

NATIONAL TRANSPORTATION SAFETY BOARD

Office of Aviation Safety
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July 30, 2020

Attachment 5 – Envoy Airplane Operations Manual [Excerpts]

OPERATIONAL FACTORS

DCA20CA038



EMB-140/145

Aircraft Operating Manual Volume 1



Revision - 12

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Cruise Procedures

Cruise Altitude, Speed and Routing Determination

Altitude

The flight release is normally based on the optimum cruise altitude and speed for planned fuel consumption within the scheduled flight block time. This computed fuel burn is based on certain assumed conditions for minimum time, minimum cost or minimum fuel. These include takeoff gross weight, cruise altitude, route of flight, temperature, wind enroute and cruise speed. The Flight Planning System also considers turbulence in the planning process.

The actual fuel burn can increase due to:

- Temperature above planned
- A lower cruise altitude than planned
- Actual speed faster than planned or appreciably slower than long range cruise speed when long-range cruise was planned
- Stronger headwind component
- Unbalanced fuel
- Improperly trimmed aircraft
- Excessive thrust lever adjustments

Approximate cruise fuel penalties include:

- ISA + 5°C: 1% increased fuel flow from standard ISA
- ISA - 5°C: 1% decreased fuel flow from standard ISA
- Above FL210, every 1,000 ft increase in altitude reduces fuel burn by approximately 80 pph
- An increase of .01M above Flight Plan increases fuel burn by 1%
- Anti-ice ON increases fuel flow by 8%

If the actual cruise altitude is significantly lower than the planned altitude, fly at Long Range Cruise speed schedule. When ahead of schedule or when anticipating arrival delays, operation at Long Range Cruise speed schedule will reduce enroute fuel burn.

Reduced Vertical Separation Minimum (RVSM)

(Title 14 CFR 91.180, 91.706, and Appendix G to Part 91)

General

RVSM operations reduce the minimum vertical separation from 2,000 ft. to 1,000 ft. between FL 290 and FL 410.

Limitations

RVSM Required Equipment List	
Equipment	Required for RVSM
Autopilot with an operative Altitude Hold Mode(1)	Must be operational.
Altitude Alerting System	Must be operational.
Altitude Reporting Transponder (2)	One (1) must be operational.
Operationally Independent Primary Altimeters(2)	Two (2) must be operational.

Emergency/Abnormal

If any of the required equipment fail prior to the aircraft entering RVSM airspace, request a new clearance to avoid entering the RVSM airspace.

In case of emergency or abnormal situations or contingencies such as equipment failure, weather, etc. which affect the ability to maintain the cleared flight level, notify ATC to coordinate the appropriate action.

Notify ATC when encountering greater than moderate turbulence.

If unable to notify ATC and obtain an ATC clearance prior to deviating from an assigned Flight Level, follow the applicable E/A Procedure and obtain an ATC clearance as soon as possible.

Workload permitting, ATC may issue a clearance above FL 280 to aircraft that are not RVSM capable. If operating a non-RVSM aircraft above FL 280, the term "Negative RVSM" must be included upon contact with ATC when:

1. Contacting another controller
2. Requesting another FL within RVSM airspace
3. Vacating one FL for another within RVSM airspace

Preflight

Particular attention should be paid to the condition of static sources and to the marked area on the fuselage skin near each primary static source.

Before Takeoff

The maximum difference between ADC altimeters should not exceed 50 ft.

During normal operations when flying with the autopilot coupled to the ADC 1 in conjunction with Transponder 2 (or ADC 2 in conjunction with Transponder 1), the altitude difference between the two ADC, may be observed by ATC as a discrepancy between the assigned altitude and the actual altitude which can add to the total altitude error. To prevent this, use ADC 1 in conjunction with Transponder 1 and ADC 2 in conjunction with Transponder 2.

Cruise

All required equipment must remain in proper operating condition.

Ensure that the aircraft is flown at the cleared flight level and that ATC clearances are fully understood and followed. Do not depart from the clearance flight level without a positive clearance from ATC except for an emergency situation.

While changing flight levels, do not overshoot or undershoot the cleared flight level by more than 150 ft.

The autopilot shall be operative and engaged during level cruise, except for circumstances such as the need to re-trim the aircraft, or when it must be disengaged due to turbulence.

After Landing

In case of required system malfunction or failure, the following should be recorded as applicable:

- Primary and standby altimeter readings.
- Altitude selector setting.
- QNE setting.
- Flight Director used with the autopilot to control the aircraft and any differences when the other Flight Director was coupled.
- Use of air data computer selected.
- The transponder selected to provide altitude information and any differences noted when the alternate transponder was selected.

Turbulent Air

General

When entering an area of turbulence, secure all loose equipment. Shoulder harnesses will be worn. The recommended technique for flight in turbulence is as follows.

Airspeed

Flight through severe turbulence should be avoided if possible. When unavoidable, observe the recommended target airspeed for turbulence penetration of 250 kts. or 0.63 Mach, whichever is lower. (At or below 10,000 ft. - 200 kts.) These speeds allow greater latitude of speed reduction while providing the maneuvering and structural limit margins.

These speeds are for severe turbulence. Most turbulence encounters at high altitudes are not severe and do not require an airspeed reduction. There is very little to be gained from reducing airspeed at high altitudes in moderate turbulence. Also, aircraft control is better at the higher Mach numbers and less time is spent in the turbulent area.

Severe gust or drafts will cause large and often rapid variations in IAS. Do not "chase" airspeed in an attempt to hold recommended speed.

Altitude

Large altitude variations are possible in severe gust or drafts; but do not "chase" altitude. Allow it to vary, that is, sacrifice altitude in order to maintain desired attitude. Descend, if necessary, to improve buffet margin.

Attitude

Hold wings level and the desired pitch attitude, using the PFD as the primary instrument. In extreme drafts, large attitude changes may occur. Do not use sudden or large control inputs, instead, use moderate inputs to resist changes in attitude. Maintain pitch attitude with elevator. After establishing the trim setting for penetration speed, do not change stabilizer trim.

Trim the aircraft for the required speed, after that, do not change stabilizer position. Control the aircraft with the elevator. Avoid large elevator inputs.

Engine Control

Flight in moderate to heavy rain, hail, sleet, and turbulence could adversely affect engine operation, especially at lower engine power levels. If encountered, the FAA recommends that for most turbofan engine applications, maintaining an increased minimum thrust setting will improve engine tolerance to water and hail ingestion.

Thrust Lever movements should be minimized. Thrust changes made in the midst of extremely heavy precipitation should be made slowly and the engine stabilized at the selected thrust setting prior to reversing the thrust lever direction.

Ignition System

During moderate or greater turbulence or heavy precipitation, turn the ignition switch to ON to reduce the possibility of engine flameout due to interrupted airflow.

Passenger/Flight Attendant(s) Considerations

Notify the Flight Attendant(s) before, or shortly after entering areas of turbulence. This is done to aid the Flight Attendant(s) in planning their activities.

In light turbulence, turn the FASTEN SEATBELT Sign ON and make a PA advising passengers of the turbulence.

If the turbulence is greater than light, make a PA advising the passengers to fasten their seatbelts snugly. Advise the Flight Attendant(s) on the interphone to check the passengers seatbelts and then be seated. After passing through the area of turbulence, make a PA advising passengers the flight is clear of turbulence and the FASTEN SEATBELT Sign may be turned OFF.

Windshear

General

Avoidance is the First Rule.

Avoid areas of known severe windshear. PIREPS of windshear in excess of 20 kts. or 500 FPM climb or descent, below 1,000 ft. AFL, are a good indication of such areas. However, the Captain must consider the time elapsed since the report and the change in reported or observed (radar or visual) weather.

Microbursts in particular can create severe windshear conditions, but these conditions develop, change and dissipate rapidly.

The most dangerous form of windshear is a convective microburst. Some have been documented with wind changes in excess of 150 kts. Because Microbursts intensify for several minutes after they first impact the ground, the severity may be twice that which is initially reported.

Search for clues which may indicate the presence of severe windshear. Severe windshear has been encountered under the following conditions:

- Thunderstorm and convective clouds
- Rain and snow showers
- Frontal Systems
- Low altitude jet streams
- Strong or gusty surface winds

Takeoff

When positive indications of severe windshear exist, delay takeoff until conditions improve.

When conditions are such that moderate windshear may be encountered, even though not reported, the following precautions are recommended:

- Use Maximum Rated Takeoff Thrust.
- Use the longest suitable runway.
- Maximize available margins between V_R and stick pusher through runway selection, flap selection and delayed rotation. The delayed rotation speed must not exceed either:
 - The runway weight limit V_R speed or a 20 kts. increase whichever is less. For example, if the actual gross weight is 45,000 lb. and the runway limit is 48,000 lb., rotate at the V_R speed which corresponds to the runway limit of 48,000 lb. Do not set the reference speed bug to the increased V_R .
- If windshear is encountered at or beyond the actual gross weight V_R , do not accelerate to the increased V_R , but rotate without hesitation. In all cases, rotation must commence no later than 2,000 feet from the end of the runway.

Landing

When positive indication of windshear exist, avoid the areas by:

- Diverting around the areas.
- Go-around and/or delay approach until conditions improve.

When conditions are such that moderate windshear may be encountered, even though not reported, the following precautions are recommended:

- Add an appropriate airspeed correction.
- Select longest runway available that avoids areas of suspected windshear.
- Use the autopilot for the approach to provide more monitoring and recognition time.
- Avoid large thrust and/or trim changes in response to sudden airspeed increases (headwind shear), do not bring the thrust levers back to idle.

Identifiers of Dry Microbursts

- PIREPS

CAUTION

Actual windshear may be up to twice as severe as PIREP.

- LLWAS – Detects microbursts within 2 1/2 miles of the airport.
- VIRGA – Weak precipitation areas that do not reach the surface.
- TURBULENCE – Moderate or greater turbulence may be associated with the outflow from a microburst.
- VISUAL CUES – Blowing dust, rings of dust, dust devils or other tornado-like features, and other evidence of strong local outflow near the surface.
- AIRBORNE WEATHER RADAR – Indications of weak (green) cells with bases from 5,000 to 15,000 ft. AGL which indicate weak precipitation, usually virga.
- WINDSHEAR FORECAST – Potential for convection; mid-level moisture, very dry surface condition, 30° - 50°F temperature/dewpoint spread.

Identifiers of Wet Thunderstorm Microbursts

- PIREPS

CAUTION

Actual windshear may be up to twice as severe as the PIREP.

- LLWAS – Detects microbursts within 2 1/2 miles of the airport.
- THUNDERSTORMS – In addition to the well-known hazards of thunderstorms, an estimated 1% of thunderstorms contain embedded microbursts.
- TURBULENCE – Moderate or greater turbulence may be associated with the outflow from a microburst.
- VISUAL CUES – Heavy rain, lightning, blowing dust, rings of dust, dust devils, and other tornado-like features and other evidence of a strong local outflow.

CAUTION

Visual cues may be obscured by low visibilities in wet thunderstorm microburst situations.

Engines

Engine Starts

Quickly moving the Engine Start/Stop selector from STOP to START without a pause in the RUN position can trigger a subsequent on-ground shut down that may take place during the current ground operation or during ground operations related to subsequent flights. Embraer recommends that pilots hold the Start/Stop selector in the RUN position for two seconds before moving the selector to the START position.

Ignition ON

The ignition selector should be ON:

- Prior to engine start below 5°C SAT when the engine has not run in the past 90 minutes (i.e., the SAT and the engine are both cold).
- After encountering any start difficulties. Return the ignition selector to the appropriate position for the operating conditions after the start attempt.
- Prior to takeoff on a runway with standing water, ice or snow present (including contaminated runways).
- As directed by an Emergency/Abnormal/Normal checklist or procedure.
- During moderate or greater turbulence or heavy precipitation.
- When the flight crew deems it necessary.

Engine Starter Valve Manual Operation

When ready to start:

Hydraulic Pumps BOTH OFF
Pack 1 and 2 OFF

Direct Maintenance Personnel to open Engine Start valve.

NOTE

An EICAS E1 (2) ATS SOV OPN caution message will be presented above 53% N₂ when the Starter Valve is manually still open.

ENGINE START procedure [NORMALS] ACCOMPLISH

At approximately 56.4% N₂:

Direct Maintenance Personnel to manually close the Start Valve.

Verify that the E1 (2) ATS SOV OPN caution message is extinguished.

After the engine has stabilized at idle RPM, complete the After Start Checklist.

Weather Radar

General

This section provides operational procedures and techniques for the weather radar system. More detailed information regarding the specific functions and operational modes can be found in *EMB-140/145 AOM Volume 2, Warnings & Alerts*.

The weather radar utilizes a 12 inch antenna which corresponds with an 8° beam width (4° either side of the center of the beam).

To determine the size of the radar beam in feet at a given distance, a rule of thumb is that **each degree corresponds to 100' per NM**. Using this formula, an 8° beam covers 800' per NM (400' either side of center).

Example 1: $50 \times 800 = 40,000'$, meaning that the radar beam at 50NM is depicting a 40,000' diameter of radar returns (20,000' radius from the center of the beam).

Example 2: If the radar tilt is +2, 6° of the beam will be above the horizon and 2° below the horizon. 2° equals 200' beam width per nm, so $200 \times 50\text{NM} = 10,000'$, meaning that the radar is showing 10,000' below the aircraft and 30,000' above

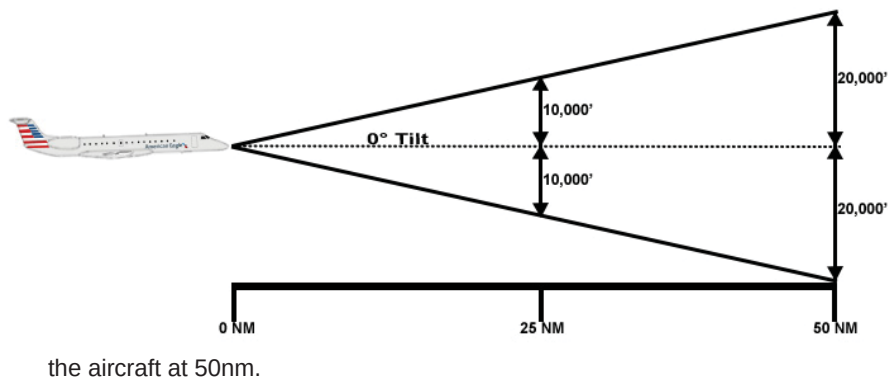


Figure - 1
Radar Beam

Theory

Radar is an acronym which stands for RAdio Detection And Ranging. Any radar system is used to determine distance, direction and reflectivity of an object (radar target). When used for weather-related purposes, an airborne radar is essentially a water detector, used to display where liquid water is located and its intensity. "Dry" precipitation, such as dry hail or ice crystals, is a poor reflector of radar energy and therefore the depicted radar image will generally be less intense than the actual conditions (if depicted at all).

WARNING

Dry hail and ice crystals can be prevalent at higher altitudes. They may not be detected since their radar reflective return is poor.

One of the most important things to remember when operating the weather radar is what you see on your display is limited to the targets that fall within the sweep of the radar beam.

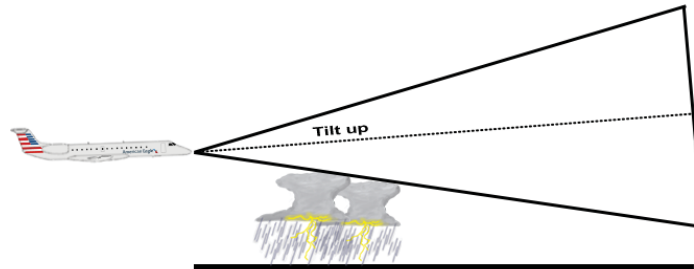


Figure - 2
Radar Tilt Example (Storms would not be visible on the display)

Airborne radar is calibrated to display a “weighted” return depending on calibrated rainfall rates. It is therefore important to always try to tilt to ensure the heaviest rainfall in the storm is encompassed by the radar beam. For example, a calibrated magenta return will be weighted much more than a yellow return. This should mean that the most severe weather will always be displayed even if it is within a comparatively small percentage of the radar beam. However, if the radar beam is sensing mostly green and yellow returns with a small amount of red (possibly due to improper tilt setting), you may only see yellow on the display, even though stronger returns were sensed.

Operating Modes

More detailed information regarding the specific functions and operational modes can be found in *EMB-140/145 AOM Volume 2, Warnings & Alerts*.

Off (OFF)

Radar system is completely powered off.

Standby Mode (SBY)

The Standby Mode should be selected when it is desired to keep the system powered without transmitting.

Forced Standby Mode (FSBY)

The Forced Standby Mode is an automatic, non-selectable radar mode, that forces the radar into standby when the aircraft is on the ground (weight on wheels logic) regardless of the selected active radar mode.

The Forced Standby Mode may be overridden on the ground by slowly pressing the STAB button four times in three seconds.

CAUTION

The transmitter is turned on if the FSBY mode is overridden on the ground and any active radar mode is selected. The radar must not be operated under this condition while refueling, near fuel spills, or near people.

Weather Detection Mode (WX)

This position selects weather detection mode. The system is fully operational and all internal parameters are set for enroute weather detection.

Ground Mapping Mode (GMAP)

The GMAP position puts the radar in the ground mapping mode. The system is fully operational and all parameters are set to enhance returns from ground targets. Do not use GMAP mode for weather detection.

NOTE

REACT or TGT modes are not selectable in GMAP.

Flight Plan Mode (FP)

The FP position puts the radar system in the flight plan mode. This clears radar data from the display to allow long range map information. The radar transmitter will not be active unless TGT mode is selected.

TEST Mode (TST)

The TEST Mode may be selected after the radar warm-up period is over. If the first page announces "RADAR OK" the radar is ready for use.

WARNING

In the test mode, the transmitter is on and radiating X-band energy.

NOTE

If weather is in the vicinity of the departure airport, a radar test may be completed once clear of the terminal area.

Receiver Gain (GAIN)

The GAIN knob is a rotary control and a push/pull switch that controls radar receiver gain. Two gain modes are available: calibrated or variable.

Calibrated: The receiver gain is preset and calibrated when the GAIN knob is pushed in, which is the normal mode of operation. The rotary function of the GAIN knob is disabled in calibrated gain.

Variable (VAR): The system enters the variable gain mode when the GAIN knob is pulled out.

NOTE

The system will be forced into calibrated gain when REACT or TGT modes are selected.

CAUTION

Variable gain may be used only for short periods of time. Do not leave the radar in variable gain since significant weather targets may not be displayed.

Tilt Management

Tilt Management is crucial to the safe operation of the weather radar. If improperly managed, weather targets can be missed or underestimated. Remember that the total reflection from a thunderstorm is solely based on the energy returned from all reflectors in the radar beam. Therefore, if the majority of a storm is outside of the radar beam, the radar will not accurately reflect the severity of the storm.

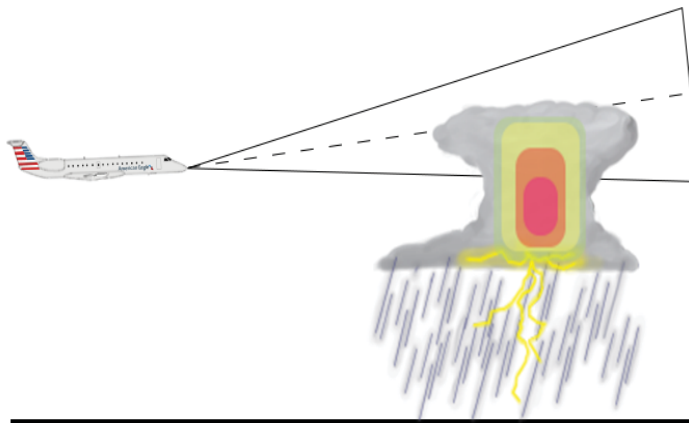
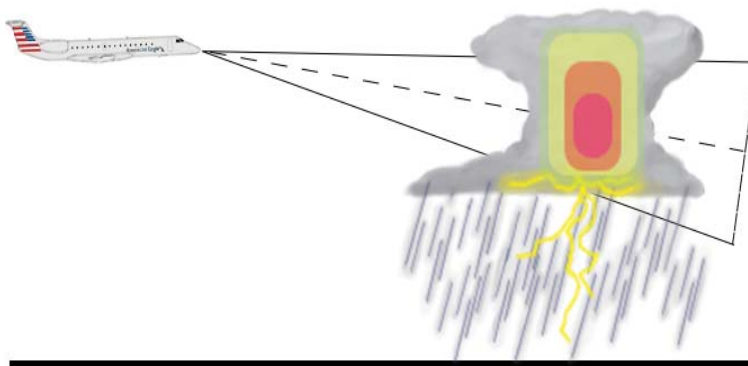


Figure - 3



Radar image would indicate a weak return

Figure - 4

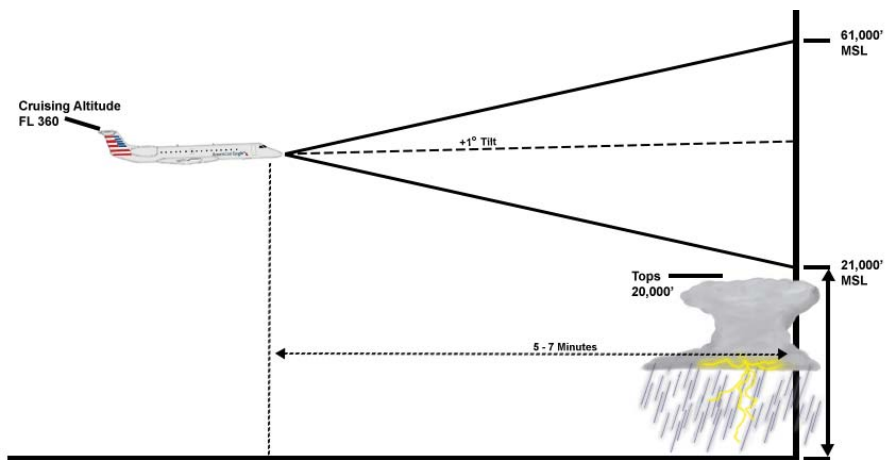
Radar image would indicate a calibrated (correct) return

Severe Turbulence Avoidance

One significant contributor in severe turbulence encounters is overflying

convective activity. Thunderstorms can build at rates in excess of 5,000'/min or more, therefore it is extremely important to tilt downward when flying in the vicinity of convective activity. The images below represent a severe turbulence encounter experienced by an Envoy EMB-145 which was flying in clear skies over the top of convective activity. The radar was tilted up 1°, therefore the rapidly building storm beneath them was not depicted. The tops of the thunderstorms were near 20,000' approximately 6 minutes prior to the severe turbulence event and grew over 2500'/min until the tops were at 35,000' at the time of the severe turbulence.

Figure - 5



Depiction of conditions approximately six minutes prior to the severe turbulence event

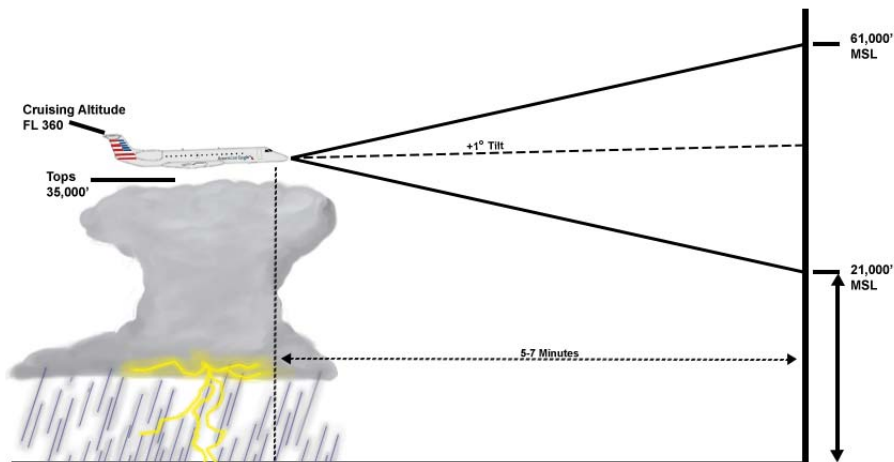


Figure - 6

Depiction of conditions at the time of the severe turbulence event

Tilt Management must be performed when flying at low altitudes or approaching for landing by vertically sweeping from up to down to avoid flying above or below a storm line.

Prior to initiating the takeoff roll, if precipitation is in the aircraft's departure path, pilots should consider adjusting the tilt upwards to a climb angle. If time permits, disabling forced standby and allowing the radar to make several sweeps may provide valuable planning information for the initial climb.

Radar Shadows

When tilt is properly managed, radar shadows are an easy way to recognize and avoid hazardous storms. Cities do not cast shadows, but they can present considerable reflective returns. Identify potential shadows and subsequently look for significant returns just prior to those shadows to differentiate the source of the target.

Airspeeds

General

The airspeed limitations are given in KIAS and when appropriate, Mach number. When both KIAS and Mach values are given, the limiting value is the lower of the two.

Flight Envelope

Maximum Allowable Airspeeds		
Pressure Altitude (ft.)	KIAS	Mach
SL	250	.50
10,000	320	.78
26,000	320	.78
30,000	296	.78
35,000	261	.78
37,000	250	.78

Maximum Allowable Airspeeds

Limitation	Abbreviation	Limitation
Maximum Operating	V_{MO}/M_{MO}	320/.78 (1)
Maximum Operating (KIAS) 8,000 to 10,000 Pressure Altitude (ft.)	V_{MO}	Red Line (1), (2)
Maximum Operating (KIAS) - up to 8,000 Pressure Altitude (ft.)	V_{MO}	250 (1)
Maximum Turbulence Penetration	V_B/M_B	250/.63 whichever is lower. 200 at or below 10,000 ft.
Maximum Maneuvering	V_A	200 (3)
Landing Gear Extension	V_{LOE}	250
Landing Gear Extended	V_{LE}	250
Landing Gear Retraction	V_{LOR}	200
Flap Placard Speeds		
9°	V_{FE}	250
18°	V_{FE}	200
22°	V_{FE}	200
45°	V_{FE}	145*
Maximum Wiper Operating	-	160

CAUTION

1. Do not deliberately exceed V_{MO}/M_{MO} in any regime of flight (climb, cruise or descent).
2. V_{MO}/M_{MO} increases linearly from 250 kts. at 8,000 ft. to 320 kts. at 10,000 ft. Do not deliberately exceed red line.
3. Full application of rudder and ailerons, and maneuvers involving angle of attack near stall, must be confined to speeds below V_A .

4. A full or nearly full rudder deflection in one direction followed by a full or nearly full deflection in the other direction, even at speeds below the design maneuvering speed, can dramatically increase the risk of structural failure of the vertical stabilizer or the rudder.

NOTE

- *Momentary airspeed excursions that are due to wind gusts or turbulence are allowed up to 155 kts. with no crew or maintenance action required.
- *Steady state operation over 145 kts. is not allowed and must be entered into the AML.

Minimum Control Speeds

V_{MCG} Envoy V_1 speeds are always higher than V_{MCG}
 V_{MCA} Envoy V_R speeds are always higher than V_{MCA}
 V_{MCL} Envoy V_{REF} speeds are always higher than V_{MCL}