does it have on the pressure instruments?

   (d) Which flight instruments are operated electrically?

   (e) Which flight instruments are gyroscopically operated?

   (f) Which instruments are operated by vacuum?

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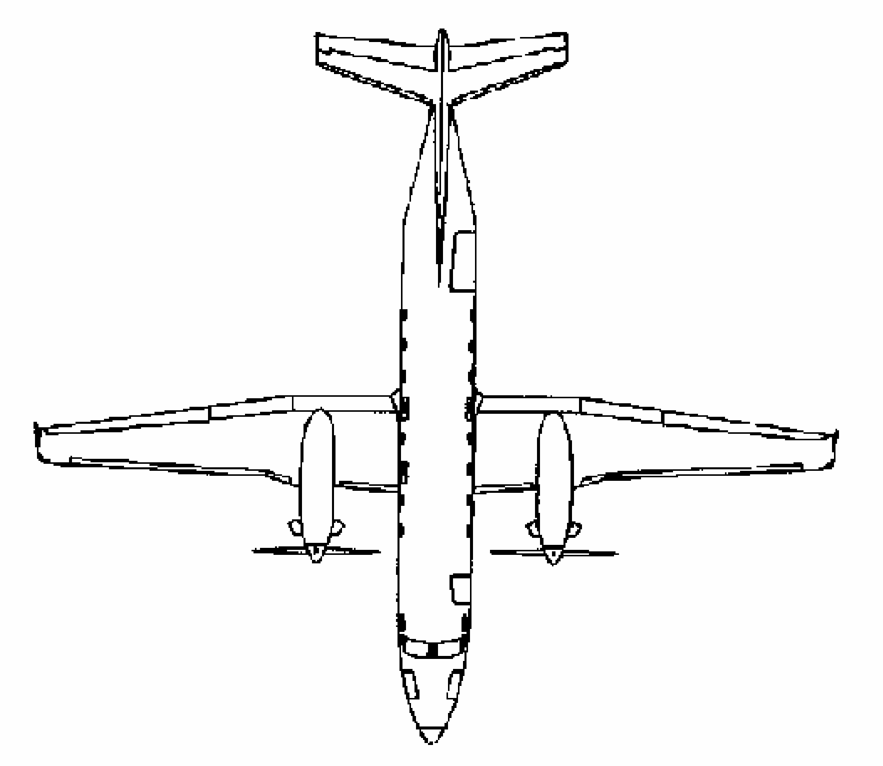
Appendix E to CAAP 5.23-2(0)

MULTI-ENGINE TURBO-PROP AEROLANE ENDORSEMENT



ENGINEERING, DATA AND PERFORMANCE QUESTIONNAIRE

FOR____
(Aeroplane make & model)

Version 2 -April 2007

Name: **ARN.**_____________

Endorser: **ARN:**_____________

(Signature/Name)

The endorsement questionnaire

To qualify for an aeroplane endorsement you must be able to fly the aeroplane to an acceptable standard and demonstrate a level of knowledge which satisfies the Endorser that you have completed '*training in the operating limitations, procedures and systems of the type of aeroplane for which the endorsement is sought' Civil Aviation Order (CAO) 40.1.0*, paragraph 4.3 Note 1).

This questionnaire will assist you to fully satisfy these knowledge requirements, thereby enhancing safety and reducing industry costs.

The questionnaire will also be a useful ready reference for you in the future, particularly if you do not fly regularly.

In any case, the Civil Aviation Safety Authority (CASA) recommends that both you and your instructor retain a copy of the questionnaire for at least 12 months as proof of completion of training.

How to answer these questions

You should use references such as Flight Manuals, Pilot Operating Handbooks (POH) and theory texts, and make liberal use of notes and sketches on the applicable questionnaire page.

To assist you, the layout of the questionnaire corresponds to the sections of most POH.

Some of the questions may not apply to the aeroplane type on which you are being endorsed you should mark these 'N/A' (not applicable).

The questionnaire is comprised of 17 pages and may be copied.

General Aircraft Data

1. (a) What is the make, type and model of the aeroplane?

   (b) In which category (categories) is the aeroplane permitted to fly?

Airspeed Limitation

2. List the applicable airspeed for the aeroplane type:

   (a) V_{NO} (normal operating)

   (i) $V_{MAX\ X/W}$ (maximum crosswind);

   (ii) V_A (design manoeuvre speed);

   (iii) V_X (best climb angle);

   (ix) V_S; (stall speed)

   (x) V_Y (best climb rate); and

   (xi) V_{FE} - flap extension.

   Add: Vmca

   (b) V_B Turbulence penetration speed:

   (i) V_{LO}, (landing gear operation up);

   (ii) V_{LE} (landing gear extended);

   (iii) V_{LO2} (landing gear operation down); and

   (iv) $V_{NE.}$ (never exceed speed).

   (c) Maximum landing light operating speed;

   (d) Maximum load factor (flaps up) is + g and - g; and

   (e) Maximum load factor (flaps down) is + g and - g.

Emergency Procedures

3. Detail the emergency procedures for the following situations if applicable:
   (a) Engine fire on the ground;

   (b) Engine failure after take-off,

   (c) Engine failure in the cruise;

   (d) Engine fire airborne;

   (e) Electrical fire on the ground;

   (f) Electrical fire in flight;

   (g) Cabin fire in flight;

   (h) Rapid depressurisation;

   (i) The optimum glide speed for the aeroplane is _______kts;

   (j) Propeller over-speed; and

   (k) Emergency under-carriage extension.

Normal Procedures

4. State, describe or detail:
   (a) The cruise power setting, indicated air speed (IAS) and fuel flow for the aeroplane;

   (b) The climb power setting, IAS and fuel flow for the aeroplane;

   (c) A typical power setting, true air speed (TAS) and fuel flow at 20000 ft pressure height; and

   (d) Using the aeroplane flight manual, calculate the endurance for the aeroplane at 5000 ft above mean sea level (amsl) international standard atmosphere (ISA) with endurance power set.

Weight and Balance and Performance

5. Specify the correct values of:

(a) The maximum ramp weight;

(b) The maximum take-off weight;

(c) The maximum landing weight;

(d)The maximum zero fuel weight;

(e) The maximum number of adult persons on board (POB);

(f) The maximum baggage weight; and

(g) The maximum fuel which can be carried with a full load of adult passengers (80 kg/person) and maximum baggage weight.

Add:
Max. (lateral) fuel asymmetry?

Do any of the weight limitations in (a) to (g) vary between categories?If so, what are the weight limitations of each category?

(j) Using the aeroplane flight manual, and a typical loading problem posed by the endorser, determine the take-off weight and balance solution (maximum take-off weight and centre of gravity (CG) position), the amount of fuel that can be carried and the endurance;

(k) Calculate the take-off distance required at maximum take-off weight, 2500 ft (amsl) and outside air temperature ~~(CG)~~ 30° C; and

Fuel System, Fuel and Fluids

6. State, describe or sketch on the aircraft diagram:
   (a) The correct grade of fuel;

   (b) Any approved alternate fuel;

   (c) The location of fuel tanks and drain points;

   (d) The total and usable fuel in each tank;

   (e) The position of the fuel tank vents;

   (f) Where the fuel boost/auxiliary pumps are located;

      (i) When should these pumps be used?

   (g) If applicable, the fuel tank change procedure;
      (i) What conditions apply to tank selection for take-off and landing?

   (h) When refuelling to less than full tanks, what restrictions apply and how is the quantity checked?

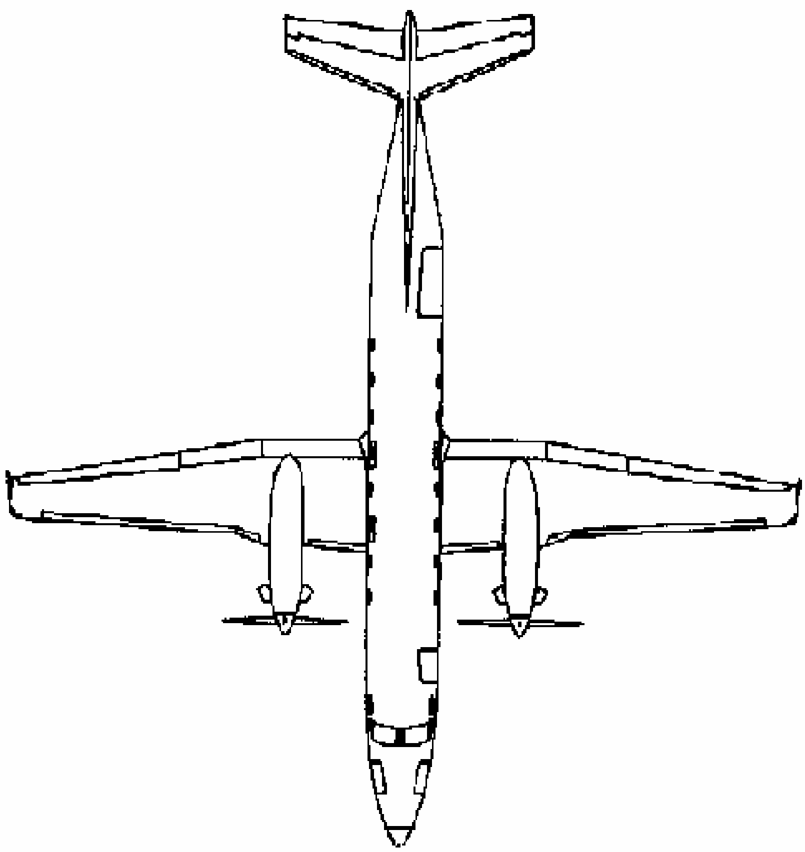
(i) If applicable, describe the cross feed system;

(j) If applicable, the minimum and normal hydraulic fluid capacity;

(k) The correct grade of oil for the aeroplane;

(l) The minimum oil quantity before flight; and

(m) The maximum quantity of oil.



Asymmetric Performance

7. Answer the following questions:

   (a) What IAS is V_{MCA} in the take-off configuration?

   (b) What effect will full flap have on V_{MCA}?

   (c) What IAS is V_{SSE}?

   (d) What is the TAS and fuel flow rate with one engine shut down at 1000 ft and 10000 ft amsl on an ISA day?

   (e) What is the rate of climb with one engine shut down, propeller feathered, maximum all up weight (AUW), 1000 ft amsl, take-off power, undercarriage and flap retracted, on an ISA day?

      (i) On an ISA +20° C day?

Effect of critical engine is included in Vmca.
The effects of variables that are under control of the pilot are not included in Vmca. Ask about these.
Refer to the note on page 69.

   (f) Which engine is the critical engine?

Replace: What is the effect on Vmca of bank angle, weight, cg, engine power.

   (g) What is the single engine rate of climb speed (V_{YSE}) ?

   (h) How does single engine flight affect the range of the aeroplane?

Turbine Engine

8. Answer the following questions:
   (a) What is the type and number designation of the engines?

   (b) What is the shaft horse-power (SHP) of the engines?

   (c) Maximum inter-stage turbine temperature (ITT) turbine outlet temperature (TOT) on:
      (i) Start;

      (ii) Take-off,

      (iii) Climb;

      (iv) Maximum continuous power;

      (v) Idle;

      (vi) Reverse; and

      (vii) Transient;

   (d) Maximum N_g (N_1) on take-off,

   (e) Maximum propeller speed N_p (N_2) on take-off/climb;

   (f) Max torque on:
      (i) Take-off,

      (ii) Climb;

(iii) Maximum continuous power;

(iv) Idle;

(v) Reverse; and

(vi) Transient.

(g) What is the in flight minimum power limit?

(h) Starter cycle limitations:

(i) Seconds on minutes off;

(ii) Seconds on minutes off; and

(iii) Seconds on minutes off.

(i) What oil pressure illuminates the warning light if fitted?

(j) Before shutdown, the engine must run at or below ______°C ITT for ________________(minutes/seconds).

(k) What is the critical/prohibited revolution per minute (RPM) range and what limitations apply in this range?

(l) What are the manual ignition time limits?

(m) When should the anti-icing be activated?

(n) What is the purpose of the over-speed and under-speed governor and what are the settings/range of the governor?

(o) What is the auto-ignition and when is it used?

(p) What are the settings of the condition lever, and what is the purpose of each setting?

Propellers

9. Answer the following questions or describe:

(a) The propeller system in general;

(b) What is the BETA mode and range?

(c) Over what RPM range in flight does the propeller governor operate?

(d) How is an over-speed/under-speed prevented?

(e) What drives the blade into:

(i) fine pitch?

(ii) coarse pitch?

(iii) reverse? and

(iv) feather?

(f) What precautions apply to propeller operations both in the air and on the ground?

(g) How does the auto-feather system feather the propeller?

(h) What is the purpose of the Negative Torque Sensing System (NTS)?

(i) What indications show that the propeller is in the NTS range? and

(j) What actions would correct this unfavourable NTS situation?

Airframe

10. Answer the following:

(a) What type is the undercarriage system? (fixed/retractable) (tricycle/conventional)?

(b) Which control surfaces can be trimmed?

(c) How are the flap systems activated?

(d) Describe the flap indicating system.

(e) What is the flap operating range?

(f) Sketch the location of all exits on the diagram on page 133;

(g) If a fuel burning heater is installed, describe the method used to turn the heater on and off and state any limitations;

(h) What is the fuel consumption rate of the heater?

(i) Describe/sketch the location of.

(i) Landing/taxi lights;

(ii) Pitot heads;

(iii) Fresh air intakes;

(iv) Fuel caps; and

(j) What is the wing span of the aeroplane?

Ancillary Systems

11. Answer the following questions:

(a) What systems are hydraulically operated?

(b) What procedures are followed when a hydraulic system failure is suspected?

(c) What provision is there for emergency hydraulic systems?

(d) How many brake applications would be expected from a fully pressurised brake accumulator (if applicable)?

(e) What are the sources of electrical power?

(f) What is the DC system voltage?

(g) Where are the battery and external power receptacle located?

(h) How long can the battery supply emergency power?

(i) Can an external power source be used?

(j) Which, if any, ancillary system(s) would be lost if the left engine was shut down and propeller feathered?

(k) Which, if any, ancillary system(s) would be lost if the right engine was shut down and propeller feathered?

(l) Following an alternator/generator failure in flight, which non essential electrical equipment should be switched off?

(m) How is the cockpit ventilated?

(n) How is the cockpit heated?

(o) Describe the pressurisation system (if fitted);

(p) What is the maximum permitted cabin pressure?

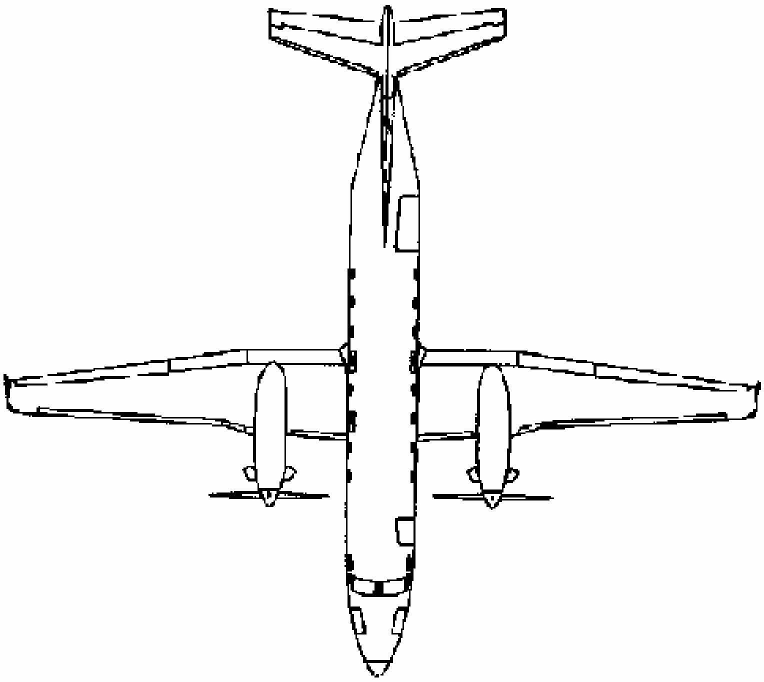
(q) Explain all the methods of disengaging the autopilot.

(r) Under what conditions will the autopilot automatically disengage?

(s) Explain how an electrical trim can be overridden if it runs away; and

(t) What are the symptoms of, and dangers associated with an outlet valve which is jammed closed? and

(u) Show the location of the following safety equipment:
- (i) Fire extinguisher;
- (ii) Emergency locator transmitter (ELT);
- (iii) Torches; and
- (iv) Survival equipment.



Flight Instruments

12. Answer the following questions:
    (a) Where are the pitot head(s), static vent(s) and any water drain points for the pitot/static system located?

    (b) What type of pitot heat system is fitted to the aeroplane?

    (c) Is there an alternate static source fitted? - if so;
        (i) Where is this located?

        (ii) What is the purpose of this system?

        (iii) If used, what effect does it have on instruments?

    (d) What instruments and gauges are alternating current (AC) powered?

    (e) What instruments and gauges are direct current (DC) powered?

    (f) What is the limit of generator reset attempts?

    (g) At what temperature will the battery overheat light illuminate?
        (i) If illuminated, what action is required?

    (h) What does the auxiliary battery provide power for?
        (i) How is an inverter failure indicated?

End of Questionnaire: Satisfactorily completed on / /