Descent Energy Management

Guide to Descent Planning
and Energy Management
for civil airliners

Featuring the Boeing 737-800
Update December 30th, 2017

by
Captain Eric Goossens

BOEING 737-800 Descent and Energy Management Guide

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For feedback, contact & updates: www.descentmanagement.com

Written by Capt. Eric Goossens, Belgium.

Chapter 1: Introduction and Motivation…

Welcome

Dear colleagues, this is a practical guide by pilots and for pilots and a few rules of thumb on how to improve your descent-profile awareness and manage the energy of your aircraft concerning descent and approach during the actual daily airline-flying on our B737-800:

"Your FMC does not solve all your problems all the time…."

Objective

The objective of this guide is to improve and apply knowledge on:

Descent Planning

- Plan, follow-up and correct an actual descent: improved situational awareness (SA)
- Predict if your descent-corrections make sense and adapt them.
- Predict and avoid High Energy Approaches (HEA) and Go Around: safer flight.
- Predict aircraft behaviour before descent and in an actual descent.

Descent Follow-Up

- Correct vertical profiles instantly before adapting the FMC = "fly the aircraft first".

Use of Automation during descent

- Monitor the FMC VNAV-performance according to actual flight-circumstances = better active Pilot Monitoring-skills.
- Accept or refuse ATC-route-shortcuts and/or runway-changes instantly.
- Predict aircraft behaviour in any approach: ILS-, NPA-, Visual-, Circling-approach, etc.
- Apply these rules from the top of descent up to final approach and landing.
- Better descent = less FMC-"head-down"-time = more time to handle weather radar, more active monitoring and more time to cope with Non-Normal Checklists.
- Raw-Data flying (e.g.: during dual FMC-fail): good descent-management results in more time for instrument scanning = easier and more accurate raw-data flying.
- Unscheduled en-route descent/diversion (e.g.: smoke, medical…): better management of your selection of a diversion airport and the route to fly.
- Better descent-management = better decision-making and as a bonus: fuel-saving.
- Dual engine-out flight: better descent-awareness & remaining energy management.
- Improved descent management = less training required = potential saving on training-costs.

Let's start with a definition:

> *"A rule of thumb is a principle with broad application that is not intended to be strictly accurate or reliable for every situation. It is an easily learned and easily applied procedure for approximately calculating or recalling some value, or for making some determination."* (Wikipedia '16)

Keep this in mind that this guide and especially the rules of thumb are not exact science, OK?
Are these rules of thumb important?
Are they "the right stuff" or "the missing link" you've been waiting for?
Can they help YOU, the pilot?

We often hear pilots saying to each other in daily operation: "*What's the aircraft/autopilot doing now*?"
This means that we, pilots, maybe do not fully understand what the plane is actually doing at that particular moment…

Background information:

On older aircraft types, pilots learned to actually fly aircraft without the help of any FMC. There was no LNAV, VNAV or a FMC giving you the remaining track-miles nor was there any actual wind-information displayed. That's how some of these rules of thumb were born and expertise shared between colleagues.

Today, current high level of automation has lead to complacency and over-reliance on its use by just following the FMC-descent-profile, that's the modern-pilot-attitude.
But, FMC's cannot predict unforeseen, unplanned situations. Most approach or landing mishaps happen due to poor situational awareness concerning descent-path management or it has at least a significant play in it. And the problem starts a long way before the incident actually becomes uncontrollable…

It's an amazing fact that one of the most complex things a pilot has to manage, his descent, has so little information in the manuals provided by the aircraft-manufacturer, the airline-companies or Internet. It is as if nobody has the courage to explain or take any responsibility for it. This is what this guide is all about, explaining in more detail the descent and energy-management as viewed by a pilot, for pilots.

An example: you plan and fly the STAR-route (Standard Arrival Route) by use of the FMC on routine operations. But, as you might expect for that airport you fly several times a month, the usual ATC-shortcut is not yet given by the ATC-centre in the early stage of descent. So, what do you do as a crew? Follow the FMC and be too high on the re-routed descent-profile and hope for the best "FMC-help" later? Or, anticipate an earlier descent, which is the best course of action.
But how do you do that? The problem is when do you plan to start that descent in this case and how do you actually fly it as the FMC "does not know" that your shortcut is coming and cannot guide you. As you see, some help is required here and this is the exact purpose of this guide: to open your eyes and to make you, the pilot, as PF and PM, in control of your descent-path.

Of course, when you will read these rules of thumb I will revert to our beloved FCOM's as much as possible but not all these thumb-rules are written in manuals and most of them are based on experience of myself and my former Captains long time ago who have learned me the famous "Belgian way of flying" ☺.

There is always a way to find an error of logic in some of these rules (mostly aerodynamically) but I want to keep them as simple as possible as you will see that applying these rules takes brain-power. We all know that in descent the workload can be high and time consuming. And, simple explanations stick longer in our pilot-brains than more accurate, scientific ones. As you read about them in this guide you might feel oversaturated and willing to stop reading/learning and rely to your usual magenta-friend, the FMC. But I can assure you, I've seen it numerous times, if a young 300hr cadet-pilot can master them in a few flights, I'm sure you can, it just needs a bit of your motivation, energy and time.

Important remark: as you line-fly, you will see that these rules of thumb will not work out as expected once and a while, but, my personal experience has shown that when I was wrong and the FMC was right (yes, it happens) it always resulted in being only slightly too low on profile, meaning these rules are conservative.

This guide, this way of thinking, these thumb-rules and principles also apply for other similar aircraft types of course…and even apply on wide-body-aircraft. For instance, on the Boeing 787 *Dreamliner*, the rule of thumb is closer to Distance x 4 instead of Distance x 3 for the B737-800. It's the way of thinking that matters here and that I want you to discover. After a few flights on another aircraft type you will be able to write your own

descent-Guide with its rules of thumb applicable to your new aircraft and pass on your experience to your colleagues resulting in a more efficient and safe operation.
This guide is quite long to read, I know, but my experience has shown when I explained these rules, that very often the student-pilot replied he understood until I asked a question in the form of an example….
Then, it usually remained suspiciously quiet on the flightdeck…
Be aware that English is not my mother tongue but the purpose is not to write like Shakespeare did but to use simple words that the whole pilot-community can relate to and understand.

Enough talking, let's get started with some rules of thumb ☺.

Chapter 2: Descent Planning and Follow-Up

2.1 X-Check & Visualisation

As we go along explaining the rules of thumb I will explain how to x-check your profile. There are two ways of proceeding. I personally like to make the mental descent calculations and convert them into an optimum descent-profile = "altitude in feet". Then, compare it to my actual altitude during descent as to determine if I am actually "high or low" on profile. Some pilots prefer it the other way around and convert the corrections into track miles and compare it with their actual expected track miles. It's up to you to decide the way you prefer. In this guide I will stick to my own method as the answer to the question being "high-or-low" is given in feet ☺.

TOD Visualisation

It is very important to "see" or "imagine" your own distance-to-go (DTG) or remaining track miles to the landing runway on the Navigation Display (ND). Do not only rely on your FMC Progress Page: flight plan DTG to DEST trackmiles.
Use the ND to estimate your track miles using the ND range-rings as it will improve your SA and learn you to become completely independent of your magenta friend…Expected short-cuts, deviations due to weather, thunderstorms, terrain, ATC-traffic etc. which could result in a longer or shorter route are not in the FMC. And, due to high workload in these particular conditions it's usually difficult to program it into the FMC Legs-page.

Example on the pictures (below) on the ND: Charleroi, Belgium, FL320, STAR via waypoints "BATTY-FLO-etc…" to runway 25: FMC-progress page: 180NM DTG (Total Distance to Landing) and "to T/D" (to TOD): 73NM. This is the standard arrival, but in practice, for that particular airport and time of day, you can expect a direct to the airport for an ILS approach that starts at 10NM final.
Question: what is your own, practical TOD? The FMC says it is 73NM from your actual position…
This is one that you have to calculate by yourself as the shortcut is not yet received by ATC. If you keep flying at FL320 you will end up to high in case of re-routing and as long as it is not yet programmed in the FMC-route the FMC cannot help you here.
So: you have to visualise the magenta-line in your mind as on the ND on the right-hand-picture, completely disregarding the real ND in front of your eyes as on the left-hand-picture. This is very, very important to understand. This is the right way to work and visualise your own descent-track.

Calculate as follows:
FL320 requires approximately 96NM (32 x 3) to descent.
Counting backwards:
runway to 10NM final = 10NM,
then, actual position to that 10NM-final-fix is 100NM:
total track miles to go is 10 + 100 = 110NM.

➔ Your TOD is 110 – 96 = 14NM away from your actual position, about 2 minutes of cruise-flight. This is much closer than the FMC T/D of 73NM. This is the correct way of thinking!!!

Another example below: Charleroi, Belgium: Runway 25, on the ND-picture below, right-hand downwind. The STAR-route via points "A-B-C"-FMC-route, you operationally plan and expect to fly via "D-E-F".

Question: DTG in "G", abeam the airport?

Answer: 18NM. Why? Counting backwards: runway to "F" = 7NM, then, "F" to "E" = 4NM, then "E" to "G" = 7NM. Total sum 7 + 4 + 7 = 18NM to go in point "G".

Another example (picture below), Pescara, Italy: ILS runway 22, elevation 48ft.

Question: DTG as programmed?

Answer: 24NM. Read the Progress-page here on the CDU or estimate on the ND using the range-rings: runway to approximately 13NM and base = 11NM. Sum: 13 + 11= 24NM.

Question: DTG if direct to 10NM-final is approved by ATC?

Answer: 22NM. As stated above, disregards the magenta line from your actual position to the 10NM-final segment. From runway 22 to 10NM final (10NM-fix-ring displayed) = 10NM, from that point to your actual position: 12NM. Sum: 10 + 12 = 22NM. This is actually 2NM shorter than the FMC magenta line….

Question: DTG if flying a visual approach, direct to 4NM final?

Answer: 17NM. Disregard the magenta line again as explained before: from runway 22 to 4NM final = 4NM. From that point to your actual position = 13NM. Sum: 4 + 13 = 17NM. This is 7NM shorter that the FMC magenta track line, which means that if you fly a visual approach you will be at least 2.100ft (7x300ft/NM) to high on profile. What to do to correct this situation will be explained later.

In chapter 10.2 some more DTG-Visualization or remaining track miles exercises.

2.2 Basic Rule of Thumb

Altitude (ft) = 3 x Distance (NM)

Economic descent: idle thrust and convert stored potential energy (altitude) into distance. Modern airliners with their efficient wing-profiles have a clean configuration Lift/Drag-ratio of about 20/1 and thus a gliding-ratio of approximately 1/20. So, 1NM (Nautical Miles) altitude equals 20NM of gliding-distance available. 1/20 equals a 5% descent-gradient which is 3 degrees gliding angle. This equals approximately 300ft/NM descent-angle, because 5% = 5% of 1NM -> 5% of 6076ft = 300ft, that's a 300ft/NM angle. (Same value as in the Boeing FCTM, year 2015, chapter 4)

300ft (Vertical) = 1 NM (Distance)

Distance (NM) = (FL / 10) x 3

Take the B737-800 FCOM, Volume I/Performance Inflight/All Engine/Descent. (table) (See chapter 6)

Let's take an example, pressure altitude 33.000ft: apply the basic rule of thumb: first two digits of the cruise-flight-level (FL) multiplied by 3: so, 33 x 3 = 99NM. You will notice in the FCOM-table these figures, on average, correspond to the column with a landing-weight of 50tons. The landing-weight close to the TOD-weight (Top Of Descent weight), usually 300 to 400kg of descent/approach fuel-burn from typical cruise altitudes above FL300.
By the way, the actual real landing weight of the aircraft is rarely that accurate. Load sheets use standard passenger-, hold-baggage- and cabin-baggage-weights…so, depending on your destination this may vary significantly. There have been differences of more than 2tons on a 180 passenger-load in practice, the difference between a business-destination (short stay = less heavy luggage) and a holiday-flight (heavy luggage's) for example. For info: to determine your approximate actual real in-flight CRZ-weight: use the FF, adjust eventual fuel-bias (older aircraft, twisted, bend) and look into the Performance Inflight Cruise-tables (=new aircraft) and read your actual in-flight weight.

2.3 Reference-Weight

So, our basic rule of thumb works for 50 tons as we saw in the Boeing FCOM-Descent-table. This is the Boeing descent schedule of Mach.78 (M.78), on transition from to KIAS (Knots Indicated Air Speed), 280KIAS and finally, below FL100: 250KIAS. But, let's say we fly a (Cost Index) CI=6 in the FMC that corresponds to a descent-speed-schedule of M.78 or 245KIAS, this CI reflects a more economical fuel-consumption optimisation.
This CI 6 speed-schedule (M.78/245KIAS) is closer to the up-speed (lowest drag-speed for a given weight), meaning that we have less drag, so, better Lift/Drag-ratio, so more weight for the same altitude and distance compared to the Boeing FCOM-Descent-Table.
Result: rule of thumb: "altitude times three" works for 58tons @ our descent-speed-schedule M.78/245.
For other speed-schedules (in other companies), another slightly different weight-reference will be valid but in any case we all fly maximum 250KIAS below FL100, regardless of the speed-schedule, so the same rules of thumb apply in all cases below FL100 and are valid for 58tons. In chapter 6, we will discuss other speed-schedules.

Reference Weight: 58 tons

This is a "*magic figure*" that I will take with us along as we explain the rules of thumb.

Again, I cannot insist enough how that magic figure "58" is important.

As we explain further, you will see that weight of the aircraft has a huge effect on almost all flight-parameters and aircraft behaviour…So, very important to remember, I cannot overstate the importance of it.
Why 58? That's based on my personal experience on the line, 56 was too low for the rules of thumb to work, and 60 was too high…so, lets stick to 58. I'm sure Boeing has a more accurate figure but I'm not Boeing and I've no access to their magic numbers, otherwise I would not be sitting here trying to explain ☺.
Ask any pilot about descent-planning and they will all come up with some rules but in my career I nearly never ever met a pilot who talked about the weight of the aircraft, and this is together with the wind (explained later) the most important parameter to take into account for profile awareness and energy-management on any aircraft type.

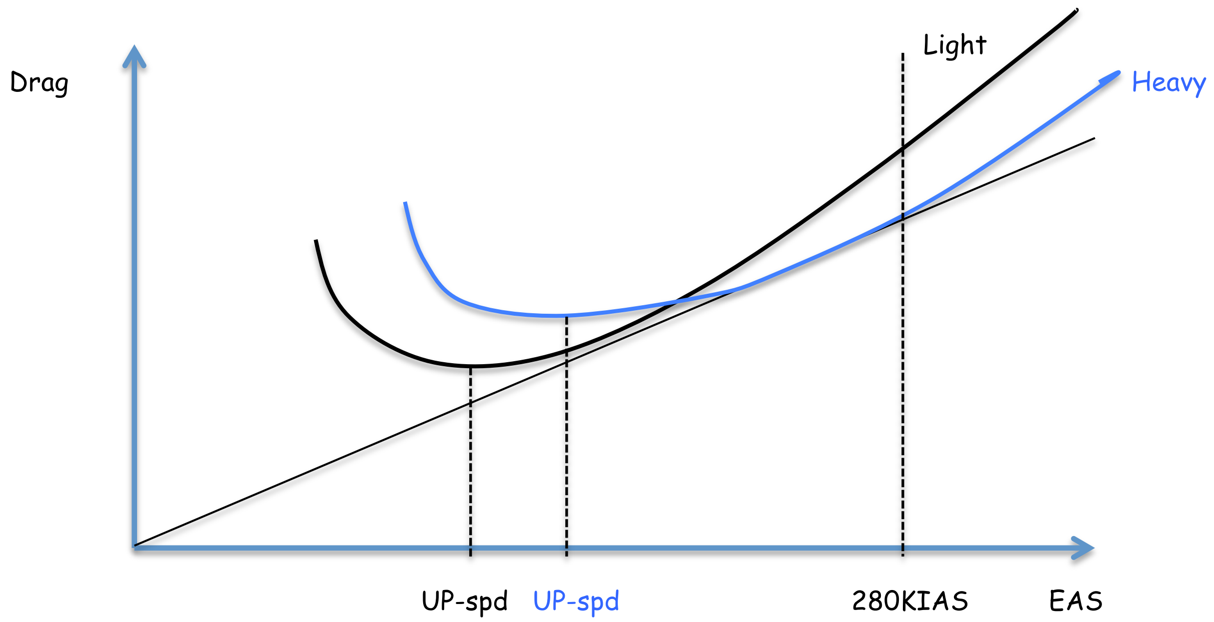
2.4 Weight-Correction

Weight-related rule of thumb:

1 ton = 1 NM

Question: Should a heavy aircraft descent earlier or later than a light aircraft?
Answer: Try to reply before you read the answer in the FCOM-table or here below.

Most pilots reply that a heavy aircraft will have to descent later because it is more heavy, more drag.... Intuitive answer, but not correct, sorry. As we fly a fixed speed above the Up-Speed (Vman-clean). If, and only if, both aircraft would fly at their respective Up-speed your intuitive answer is correct.
The right answer is: a heavy aircraft needs an earlier descent, it needs more track miles to descent.
Why? Remember the Drag-EAS-curve from your pilot-school-days?



Our fixed speed-schedule M.78/280KIAS descent-table does not vary the speeds in function of weight.
Now, take the Boeing descent-speed of 280KIAS: a heavier aircraft has a higher Up-speed (minimum-drag-speed)(Calculation: Up-speed = minimum-drag-speed = Vref40 + 70, see Boeing FCTM), meaning that the Up-speed is closer to 280KIAS. Result: your wing is more efficient (= less drag) at that 280KIAS compared to a lighter aircraft = lower Up-speed. A light aircraft flies at a greater speed above the Up-speed at 280KIAS, meaning: a lot more drag = less efficient wing = later descent-initiation required.
Glider pilots use this principle when taking water in their ballast tanks on a strong thermal day: it will allow them to fly at higher speeds in between thermals while staying nearer to the aerodynamic point of max Lift/Drag and thus glide ratio. An airliner during descent is just like a big glider.

Take the Boeing FCOM-Vol I-table – Descent (See chapter 6):
You will see that an average value for the whole table of 10NM is valid for a difference of 10tons of landing-weight, which I consider the top of descent weight. That is the Weight-rule-of-thumb of 1NM/ton.

Try to make the exercises now..

Given: Cruise FL370.
Question: TOD (Top Of Descent) track miles?
Answer: 111NM. Why? 37 x 3 = 111NM.

Given: Cruise FL370, 62tons.
Question: TOD track miles?
Answer: 115NM. Why? 4tons heavier than 58tons = 4NM earlier descent: 111 + 4 = 115NM.

Given: In descent: 25NM track miles.
Question: Optimum altitude?
Answer: 7.500ft. Why? 25 x 3 = 7.500ft.

Given: In descent: 25NM track miles, 64tons.
Question: Optimum altitude?
Answer: 5.700ft. Why? 25 x 3 = 7.500ft. Weight-correction: 6tons heavier = 6NM = 1.800ft, so, heavier means more efficient wing, so you have to be lower. Result: 7.500 – 1.800 = 5.700ft.

Or, another answer that is possible and better is being still at 7.500ft, our famous 3 degrees profile, but this means too much energy in the aircraft, you are virtually 1.800ft too high on profile due to weight. Solution: at 7.500ft standard descent-profile, you are in a high energy-state (HEA developing here), so you will have to start deceleration much earlier than standard. How much earlier? Same rule: 1NM/ton. Result, start your flap-selection approximately 6NM earlier than standard. (Standard @ standard weight & low-drag-approach = 10NM track miles to go) In our case, flaps 1 at 16 to 17NM due to the energy-state at 64tons.
Remark: it is also true that inertia of a 64tons-aircraft is higher than a 54tons-aircraft….Correct, it has effect, but let's keep things simple.

A "GOP" (Good Operating Practice): I always aim and prioritise to be at my 3-degree descent angle, my first target, whatever my speed. (If no ATC, terrain or procedure restrictions of course)

If I'm high, I always first correct my path to regain my 3 degree and let the speed build-up eventually (if not to close to the airport and above FL100 where the 250KIAS is applicable) Then, when that's under control, the only parameter that needs being taken care of is the speed….If you're far away, that speed will bleed of by itself if not well above that 58tons and if heavier you will need speed-brakes to help deceleration. If, on the other hand you're close to the destination (and below FL100), you cannot let any speed building up, you have no time for this to recover your energy-state. So, only drag will help: use speed-brakes. If you first want to recover the speed before recovering the 3 degree you will have 2 problems to solve, speed first, than altitude…not comfortable, more complex (see chapter 4). On the other hand you have to avoid being below the 3-degree profile because all our standard arrival routes (STAR) are based on it, airspace is tailored on it and terrain-clearance as well and it is more fuel-efficient.

2.5 Wind-Correction

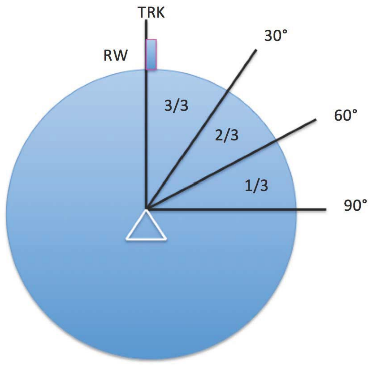
Wind-rule-of-thumb:

10 KTS = 1 NM

Based on experience, this value is very well known and commonly used by the B737-pilot-community.
Typical FL370 descent takes 25 minutes, subtract a 4 minutes final approach, gives you 21 minutes of idle-descent. Take 10KTS wind in 21 minutes and that results in 3,5NM air-mass displacement, so, the correction

should be approximately 3,5NM/10KTS? Of course, the higher the cruise-altitude the more this correction has effect.
Why than 1NM/10KTS? Nobody knows, but this rule of thumb works fine.
On the other hand, the FMC gives you the same result of approximately 1NM/10KTS (FMC-data, AUG'17, 40KTS average descent-TWC up to 40KTS HWC from FL380 to SL @ 58tons).

Wind 3D-Picture:
The descent-winds are introduced into the Descent Forecast page prior the TOD as per SOP/FCOM….
Now, I will ask you to do exactly the same: as a pilot, memorise and "see" in "3D" the winds at FL300, FL200, FL100. This results in an average descent-wind: remember direction and velocity. Now look at your average track towards your airport, straight from your position to the landing-runway (disregard the magenta-line, on the picture in chapter 2.1 this is an approximate track of 320°): now estimate with your "new" calculated descent-wind an average wind-component and apply the rule of thumb of 1NM/10KTS wind-component to calculate your top of descent. O°-30° offset: take 3/3 (=100%) of the wind component. 30°-60° offset: take 2/3 of it and for 60°-90° offset, take 1/3 (=33%) of it.



Same way to memorise the winds below 5.000ft as they will affect your deceleration for approach and aircraft behaviour in general. Compare this wind with the ATIS-wind to predict/detect wind-changes…These average descent-winds and "5.000ft-and-below winds" will give you an accurate "3D-image" of the winds to be expected. Now, you can follow-up and predict what the wind will do. Looks complex? Not at all, it will improve your SA and do this a few times and it will become second nature to you. I know, when you perform your last descent after a long week of flying and a 4 sector-day it takes energy to do it but remember the aircraft/wind is always ready to fool you and always demands your full attention, how tired you may feel.
All this results in being able to predict aircraft behaviour, meaning that you, the pilot, are in control and ahead of your aircraft, not the opposite.
Jetstream-winds: I sometimes see pilots taking the Jetstream-wind-component in cruise to calculate the TOD….not correct ☹. Look at your "3D-wind-picture", maybe the wind-component at FL200 is much reduced already or even shifting in direction?
Important remark: the B737-800 is very sensitive to tailwinds, at any weight, especially in approach. So, any tailwind, even a tiny one, results in a difficult deceleration, light or heavy landing weight, anticipate on it.

Exercises:

Given:	FL330. TWC (Tail-Wind Component) 20KTS.
Question:	TOD- track miles?
Answer:	101NM. Why? 99NM + 2NM = 101NM.
Given:	In descent, 40NM track miles, HWC 30KTS (Head-Wind Component).
Question:	Optimum altitude?
Answer:	FL129. Why? 40 x 3 = 12.000, HWC = 3NM = 900ft, result: 12.900ft or FL129 is "on-profile".

Given: FL330, 64tons, HWC 40KTS.
Question: TOD- track miles?
Answer: 101NM. Why? FL330 = 99NM, correction for weight: 64 – 58 = plus 6NM and correction for wind: minus 4NM: result: 99 + 6 - 4 = 101NM. Here, wind and weight partially compensate each other.

Given: 20NM track miles, 53tons, TWC 10KTS.
Question: Optimum altitude?
Answer: 7.200ft. Why? 20NM= 6.000ft. Correction for weight: 58 - 53 = 5tons = 5NM. Correction for wind: 10KTS = 1NM. Total correction 5 + 1 = 4NM = 1.200ft . Result: 6.000 + 1.200 = 7.200ft.

Takes brainpower, isn't it? Relax, I will explain later how it's actually done in practice.
Remember, as I explained before, the "wind and weight"-corrections are the most significant.

2.6 Speed-Correction

Speed-rule-of-thumb:

10 KTS = 1 NM

This is the same correction as for the wind-thumb-rule.
The Boeing-table PI 11.6 takes deceleration from 250KIAS to flaps-selection-speeds into account. So, no further corrections required if you fly standard speeds and weight. Flap-selection from Up-speed will usually start around 10 to 11NM before landing on typical low-drag-low-noise approach.

But, as usual, there's a catch: this is valid for 58tons, our basic reference-weight. Now, you can guess, the weight has again an impact for which you need to apply corrections. Whenever our aircraft weight is more than 58tons, a difficult deceleration to the Up-speed comes into play and this speed-rule-of-thumb has to be applied.

An example: 63tons: you are 5tons heavier than the standard weight of 58tons, meaning you will have to start your flap-selection 5NM earlier, in this case, around 15-16 track miles or distance to go before landing.

Exercise:

Given: In descent, 20NM track miles, 280KIAS.
Question: Optimum altitude?
Answer: 5.100ft. Why: 20NM= 6.000ft, 280KIAS = 30KIAS above standard-speed-schedule = 3NM correction = 900ft. As you are faster you should be lower, meaning 6.000 – 900 = 5.100ft. Another possibility: be at 6.000ft on a 3 degrees slope, on glide…But this means you are 30KIAS too fast: speedbrakes will have to help you to decelerate, the only option…I know that you avoid flying 280KIAS below FL100 but it's for the sake of the exercise and to show the urgency to start doing something by selecting the speedbrakes to decelerate or ask for extra track-miles to ATC.

2.7 Elevation-Correction

Elevation-rule-of-thumb:

APT-elev.: Add to calculated profile.

Pilots often overlook this correction!!! Just add the destination-airport elevation to your calculated optimum altitude. For TOD-calculation: subtract the elevation because you are closer to the airport already, less height to loose: destination-elevation/300 =NM to subtract. Or easier: CRZ-ALT minus Elevation multiplied by 3.
Example: Madrid Barajas airport in Spain: elevation: 1998ft. Question: During descent, 50 track miles to go, which is the optimum altitude? Answer: FL170. Why? 3 x 50 = 15.000 + 2.000 elev. = FL170.

2.8 QNH-Correction

QNH-rule-of-thumb:

1 hPa = 30 ft

This correction is usually not applied. But, when the QNH becomes very high or very low the required correction becomes significant. If not taken into account, a very high QNH will result in the aircraft being high on profile, a very low QNH in being too low on profile. Why? Take your altimeter, select a higher QNH than standard (1013,2hPa/29.92Inch), you will see the indicated altitude increases: you will have more altitude to lose for the descent. This correction becomes more important as you descent to lower altitudes.
Example: QNH 1033= 20hPa above standard = 600ft…So, 600ft is not that significant at cruise-FL340 but it is quite significant at 4.000ft when setting that QNH…As you see, your SA is already improving ☺.

Exercise:

Given: In descent, 25NM track miles, QNH1033.
Question: Optimum FL?
Answer: FL069. Why? 25NM = 7.500ft or FL075, 1033hPa is 20hPa above the standard QNH of 1013,2hPa, which is 600ft. So, you have to subtract 600ft from 7.500ft as the altimeter will increase 600ft when transitioning from standard altimeter setting to local QNH.

2.9 ISA-Deviation

ISA-deviation-rule-of-thumb:

1% per 2,5°C

Look into the FMC-Descent-Forecast page: value to be inserted as per SOP/FCOM.
In practice: sometimes, in summer, there could be an average descent-ISA-deviation of ISA+5 (rarely +10°C), which would generate being 5/2.5= 2% "higher", which is 500 to 1000ft more altitude to lose, or 2% more track miles to add in this case…not so significant and to keep our mental calculation simple, usually disregard the ISA-deviation. But, in extreme cases, your mental calculation might not work out exactly as you had hoped for, this could be generated by this deviation.
Remark: according to the FCOM the ISA deviation is an average temperature-deviation to be inserted in the descent forecast page in the FMC. This means, for the complete descent, not only for the OAT at the destination airport…In fact you should calculate an average temperature-deviation, using the rule of 2°/1.000ft temperature-gradient: example: FL200: ISA-temp = +15 – (20 x 2) = -25°C and then compare with your flight-plan figures at that level etc.…To complex to do in practice. To be remembered: take it into account in extreme hot or extreme cold temperatures.
FMC: example: insert ISA + 10, result: +4NM extra descent-distance from FL380. If you insert ISA +15: +6NM.

2.10 TAI-ON/OFF

Engine-related: selecting engine anti-ice (TAI) ON does result in an increase in idle-N1/N2 from minimum flight-idle to approach-idle. This means, higher idle-thrust, so, additional track miles required. Try it out, insert it into the FMC, your TOD-track miles change. Example: FL380 = +8NM. In practice you seldom will be switching TAI on from CRZ-altitude to ground so, mostly less than 4NM TAI-adjustment required.
Again, to keep things simple, a value not to be remembered for your usual mental calculations.
Engine parameters: actual example: idle, TAI @ FL250: +3%N2, +4%N1. TAI @ FL150: +6%N2, +6%N1.

2.11 Summary: Rules of Thumb vs Descent-Planning & Follow-Up

Basic Rule of Thumb:	**Altitude (ft) = 3 x Distance (NM)**
	300ft (Vertical) = 1 NM (Distance)
	Distance (NM) = (FL / 10) x 3
Reference Weight:	**58 tons**
Weight:	**1 ton = 1 NM**
Wind:	**10 KTS = 1 NM**
Speed:	**10 KTS = 1 NM**
APT-elev.:	**Add to calculated profile**
QNH:	**1hPa = 30 ft**
ISA (if required):	**1 % per 2,5°C**

Next time you fly, look into your FMC Descent Forecast page and the APPROACH REF page (Gross weight):
"All these parameters are in the FMC…."

Ready for some more exercises?
When other parameters are not mentioned, they are standard (STD).

Given: FL380, 62tons, TWC 20kt, destination-elevation 1.200ft.
Question: TOD-track miles?
Answer: 116NM. Why? FL380 = 114NM, 62tons = +4NM, TWC = +2NM, elev = - 4NM.
Result: 114 + 4 + 2 – 4 = 116NM.

Given: 63tons, TWC 10kt.
Question: When will you start setting flaps (from up-speed) for approach at the latest?
Answer: 16NM. Why? Usually, STD, that's 10NM to start configuring, but 63tons = +5NM, TWC = +1NM. Result: 10 + 5 + 1 = 16NM.

Given: 63tons, TWC 10kt.
Question: When will you start decelerating from 250KIAS to Up-speed for approach?
Answer: 20NM. Why? Approximately 4NM from 250 to up-speed, 63tons = +5NM, TWC = +1NM. Result: 10 + 4 + 5 + 1 = 20NM. Looks far ahead of the threshold, isn't it? You will see, you will need each and every mile to decelerate and configure. Do the same exercise by looking next time on your ND at the FMC-determined "DECEL"-point. Then, calculate it yourself and compare what the FMC calculated and displayed on your ND.

Given: In approach, 63tons, 250KIAS, 15NM to go, 4.500ft, TWC 10kt.

Question: What's your energy-state & what to do? This is a good recipe for HEA. Why?

Answer: Distance: 15NM = 4.500ft & 250KIAS is on STD-profile, but your weight is 5 tons above 58 tons & 10kt-TWC = 5 + 1 = 6NM, equals 1.800ft. Your choice, you should be at 4.500-1.800=2.700ft in order to decelerate at low ROD (rate of descent) or, usually the practice as going so low is not allowed/practical, so you should start to select flaps at STD + 6NM on a 3 degree slope, which is 16 to 17NM final, which is already 2NM passed your position….So, in fact you are already too late to decelerate in a normal way and this means you should immediately select speed-brakes in order to avoid a HEA. Do you see how to "manage" your approach using these rules of thumb? These simple rules are there to predict aircraft behaviour well ahead before it happens, and that's what is important. You, as the PF, are in command and can act before the problem actually arises….
This is effective TEM & energy-management and what this guide is all about.

Unique Descent-Correction

Exercise:

Given: 50NM track miles DTG, 56tons, HWC 30kt, destination-elevation 600ft.

Question: Optimum Altitude?

Answer: FL171. Why? 50NM = FL150, 56tons = +2NM, HWC = +3NM, elevation= +600ft. Result: corrections = +5NM = 1.500ft plus the elevation of 600ft = 2.100ft + FL150= FL171.

Difficult/complex? …. Yes, it looks that way ☹.

But, make your life easy, we are pilots after all and have more on our hands and mind in descent (workload). Calculate the sum of the corrections and you take them with you during the whole descent, **they do not vary** (except for the actual wind, to be followed-up). So, this 2.100ft-correction is a **unique** constant value applicable for that particular descent in your descent-calculation & follow-up…
During descent, you just multiply your track miles times 3 and add your unique descent-correction of approximately 2.000ft each and every time, for the duration of the whole descent.
Not as complex as it looked like in the first place, isn't it? ☺.

Optimum Profile = Track Miles x 3, plus unique DES-correction

Chapter 3: Descent-Execution

Question: How do you start a 3 degrees descent? (Disregard any use of FMC/MCP/VNAV/…)

Answer: There are many ways of doing that, let's give 4 possible answers.

Answer 1: Select LVL-CHG. Thus, the engines revert to idle-thrust and allow the aircraft stabilise itself in a descent-path at the current MCP-speed….Don't forget as current Mach is kept the IAS will increase as altitude decreases. So, select the appropriate descent-speed from Mach to KIAS in time by pushing on the C/O-button (Changeover-button) on the MCP around FL300…If not, your speed might end-up into VMo…and as Mach is kept your speed increases, more drag, more steeper DES-path. Not at all the targeted 3 degree profile. Just be aware of that possible snag concerning speed-conversion in descent.

Answer 2: In CWS, simply decrease the current cruise-pitch (body-attitude) of the aircraft by 3 degrees and select idle-thrust: usually from +2,5° (CRZ) to -0,5°-attitude: on or just below the horizon.

Answer 3: Current Mach-number times 3: Thumb-rule: M x 3 = ROD. Example: Mach .78. So, 3 x 78 = 2.340FPM-ROD (Feet per minute rate of descent). This method was used on aircraft without indication of TAS/GS on the instruments (ND). Your Mach-number being your so called "speed-number"…the number of

NM you do per minute. You can also determine this speed-number by dividing your TAS by 60: example: 420kt/60 = 7NM/min. In approach: 210kt = 3,5NM/min, etc.

Answer 4: 3 degrees = 5%, so vertical speed is 5% of forward speed. So, take your speed in KTS and multiply by 5: example: 420KTS: 5 x 420 = 2.100FPM. Easier is to divide the first two digits by 2: same example: 42/2 = 2.100FPM. So, to reply to our first question: select a ROD of 2.100FPM and that will result in an idle-thrust descent and a 3-degree descent-angle. As altitude decreases, your selected-descent-speed is constant but your speed in KTS will decrease, so your selected ROD will have to decrease as well. This requires constant monitoring of the speed and reselecting a corrected ROD. This method is valid up to touchdown. Same remark as in answer 1 above: remember to change in time from Mach to KIAS by pushing on the C/O-button on the MCP. Difference here: your 3 degrees descent will be OK but as altitude decreases and constant Mach is kept the throttles will gradually open and add thrust to keep that Mach…increasing it towards Vmo. (Fuel-waste)

Important remark:

Given: Look at your ND here below.
Question: Do you take your ground-speed (GS) in knots or true airspeed (TAS) to calculate your ROD for a 3 degrees descent-slope?

Try to reply before you read the answer …☺.

Answer: Most pilots reply: “GS- ground-speed”. Sorry, that’s is wrong, the correct one is: TAS.

Why?
Imagine that you are descending in idle, at a fix speed-schedule in KIAS. You are performing a 3 degrees descent-path in a big mass of air like a glider (idle-thrust). This mass of air does not “feel” that it is moving compared with the earth as the actual wind moves that mass of air around the globe. So, in fact, your aircraft, your wing, does not know anything about groundspeed but does only “feel” true airspeed - TAS.
So, always take TAS in descent. In the example above, this means approximately 1.800FPM-ROD.
Confusing? No, because remember that you took already the average descent-wind-component into account when calculating your TOD. In fact, you took already the moving of that mass of air in which you’re descending compared to the earth into account. Makes sense?

But, I can hear you thinking: why is there GS vs ROD written on all our approach-charts?
This is also logic because your approach descent-path is a fixed angle in relation to the ground. So the wind-component has to be considered, meaning you always take GS for ground-based descent-angels.

TAS vs GS rule-of-thumb:

For Descent, you always take the TAS

For Approach, you always take the GS

Practice and experience will show the transition between the two. The closer you get towards the approach, the more you take GS into account. Usually, 15-20 track miles remaining for example.

<u>245KIAS-descent, CI = 6</u>: details for the "purist-pilots" …
In fact, this fixed descent-speed-schedule, close to the up-speed is not exactly 3 degrees but slightly less than 3 degrees as our B737-800 has a very efficient wing (see chapter 6). So, when you descend, you take the TAS divided by 2 to determine your ROD.
Example: in descent, your ND-display shows: "GS387 TAS360". Required ROD?
Answer: TAS/2= 36/2 = 1.800FPM.

For a 3 degrees angled approach (e.g. ILS) you take your GS, divide it by 2 and round it up slightly to have your ROD to keep tracking your descent-path, a glide-slope for example.
Here's a sample of an approach chart to confirm the way of calculation:

Gnd speed-Kts	*70*	*90*	*100*	*120*	*140*	*160*
ILS GS 3.00°	377	484	538	646	753	861

Example: ILS 3°: your ND-display shows: "GS180 TAS165". Which is your required ROD? Answer: GS/2= 18/2 = 900FPM, rounding up, which is 950 to 1.000FPM to remain on the glideslope.
This simple but effective rule helps you to cross-check your ROD required to keep the glideslope or any other approach-path. This results in better monitoring, trimming, instrument-scanning and raw-data flying.
If, for example, you are on the glide-slope, and you see a ROD of 650FPM and a GS of 160, you know that you will end-up above your glide-slope because GS160= approximately 850FP and your actual ROD is to low. So, before the glide-slope even starts to move downward (you get high) you decrease your pitch-attitude slightly (1 degree for example) and re-trim the aircraft if required. Then, release the stick-pressure to see if you're in an "in-trim-condition" and x-check your ROD again to aim the 850FPM-value. Takes a bit of practice, but it will become second nature to you.
This rule of thumb also works for a visual traffic pattern or a circling approach where you have to start your final descent to the runway in base-leg, with or without the help of the PAPI-lights.

ROD rule-of-thumb:

DES: ROD = TAS / 2

APP (3°): ROD = GS / 2, rounded-up

What about different descent-angle for approach? For example: a 4° approach-path?

As you will master the quick calculations for a 3 degrees slope, just use "the rule of three" to adjust our required ROD.

Exercise:

Given: In approach, you see "GS160" on the ND on a 4° approach.

Question: ROD?

Answer: Calculate your 3 degrees as usual, which is 850FPM and just add one third or 33% (3° x 1,33 = 4°), in our case approximately 300FPM to add, which is 1.150FPM ROD to fly that 4° slope.

For a 3,3°- slope, add 10% to your usual mental 3° calculation. For a 2,7°- slope, subtract 10%….etc.
You will see, these numbers and calculations will become second nature for you as you fly and apply them regularly. See it as a challenging game and you will see how easy and how predictable it all gets. Do these mental exercises also when you're the pilot monitoring, even with the autopilot engaged.

Result: your SA improves a lot and a HEA is a thing of the past. These skills make you a better pilot as PF (Pilot Flying) and PM (Pilot Monitoring), meaning exactly that, you will be a better "active" PM as you will understand much better all these aircraft behaviours and you will stay mentally ahead of the aircraft. Finally, you will provide better assistance to your PF/FMC resulting in better teamwork and lower workload, increasing the overall efficiency and safety of your flight together as a crew.

In practice, you will see sometimes that the ROD-values flown by the autopilot differ from your own calculated ones. Why? It sometimes happens that the inserted winds into the FMC-DES-Forecast-page are different than the actual ones encountered. And, remember the FMC-descent-path is a fixed path towards the ground for the FMC, meaning that the FMC follows this path at any cost vertically, it does not take the actual conditions into account, sometimes generating different ROD-rates. Finally, as mentioned before, these thumb-rules are not exact science either ☺.

Chapter 4: Descent Corrections and Predictions

Typical situation: you approach your TOD and you ask ATC to descent…unfortunately, it is refused by ATC as there's a conflicting traffic below…So, you pass your TOD, what now?

First important step: Reduce adding energy in your path by reducing the airspeed to Minimum Manoeuver Speed (amber) +10KIAS. Consider allowing a 10kt buffer for safety and unexpected turbulence.
Let's discuss now what to do next when above your optimum descent-profile? Several options can be selected.

Option 1: FLY FAST, high-speed-DES: (> FL100, below that, the usual ATC 250KIAS speed limitation is applied)

Increase your descent-speed to Maximum Manoeuver Speed (amber) – 10KIAS.
Allow a 10kt buffer for eventual turbulence and/or wind velocity change.
This will result in approximately +20 to +25% extra drag, meaning, you catch-up your selected ECON-descent-profile by 20%. Nice to know, but what does it mean in practice?

Let's say you're flying a descent trough FL350 at Vmo/Mmo-10KIAS, and your TAS equals 460kt. This means that in a perfect 3 degrees descent profile your ROD should be 2.300FPM (46/2 x 100). But , by flying fast you will have an actual ROD of 2.800 to 3.000FPM. Again, good to know, but what can I do with this?
Next step: make the difference between the optimal 3-degree ROD and your actual ROD, in our case, 500FPM (2.800-2.300). This means that you're catching-up your optimal econ-FMC-descent profile with 500FPM.
Next step: let's calculate: for example, you are 2.500ft above your profile, so while catching-up at 500FPM you will be "on profile" in 5 minutes. Again, good to know, but what do I do with this value?
Now, calculate your speed-number, the number of NM per minute as explained above. Let's say you do 8NM/min (Mach .78 = 7,8NM/min = approx. 8NM/min or more accurate: GS/60 = NM/min, but that's more difficult to calculate, so let's stick to airspeed, meaning Mach-number, make your life easy in high workload conditions).
Result: 5 min x 8NM/min = 40NM, this means you will be on profile in 40NM, and now it's up to you to look at your track miles on the ND to see where you will be on profile.

This means that you can PREDICT now where you will be on profile and confirm if your corrections make sense. (flying fast in this case) In no way the FMC can provide you with this kind of information as precisely in all circumstances, and certainly not that fast.

Result: you are totally independent from the FMC. I repeat myself: you are in control of your aircraft and path, you manage, you're ahead of the aircraft, ahead of the game, you x-check, you act/advice. And, when corrective action has been taken, only then you ask your PM if required to update the FMC as best as possible to meet the current situation, then, re-X-check your path.

Remember: "Fly the aircraft first, Aviate, then Navigate and finally Communicate".

But, unfortunately, there is always a "but" somewhere: you will be on profile in 40NM, but a much higher speed (energy-state) than planned. But at least you can predict if your action (= flying fast) makes sense. If not, take extra measures like speed-brakes (see further) and/or extra track miles or a combination of them (ask ATC). DO NOT postpone additional actions and do not "hope" it will work out, act!!!
Do you remember your 3D-image of the descent-winds? The wind-component can change later helping you (or the opposite) in your prediction if your actions to catch-up the profile make sense….
All of this looks a bit complicated but you'll see, in practice, do this a few times and you will be able to do these simples maths quickly (we are pilots after all, a bit of mental challenge is good and brakes the routine flying) and you will be comfortable in these high-speed conditions. Pilots usually don't like to fly fast because it gives them a feeling of rushing even faster to the "problem" but in fact it is exactly the opposite it is the solution to your problem: "fly the numbers!!!".
Also, avoid making average corrections, make your corrections big enough to be ASAP on your profile or on the FMC-DES-profile.
To continue with our example: 40NM later you are on profile, at Vmo-10kt. To lose the extra high-speed-energy, how far do you go below your own or the updated FMC-DES-profile?
The same thumb-rule can help: make the difference between your actual speed and the FMC-DES-speed, for example, 70kt and apply the Speed-thumb-rule: 70kt = 7NM = 7 x 300' = 2.100ft. Action: go 2.100ft below the FMC-DES-profile, then re-select VNAV and your aircraft will decelerate to FMC-DES-speed and will be catching up at approximately your FMC-DES-profile: problem solved. When you are still at higher altitudes (above FL150 for example) you can re-engage VNAV when on the FMC-DES-profile if not well above the reference weight of 58tons. The excess speed will decay slowly by itself to the FMC-DES-speed, no need to go below the FMC-profile as described above.
Important remark: remember how we told you how weight has effect on nearly everything? Here it has the same effect: "flying fast with a heavy aircraft is less effective that flying fast with a light aircraft". Why?
Same logic: heavy = higher up-speed (see chapter 2.4) = less drag at Mmo/Vmo compared to a light aircraft = very low up-speed = very high drag at Mmo/Vmo. Again, keep your weight in the back of you pilot-mind all the times in descent.
Conclusion: flying fast with a heavy aircraft will generate maybe 20% extra drag, while for a light aircraft maybe 30-35% extra drag. Same reasoning to make concerning how far you go below the FMC-DES-path when above 58tons: take our example: with a heavy aircraft, certainly 2.100ft below profile before selecting VNAV, with a light aircraft maybe 1.000ft or even zero is enough. Do you start to understand how your SA is improving? You will see in practice, it will amaze you to see how well it feels that you can predict aircraft behaviour, the B737 revealing all it's hidden secrets to you….And, maybe you can teach something to your 20.000hr Captain who is less aware of these rules of thumb….
Operational info: when you fly fast to catch-up your descent-profile, insert that new higher-speed into the FMC DES-page: this "new" FMC-DES-profile will help you to re-actualise your profile and it takes into account the usual ATC speed restriction of 250KTS < FL100.
The "Fly Fast" option is usually useful at high altitudes, well above FL100. Let's say you are at FL150, high on profile, does it make sense to start speeding-up the aircraft to very high speeds? No, by the time you reach that new high-speed you have to start reducing to 250KIAS (< FL100) already.

Option 2: Speed-Brakes (SB):

This results in approximately 30% extra drag.
Weight has no influence here, speed has. Using your SB in descent at Mmo/Vmo is more effective than at the Up-speed. See Boeing FCTM: chapter 4: 250KIAS & SB = +30% drag, 280KIAS & SB = +40% drag.
Combining the "flying fast"-option and the "use of SB"-option does not mean the sum of both drags, OK? This is not exact science, remember?
Remark: SB extended = keep your hands on the SB-lever as a reminder they're extended as to avoid thrust being used later on in combination with SB. This is also a reminder to prevent using them longer than required, wasting precious fuel/energy/passenger-comfort.

Option 3: Landing-gear (LG):

Simple math: approximately 40 to 50% extra drag.
This is quite a drastic solution. Use it only if drastic measures are required to catch-up the profile and/or decelerate your aircraft.
In normal operations, you should not be in this situation to have to select the LG if you applied the above thumb-rules and if ATC shortcuts (could be a runway-change) provide enough track miles to descent/decelerate. Of course, un unexpected tailwind-component could be active on intermediate or final approach, which means the LG is a good quick and efficient option to decrease speed when flying on profile.
For example, close to the airport, still (very) high? Select the LG down, but keep in mind this generates quite high ROD's towards terrain in idle (CFIT-risk, GPWS-auto-call-outs). Your correction will be substantial, be ready to predict where your optimum profile is (ILS glideslope for example) and anticipate to avoid descending below. (terrain-closure-risks) Keep calculating your altitude vs distance to predict where your glideslope in this example is coming alive on the PFD and do it fast = simple maths (remember to take the airport-elevation in to account)
An example: 15 track miles, 220KIAS, you're at 6.000ft and you select the LG down: the LG results in approximately 50% drag, meaning: 220KIAS= 1.200FPM + 50%= 1.800 to 2.000FPM, and at 15NM your glide is at 4.500ft, meaning you're 1.500ft to high. The LG results in 600 to 800FPM extra rate, meaning you will be on profile in about 2 min = 6 to 7NM (220/60= approx. 3,5NM/min =speed-number). Result: at about 9NM form threshold you'll be on the glideslope, at 220, ready to select flaps, slightly high on speed but the LG will generate the required drag for the rest of the approach. The outcome: a HEA-risk avoided.
Comfortable? Noisy? Not at all noisy: when you select the LG, the noise you hear in the flight-deck is from the nose-wheel well. The passengers do not hear that one as they are sitting far behind it and the main wheel well does not generate these nuisance noises in cabin when the main landing-gear is extended.

Quick-action-steps: High on profile:

Step 1: Option: increase speed and/or use of SB: select LVL-CHG, select Mmo/Vmo – 10KIAS. Wait until the ROD stabilises. Optional: insert new speed into FMC-DES-page.
Step 2: Read TAS, divide/2 = ….ROD (FMC-profile optimum ROD) and compare to actual ROD = excess ROD.
Step 3: Difference actual ALT vs FMC-optimum profile ALT = see ND = "Vertical Deviation Scale and Pointer": excess-ALT/excess-ROD (step 2) = time in minutes to reach FMC-DES-profile.
Step 4: Calculate/read the Speed-number: take Mach-nr x 10 (or GS/60=accurate): …..NM/min.
Step 5: Minutes (step 3) x Speed-nr (Step 4) = distance in NM to reach the FMC-DES-profile = your prediction where you'll be on profile (@ higher-speed), determine if your actions to catch-up the profile make sense: situation acceptable? "YES" = keep going, if "NO": take additional action, do not wait: increase speed and/or use SB, (use LG), request extra track miles to ATC….
Step 6: During your descent: recalculate regularly if your quick-action-steps make sense and now ask your PM to update the FMC-route/speed etc.
Step 7: Once on the FMC-DES-profile, select VNAV. Optional: go below profile with the speed-thumb-rule: excess-speed/10 x 300'=….ft to go below profile, than re-select VNAV (think actual weight)

Shorter text?
Step 1: Increase descent-rate.
Step 2: Determine excess ROD vs STD-ROD.
Step 3: Excess-ALT / excess-ROD =time in minutes to reach FMC-DES-profile.
Step 4: Calculate/read Speed-nr.
Step 5: Time x Speed-nr = distance to reach FMC-DES-profile.
Prediction OK? Keep going-on.
Prediction not OK? Act now: speed/speed-brakes/extra track miles.
Step 6: Follow-up your corrective actions constantly.
Step 7: on FMC-DES-profile: select VNAV. Hi gross-weight? Go below profile using Speed-Thumb-rule.

In these 7 steps, only 3 calculations are required, not that all that difficult if practiced a few times…believe me, it will save your day more often than you think. And, the "green banana" (Altitude Range Arc) displayed on your ND is usually of no help here as it is related to a actual selected MCP-altitude.

Chapter 5: Dual Engine Out Descent

Dual engine out rule-of-thumb: (Target is a 4 degrees profile)

Dual Eng-Out-DES: Altitude (AGL) = Distance x 4

First, perform the memory-items & the QRH and try an engine restart, if applicable…crucial steps!!!
If unsuccessful restart of both engines, no options left but to glide down. Try to reach an airport or off-airport landing-spot: actual altitude should be the distance x 4 as a strict minimum. That's if you're flying at the Up-speed, Vman-clean. All extra speed is a bonus in kinetic energy that you can convert into altitude/distance if required before you start the irreversible descent without engines. The 4 degrees profile is required as both engines produce a little bit more drag due to wind-milling. But the main reason is that there will be no thrust available at the 4NM final approach where usually the landing gear is selected down in daily low-drag low-noise approaches. At the 4NM-point extra energy is required in the form of potential/kinetic energy to counter the drag of the landing gear/flaps.

First step: After unsuccessful restarts, meaning you're already at lower altitudes: convert kinetic into potential energy: go as soon as possible to Vman-clean. (Up-speed).

Second step: Range? Thumb-rule: example: landing-spot at 25NM range: 25 x 4 = FL100. You should be at least at FL100 or 10.000ft in order to reach the desired landing spot. Basically being 33% higher than a "normal" descent. That's if you are heading towards it of course, if more than 90 degrees turn is required you will lose range. A 180-degree turn at Up-speed requires 1 minute (rate 1 @ 30° bank) which equals approximately 1.500ft of altitude-loss (2 engine out). And, remember the influence of weight? Higher than 58tons is better, lower than 58 tons is worse. But, I guess that due to workload being incredibly high in that situation you will have no time for this, but keep it in mind if possible.

Third step: Do the necessary memory-items, QRH, APU, ATC, SQ7700, cabin-crew, PA, etc. if you can, but remember: first fly the aircraft: Aviate!!! Consult company procedures/FCOM/FCTM for actions and guidelines.

Forth step: The approach: if above the 4 degrees-profile? Use additional track miles and/or speed-brakes to adjust your profile until you aim for that 10 track-miles to go spot, just like a "normal" approach where you will start configuring with the flaps. Avoid using the landing-gear to regain the 4 degrees profile because you cannot undo this and energy-management is much more difficult later on in the approach.

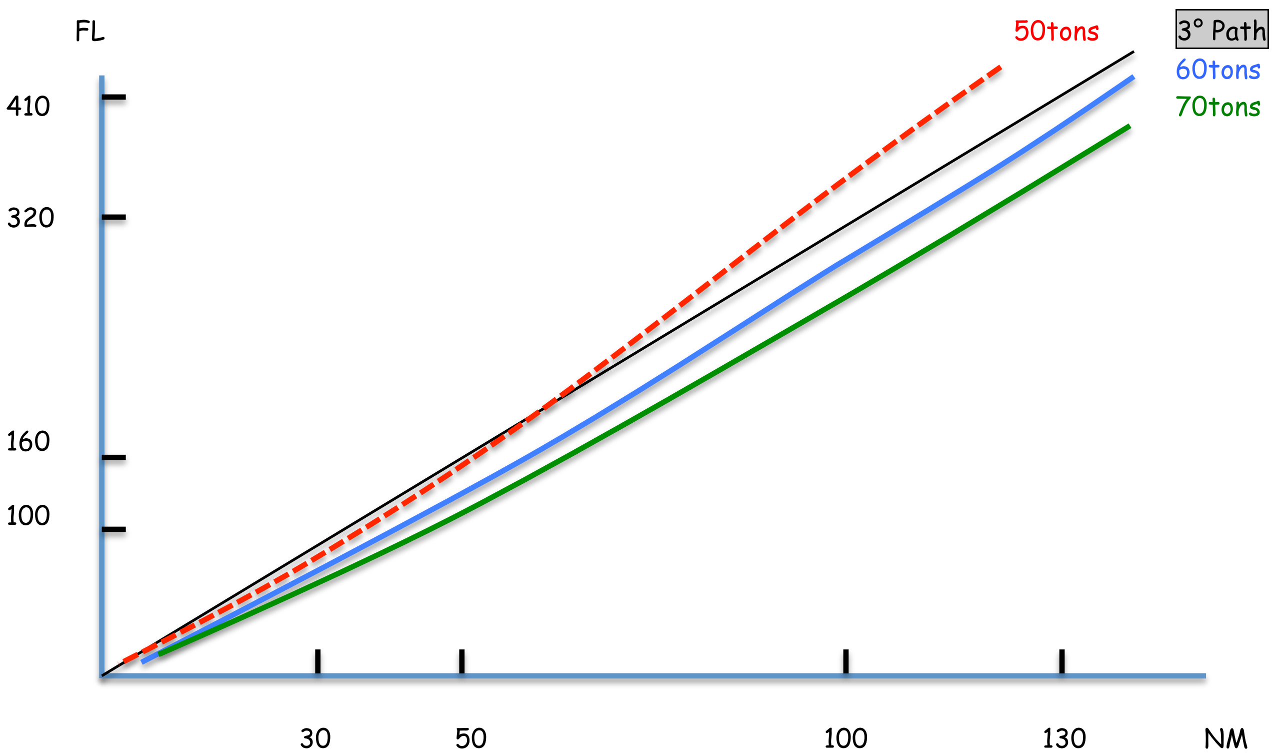
Keep doing the mental calculations distance x 4 = current altitude above ground level (AGL) and do them very frequently as you have only one shot at this. In fact, you are going for a mandatory HEA, and that higher energy is used later in the approach.
So, 10NM track miles: select flaps 1, etc. and do not select the landing gear at the flap 15 selection…The gear-horn will sound with lots of others I guess, terrain, GPWS, RAAS…Consider Ground Proximity "Gear Inhibit"-switch to Gear Inhibit-position &/or pulling the landing gear warning horn C/B and aim for the landing spot (touch-down zone, wherever it may be). We are not used to "see" a 4 degree descent-profile, you will "feel" being high, disregard it the best you can, avoid diving, keep calculating, fly the numbers….
Then, given your actual excess speed above the Vref-F15 and the way it decelerates towards the landing-spot as distance decreases you will select the landing gear down very close to the aimed touch down spot…better slightly too late (too much speed) than the opposite or you might not reach your landing spot. The landing gear takes approximately a full 5-6 seconds to deploy with hydraulic power available, slightly more if manual extension is required.
Another way of flying could be to aim for a 3 degrees profile but all at higher speeds. Normally you select the landing gear at 4NM. So, now you postpone all of your "usual" configuration changes (flaps/gear) by 4NM: flaps 1 at 6NM, then flaps 5…etc. and just prior to touchdown the landing gear.
For me personally, this is a more dynamic situation and more difficult to manage.
Remark: Vref-F15? (Vref- flaps 15): use the FMC and select Vref-F15 or use the landing-weight + 90kt as an average value. Example: current landing-weight 60tons: Vref-F15 = 150kt.
Try it out a few times on your next simulator recurrent training as to improve your SA.

Chapter 6: Boeing Descent-Table & Speed-Schedule-info: An Analysis

Take the Boeing "Descent"-table: FCOM/Performance Inflight/All Engines/Descent: a very interesting table.
The Boeing Speed-schedule: M.78/280/250.

DES-angle vs altitude & weight			
FL	50tons	60tons	70tons
410	3,2°	2,9°	2,7°
370	3,2°	2,9°	2,7°
250	3,0°	2,7°	2,6°
170	2,9°	2,6°	2,5°
100	2,8°	2,5°	2,4°
050	2,5°	2,4°	2,3°

PRESSURE ALTITUDE (FT)	TIME (MIN)	FUEL (KG)	DISTANCE			
			LANDING WEIGHT (1000 KG)			
			40	50	60	70
41000	27	340	102	119	133	142
39000	26	340	97	114	127	136
37000	25	330	92	108	121	130
35000	24	330	88	103	116	125
33000	24	320	84	99	111	120
31000	23	320	80	94	105	113
29000	22	310	75	88	98	106
27000	21	300	70	82	92	99
25000	20	300	66	77	86	92
23000	19	290	61	71	79	85
21000	18	280	57	66	73	78
19000	17	270	52	61	67	72
17000	15	250	48	55	61	65
15000	14	240	44	50	55	58
10000	11	200	30	34	37	39
5000	7	150	18	19	20	21
1500	4	110	9	9	9	9



<u>Interesting points to notice</u>:

- The graph is drawn exactly to scale from the Boeing Descent-table-data above.
- <u>Descent-angles</u>: all aircraft have a steeper descent-angle at high altitudes, gradually decreasing to approximately the same descent-angle below 5.000ft. Interesting to see that variable descent-angles exist.
- <u>Influence of weight vs distance</u>: a heavier aircraft has to start the descent earlier than a light aircraft. Example: FL370: 22NM difference in top of descent point for 50tons vs 70tons.
- <u>Influence of weight vs altitude</u>: at a same distance from landing at high altitudes there can be differences of more than 6.000ft between a heavy and a light aircraft, amazing isn't it?
  Example: 99NM, FL330 for 50tons vs FL270 for a 70tons aircraft. Remember in chapter 2 how weight of your aircraft is very, very important to take into consideration, made very visible here!!! ☺. Again, you have to take the weight into consideration for the whole descent.
- For an average landing-weight, approximately 60tons (approx. 160 pax & LDGF of 3tons), you can see that the B737-800 descents at a lower average descent-angle than the famous 3 degrees slope on which the rules of thumb are based. Only very light aircraft have a steeper initial descent and below FL100, where speed-restrictions are applied as 250KIAS, you can see that descent-angles are below 3° for nearly all aircraft-weights.
- Below FL100 you notice in the table and drawing that the difference between heavy and light aircraft diminish gradually, but, they are there. A 1.500ft difference at 20 track miles to go is more significant than at FL330…
- Example: FL370, 60tons: TOD = 121NM. If you divide FL370 by 3, that gives 123NM. So, according to the Boeing-table the correct rule should be: TOD = FL/3 or TOD = (FL/10) x 3 +10% which is 37 x 3 = 111, plus 10% = approx. 122NM. But, remember this guide is not exact science.
  Our rule of thumb of this guide is: TOD = (FL/10) x 3 : Why is there no +10%?
  The Boeing-table vs the real "econ-world": the descent table is based on an approach where the landing gear and F15 are selected at approximately 8NM final (FMC-data). This is not realistic in today's world where fuel-saving and the noise foot-print are important. So, we fly "low-drag low-noise"-approaches in good weather. We select landing gear down – Flaps 15 at 4NM final, in order to be fully configured around 700-1.000ft AGL.

Result: the three graphs red, blue and green may be shifted at least 4 to 5NM to the left, meaning you come closer to the 3 degrees profile…
Conclusion: no need to add +10% for typical low-drag, low-noise-approaches.

- Speed-schedule info: data retrieved from the FMC, B738NG-W, year 2017.

Landing-weight: 58tons. Descent from FL380. CRZ-FF 55kg/min. 1kg jet-fuel = 3,15kg CO2 (IATA 2017)
In grey: Boeing standard descent-speed-schedule: M.78/280/250.

Speed	TOD (NM)	TOD vs STD (NM)	DES-Angle	Fuel gain/loss (kg)	CO2 gain/loss (kg)	Time gain/loss (min)
220	144	+22	2,5°	-96	-302	+5
230	143	+21	2,5°	-92	-290	
240	136	+14	2,6°	-61	-192	
250	132	+10	2,7°	-44	-138	+2
260	129	+7	2,8°	-31	-97	
270	125	+3	2,9°	-13	-41	
280	122	0	2,93°	0	0	0
290	120	-2	3,0°	+9	+28	
300	117	-5	3,1°	+22	+69	
310	114	-8	3,1°	+35	+110	-1
320	111	-11	3,2°	+48	+151	
330	109	-13	3,3°	+57	+180	
340	107	-15	3,4°	+66	+208	-4

Observation: Boeing and other studies are clear: some pilots are convinced that a later descent at a very high speed gains time and fuel. Right? Sorry, the answer is: No, it's wrong!!! What's true, there will be a small time-gain, just a few minutes, but the loss of fuel is considerably higher even if the actual high-speed-descent-fuel-consumption is lower. The lower descent-fuel never compensates for the longer CRZ-flight, i.e. fuel required to reach that postponed TOD. In the table this is not taken into account, I'm not a scientist, just a happy pilot ☺.

Conclusion: flying high-speed descents cost a lot for the environment, are very noisy and at high speeds encountered turbulence is more uncomfortable for passengers and less good for the aircraft structure. And, if it would be better for fuel-consumption I guess Boeing would program it into the FMC by default.

Another observation: here, it looks that for each 10KIAS of speed increase/decrease it gives you a 3NM difference on average, while our rule of thumb is 1NM/10KIAS…Remember, this guide is not exact science, but our thumb rules work.

Chapter 7: Boeing and/or Company Related Info in Our Manuals

- To improve Situational Awareness: insert the landing runway into one of the fix-pages:
  - TOD: 3 x ALT-ring into the FMC-FIX-page = approximate TOD.
  - Insert 10NM-ring (latest flap-selection distance on final as gross x-check for H.E.A.)
  - 4/5NM-rings (VMC/IMC-conditions) = low-drag low-noise approach: landing gear and F15 selection, to meet the full landing configuration and all checklists completed at 500'AGL (VMC) or 1.000'AGL (IMC), the so called "landing gate" in some companies.

  Remark: if there's a runway change, also change the runway-fix!!! Do not forget this one!!!
- Descent-performance: approximately 1NM/300ft-thumbrule. (FCTM, chapter 4)
- Approach: GOP: 10NM-rule: "3-2-1-rule": "3.000ft-200kts-F1". Be at F5 and on glide-slope to intercept. And, GOP: at 9NM@190kts, at 8NM@180kts, at 7NM@170kts. This is to avoid a H.E.A. Consider these speeds as ground speeds if a tailwind-component is present!!! Very important point.

- High on profile above FL100: increase speed, preferred mode: SPD INTV. Update the FMC-DES-speed. If still above profile: use SB and/or extra track miles.
- High on profile below FL100: keep 250KIAS: use SB. If still high: consider additional track miles or enter the holding pattern to loose altitude.
- 360°-turn on final: more than 10NM from threshold, above the MSA or 3.000ft AAL whichever is higher, max FL10 & SB if required and VMC-conditions.
- Flap-selections: avoid selecting flaps close to flap-limit placard-speeds. Flaps are no drag-devices. Flaps are used to slow the aircraft down (they allow the aircraft to fly slower while they increase drag), SB are used to increase drag (speed-reduction and/or increase ROD).
  Remember: "*Flaps to slow down, speed brakes to go down*"-rule of thumb.
  Or, also,
  > "*Flaps down, speed brakes down*"
  > "*Flaps out, speed brakes in*"
- ROD-performance:
  - 250/SB = 1.700-1.800FPM.
  - 220/F5/SB = 2.300FPM.
  - 180/F10/SB = 1.500FPM.
- Maximum-STD-speeds on approach: 220 @ IAF, 180 @ base or on final, 160 @ 4NM final.

Chapter 8: Descent GOP's, Special Descents & MORA/MEA/… and T.E.M.

8.1 Terrain Awareness

There's a very important remark to be made, a good habit that's got forgotten into our SOP's:

"Go LOW – Look BELOW"

In today's aviation there seems to be an over-reliance by pilots to just accept received ATC descent-clearances without any problem nor even thinking to challenge these clearances: this is very dangerous flying!!!! Terrain is very important and is "hard rock"!!!

As a Pilot, you NEVER descent to ANY altitude without making reference to a CHARTED altitude!!!

If 10 clearances are given in descent, you x-check those 10 times or more, that's all, it's a very simple rule. Never take any ATC altitude clearances for granted, always challenge them. Read them from your paper or your electronic En-route/STAR/Approach-chart that's applicable to your actual position. This is part of professional T.E.M.-culture.
The descent route should be briefed of course and all its limiting altitudes and these should be x-checked in the FMC DES-page and RTE-page.
Brief and x-check between each other, PF and PM (and the FMC) the following:

- The En-route-chart MORA: Why? Between your TOD and the 25NM-distance of the MSA around the airport you are basically blind if not on your actual STAR due to for example ATC-shortcuts, ATC traffic-deviations or even adverse weather like thunderstorm-cells. It's very important to take the en-route chart and brief the MORA to the airport. This will improve your SA. Also, brief the MORA, MEA and its expected route to the alternate airport.
- The STAR-MEA's.

- The APP-altitudes: platform or interception-altitude, FAF, altitude vs distance (NPA, etc.) if applicable and the threshold elevation.
- The GA-altitude

In practice, this means, while in your descent, any ATC clearance given will have to be double-checked on your applicable charts: never ever set an altitude on the MCP-altitude-window without proper verification, day or night or VMC/IMC!!!

8.2 A Descent in Practice (GOP's)

- Select on the FMC the expected runway, type of approach, transition (if required), speed limitations and STAR as per company SOP.
- X-check if there are RTE-discontinuities and resolve them.
- Challenge any waypoint hard altitudes vs charts. If possible, change them to at or above as to aim for a constant descent profile (CDA: Continuous Descent Approach) to save fuel/noise.
- FMC Fix-page: insert the landing runway.
    - Insert the TOD-ring: FL x 3 for your SA.
    - Insert 10NM-ring: the latest point on approach to be selecting flaps…(58tons)
    - Insert 4/5NM-rings: landing gear down – flaps 15 configuration distance. (VMC/IMC-conditions)
- FMC-DES page: select the DES-Forecast page and fill up the expected winds for your descent from your flightplan/wind-charts. Select the expected QNH, ISA-DEV, TAI: ON/OFF (use the significant-weather charts for icing, cloud-base, TS).
- Now, look closely at the programmed FMC-DES-winds. Read, learn and imagine them as you would descent and make a mental 3D-picture in your head as explained in chapter 2.5. X-check the 5.000ft wind and the actual landing-wind (ATIS).
- Determine your actual landing weight: compare it to your reference-weight of 58tons, very important!!!
- Next, it's your turn: calculate all the corrections as explained in the guide in chapter 2.11 and determine one unique DES-correction-value in feet that will be used for your whole descent.
- Calculate your own TOD and compare with the displayed FMC TOD: challenge discrepancies.
- Once the FMC set-up is completed it will calculate a fixed 3D descent path. Sometimes you will observe that the actual DES-speed is above or below the programmed FMC DES-speed. This could be because of a different actual wind vs your programmed winds and/or a different weight of the aircraft (see chapter 2.2). The FMC will follow a calculated "vertical" magenta at any cost…and will increase thrust if getting low (approx. -13KIAS) on target-DES-speed or, if higher, it will display the message "Drag Required" on the CDU.
- Once you are satisfied that the FMC descent-profile is correct just follow VNAV and regularly keep challenging the profile by doing you mental calculations, every 10NM or so.
  This guide is purpose written to x-check VNAV DES-Path, not to replace it.
  But there are exceptions as explained before. And, in 90% of the cases VNAV will work, but you have to be ready for the remaining 10% and interfere and act accordingly when required.
- Intermediate CRZ-descent: a (unexpected) descent far away from the normal TOD. Happens very often due to ATC in busy airspace. Different modes can be used (DES NOW, ALT INTV, new CRZ-alt….etc) depending on available FMC software and company policy but, once level @ the new CRZ-altitude, re-calculate your own new TOD and do the same with the FMC: insert a new CRZ-altitude.
- Early continuous descent by ATC or yourself:
    - 1.000FPM-ROD: insert the new CRZ-altitude into the FMC or use de DES NOW prompt or push on the ALT INTV-button…the aircraft starts a 1.000FPM-descent.
    - V/S-DES: example: ATC asks you to descent at 1.500FPM-ROD: the FMC cannot help you. Select the V/S-button, use the thumbwheel to select 1.500FPM. Or, select LVL CHG-mode on the MCP and use a partially opened throttle to aim for 1.500FPM-ROD, more difficult in practice. I prefer to use the V/S-mode.
    - Whenever V/S-DES are used, at high altitudes, ALWAYS select an IAS instead of a Mach-number on the MCP-Speed window by pushing on the C/O-button on the MCP and select the

desired DES-speed in IAS. This will avoid that the A/T will increase the speed to Vmo as altitude decreases as it tries to keep the Mach-number. Take care with this.

  - Remember: any selected ROD above your 3-degree ROD will result in a speed increase at "normal" weights, whatever speed has been selected on the MCP-Speed window.
  - 3.000FPM-ROD: this is a value to be remembered. Whenever you see your aircraft descending more than 3.000FPM you must be vigilant. The aircraft usually increases speed towards Vmo. Any value below will keep you usually safe from Vmo, for unchanged wind-conditions of course. This value is also influenced by weight. Well below 58tons, no problem, above it, take care!!!
  - If you descent earlier than the TOD because you expect shortcuts or for example a visual approach vs a procedural approach than you start the descent at your own TOD. Select LVL CHG and follow the desired speed-schedule: first Mach, then on speed-transition IAS. If deviating above your own optimum DES-profile, increase the ROD and let the speed be or use SB to correct. If below, open the throttle a little bit, that ROD will decrease and you will catch-up your calculated profile. But, there's a catch here: I often see (and did it myself) that pilots forget that the thrust-levers are slightly advanced due to workload and that unnoticed extra thrust might get you into a high energy situation later.

    Remark: the use of LVL CHG-mode in DES is not that comfortable for passengers and crew as the aircraft pitches up and down all the time to keep the selected speed. I prefer to use the V/S (see chapter 3: ROD = TAS/2) and an IAS because the pitch is stable = more passenger-comfort. But, you will have to decrease the ROD as altitude decreases in order to avoid a speed build-up above your selected IAS. Why? Remember chapter 3: as altitude decreases your TAS will decrease as so your selected ROD will have to be decreased accordingly. If not corrected regularly the selected ROD will be higher than the required ROD (TAS/2) and the aircraft will increase its speed above the targeted DES-SPD. It's more mental work but more rewarding, comfortable and obliges you to constantly monitor your descent-profile. If the workload is high, select LVL CHG-mode.

- Descent at the FMC-TOD: a FMC path descent is the most economical one. Follow-up the descent profile by monitoring the VNAV Path Pointer on the ND. Remember to keep calculating your own descent profile as x-check: remaining track miles x 3 plus/minus your unique DES-correction-value applicable to this particular descent as we've learned in chapter 2.11.

  Remember the way to do this? Look on your ND, disregard the magenta-line, determine your own track miles, than, always take an easy number to calculate. For example, your track miles to go are 87NM, than, you calculate the required descent profile when you will pass 80NM, because 3 x 80NM is easier to calculate than 3 x 87NM, apply your unique DES-correction on this and when you will be at that 80NM point, read your current altitude and determine if you are on, below or above profile. Than, prepare the following one, at 70NM for example, etc…

  And, the lower you go, the more you calculate your profile, especially below FL100. Why? Because, the lower you are, the less time there is to eventually correct the descent-profile.
- Expecting shortcuts, not yet received by ATC:

  Calculate your own TOD with the expected shortcut (See examples chapter 2.1). Compare it with the FMC TOD as determine the difference in track miles. For example, your own TOD is 10NM closer to your position than the FMC TOD.

  Two options:
  - Re-program the FMC-route for that planned shortcut and descent at that "new" TOD.
  - Or, if this is not an option/allowed yet: descent 10NM earlier than the standard FMC TOD and remain 3.000ft (10NM x 300ft= 3.000ft) below the FMC profile on the VNAV Path pointer on the ND. Do this as explained above in LVL CHG-mode or in V/S-mode on the MCP as explained above.
- GOP: remember "wind and weight":
  - The "wind" to x-check changes vs planned winds
  - The "weight" as to predict aircraft behaviour in DES and especially in APP (energy-management and HEA-prevention)

- Extending the centre-line on final approach:
  Example on the pictures below: Pescara, Italy, elevation 48ft, ILS runway 22:
  LH-picture: enlarge it to see it more clearly: well on profile.
  A few seconds later you extend the centre-line from the 10 miles fix waypoint called “ASTUB”: the result = RH-picture: the FMC is “lost”: VNAV DISCONNECT message in the CDU scratchpad, CWS P active, the VNAV Path Pointer is suddenly 2.170ft too high and because of that your MCP SPD has reduced to the Up-speed.
  In practice, I’ve very often seen this triggers immediate panic with some pilots because their VNAV is gone and they are literally “lost in space”. Some reactions observed: pushing several times on the VNAV-button on the MCP in the hope to recover or pushing on the control column or selecting SB, without thinking further in order to regain these 2.170ft (+ speed increase will follow) or most often the reaction is being “frozen”, not knowing what to do…
  Solution: first, stay calm, remember the lessons learned: there is no reason that a stable situation reverts to a high energy state just a few seconds later.
  First step: recover the pitch-control: read the TAS: 271kt, so, select a 1.350FPM ROD (27/2 = 13,5)(look @ the RH-picture: the actual ROD is already 1.300FPM, 3 degrees) using the MCP V/S-button (Chapter 3) or a second option is to select LVL CHG with the current SPD.
  Second step: calculate your remaining trackmiles counting backwards from the runway: runway to 15NM-ring = 15NM. Plus, actual position to that 15NM-point: 10NM. Sum: 15 + 10 = 25NM.
  So, basic rule of thumb: 25 x 3 = 7.500ft. Now, take the TWC of 10kt into account = 1NM. Also, correct for deceleration from 240 to 210 (UP-SPD): 30KTS = 3NM: both corrections together are 4NM, which is 1.200FT. Optimal altitude is 7.500 – 1.200 = 6.300ft, very near your current altitude of 6.400ft. So, relax, as you are perfectly on profile.
  Another example is to proceed directly to the 10NM final fix ASTUB. Question: DTG?
  Runway to ASTUB = 10NM and from your actual position to ASTUB = 10NM. Sum = 20NM (= 6.000ft). Slightly high energy state here as you’re 400ft high & there’s a TWC (+300ft) and a deceleration will soon come into the picture…so, select SB to loose energy…the only option.
  Another option of course is to select ASTUB or another waypoint that you create quickly on final approach “on top” of the CDU-LEGS page, execute the “new route” and select VNAV who will solve all of your problems as usual, I hope ☺.


- Remark: a speed-deceleration is done by aiming 500 to 1.000FPM-ROD. That is below the 3-degree descent-rate above the Up-speed, meaning that you end up slightly higher above your ideal descent-path…So, for example, when you need to start deceleration from 250KIAS to the UP-SPD ideally you should be already a little bit below your 3-degree profile in order to reach it again at the UP-SPD. In practice, this means that around 25 to 20-track miles to go you will gradually aim to be slightly lower than the 3-degree slope in order to decelerate later, usually 700 to 1000ft lower. Don’t be surprised about that. This is fine-tuning your awareness and, that’s exactly how the FMC does it. In practice, I sometimes stay on my 3 degrees profile and pull the SB to help to decelerate but that’s less optimal…

8.3 Special Descents, Smoke, Fire, Medical, Rapid Depressurization, Bomb-Warning

Smoke/fire in CRZ: this can quickly become an out-of-control situation if smoke/fire is not positively identified and smoke/fumes cannot quickly be removed….Refer to your QRH-checklist.
An immediate landing may be required, even off-airport landing in extreme cases (water, farmland, roads,…).

Simple question: you are in CRZ, FL330: I ask you now: "landing gear down?" Can you do it? Is it allowed?
Answer: yes, it is possible & allowed.

Why? Because, at your usual CRZ-altitudes, your CRZ-speed is well below the Landing Gear Limit speed of 270KIAS/M.82. Pilots are usually not aware of this possibility.

How often do I see that in our recurrent simulator trainings pilots are trained/instructed like robots to do the same every time again and descent at high speeds up to Mmo/Vmo (& SB) when a rapid depressurization occurs or when an immediate landing is required, for example due to smoke/fumes/fire. A rapid depressurization could be due to a structural problem, and increasing speeds to Mmo/Vmo is exactly what should not be done, look at the QRH Non-Normal Checklist (NNC) Emergency Descent: "*If structural integrity is in doubt, limit speed as much as possible and avoid high manoeuvring loads*". In this case, pilots must descent at 240-250KIAS with SB, that's all, and that takes a very long time to reach lower levels.

So, limiting speeds for structural integrity can also be done by selecting the landing gear down at high altitudes, in combination with the SB this will result in substantial high descent-rates.

This is also mentioned in the Boeing FCTM, chapter 7.

Another situation (bomb-warning, smoke, fire, medical-emergency,…), & no structural problems:
Select the landing gear down, pull the SB and aim a target speed of M.81/320KIAS (gear extended limit speed)….You will see, try it on your next sim-training, this will result in very high descent-rates (up to full scale vertical speed indications and more) and you will be on the ground in no time….Much more effective than flying "as usual" at Mmo/Vmo with extended SB.

I just mention this in this guide to keep an open mind, think outside the box and improve your SA.

For normal "rapid descents" the landing gear remains up as recommended by the FCTM. I only cover the situation here where things get out of control and a life and death situation is developing, let me be clear on this.

8.4 Finally, up to you now ☺

I think this completes our descent-guide and I tried to be as brief as possible but as explained before, it's only by asking questions and giving examples that you will actually master these rules of thumb. It's up to you now to try them out one by one on your one of your following flights.

"Knowing your aircraft, that's the ultimate aim of any pilot, on any type of aircraft"

The result: when your situational awareness improves, safety improves, and if my Guide can avoid even one single HEA or go around in the future, the purpose of this Guide has made sense.

Further below a short summary of the descent-Guide on one printable page.
Feel free to send constructive feedback ☺.

Happy landings to all of you, fly safe & enjoy,

Eric,

Great thanks and appreciation goes to my colleagues, experienced and less experienced who contributed to this Guide with their knowledge, ideas and feedback as well as for the improvement of the layout.
Special thanks to Captain Pat Boone (Author of the famous www.b737mrg.net) and a few other colleagues who for privacy reasons wish to remain “below the radar”.

AND, last but not least: as a reward for the pilots who made it to the end of this Guide…(sorry for the girls).
Here’s a picture of one of my students that I briefed with “great motivation” on descent and energy-management during a long cruise flight…☺.

Chapter 9: Descent-Guide Summary

(Small characters to fit on one printable page)

Rules of thumb vs Descent-Planning & Follow-Up: (Chapter 2)

Basic Rule of Thumb:	**Altitude (ft) = 3 x Distance (NM)**
	300ft (Vertical) = 1 NM (Distance)
	Distance (NM) = (FL / 10) x 3
Reference Weight:	**58 tons**
Weight:	**1 ton = 1 NM**
Wind:	**10 KTS = 1 NM**
Speed:	**10 KTS = 1 NM**
APT-elev.:	**Add to calculated profile**
QNH:	**1hPa = 30 ft**
ISA (if required):	**1 % per 2,5°C**

Unique Descent-Correction: (Chapter 2.11)

Calculate the sum of the corrections and you take them with you during the whole descent, they do not vary (except for wind, maybe, to be followed-up): Remember: "Wind and Weight" for the whole DES.

Optimum Profile = Track Miles x 3, plus unique DES-correction

Descent-Execution: (Chapter 3)

DES: ROD = TAS / 2
APP (3°): ROD = GS / 2, rounded-up

Descent – Corrections and Predictions: (Chapter 4)

- Option 1: FLY FAST, high-speed-DES: (> FL100), Option 2: Speed-Brakes (SB), Option 3: Landing-gear (LG):
- Quick-action-steps: High on DES-profile:
  - Step 1: Increase descent-rate.
  - Step 2: Determine excess ROD vs STD-ROD.
  - Step 3: Excess-ALT / excess-ROD =time in minutes to reach FMC-DES-profile.
  - Step 4: Calculate/read Speed-nr.
  - Step 5: Time x Speed-nr = distance to reach FMC-DES-profile.
    - Prediction OK?: keep going-on.
    - Prediction not OK?: act now: speed/speed-brakes/extra track miles.
  - Step 6: Follow-up your corrective actions constantly.
  - Step 7: on FMC-DES-profile: select VNAV. Hi gross-weight? Go below profile using Speed-Thumb-rule.

Dual Engine Flame Out Descent: (Chapter 5)

Dual Eng-Out-DES: Altitude (AGL) = Distance x 4

Descent GOP's: (Chapter 8)

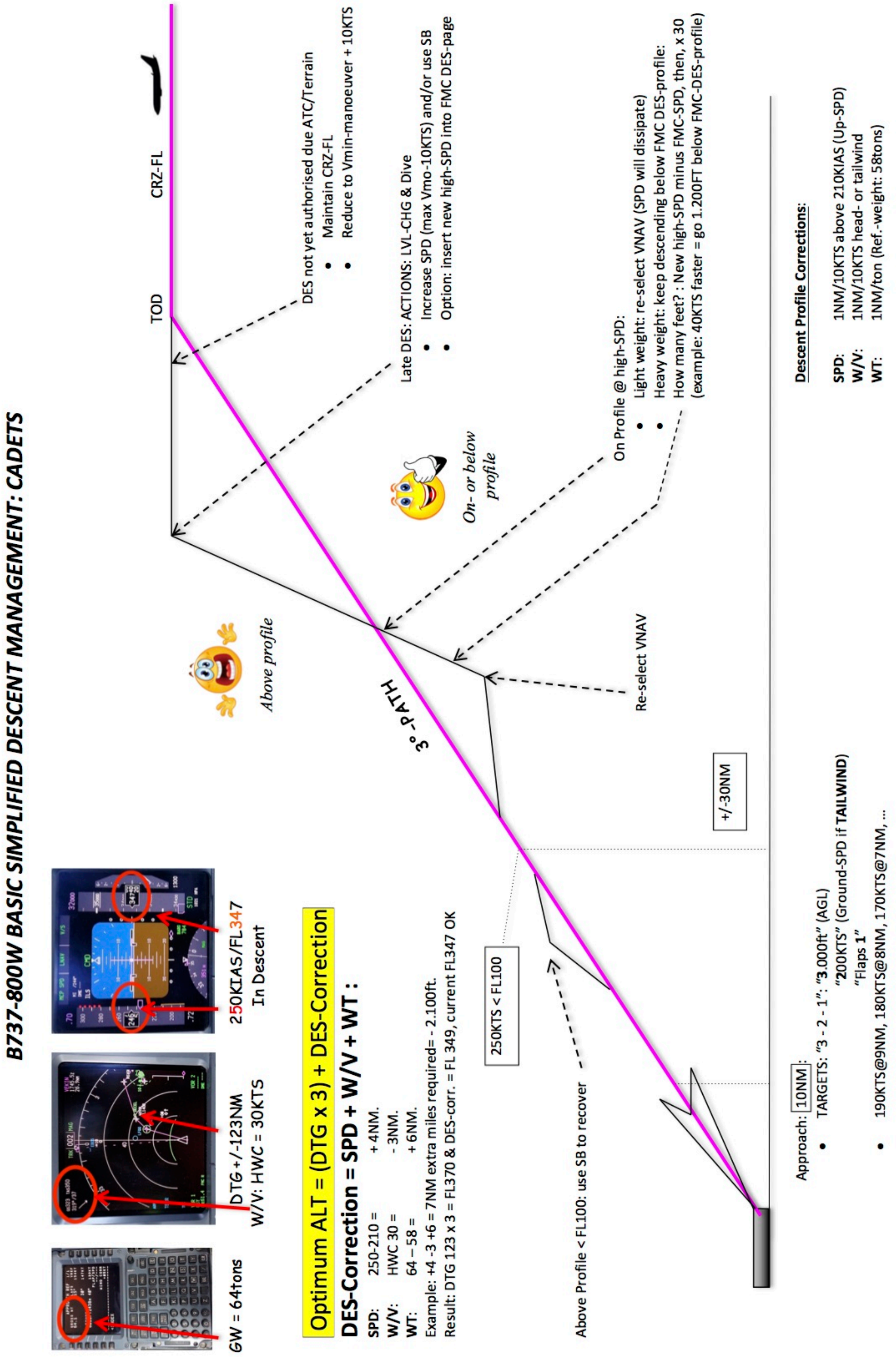
Terrain-Awareness: (Chapter 8.1)

As a Pilot, you NEVER descent to ANY altitude without making reference to a CHARTED altitude!!!

A Descent in Practice: (Chapter 8.2)
FMC-preparation. Landing-weight. 3-D winds. FMC-descent. Early descent by ATC. V/S-descents by ATC Early descent by pilots. Extending the centre-line on final APP.
Special Descents: (Chapter 8.3)
Smoke, fire, medical, rapid depressurization, bomb-warning…

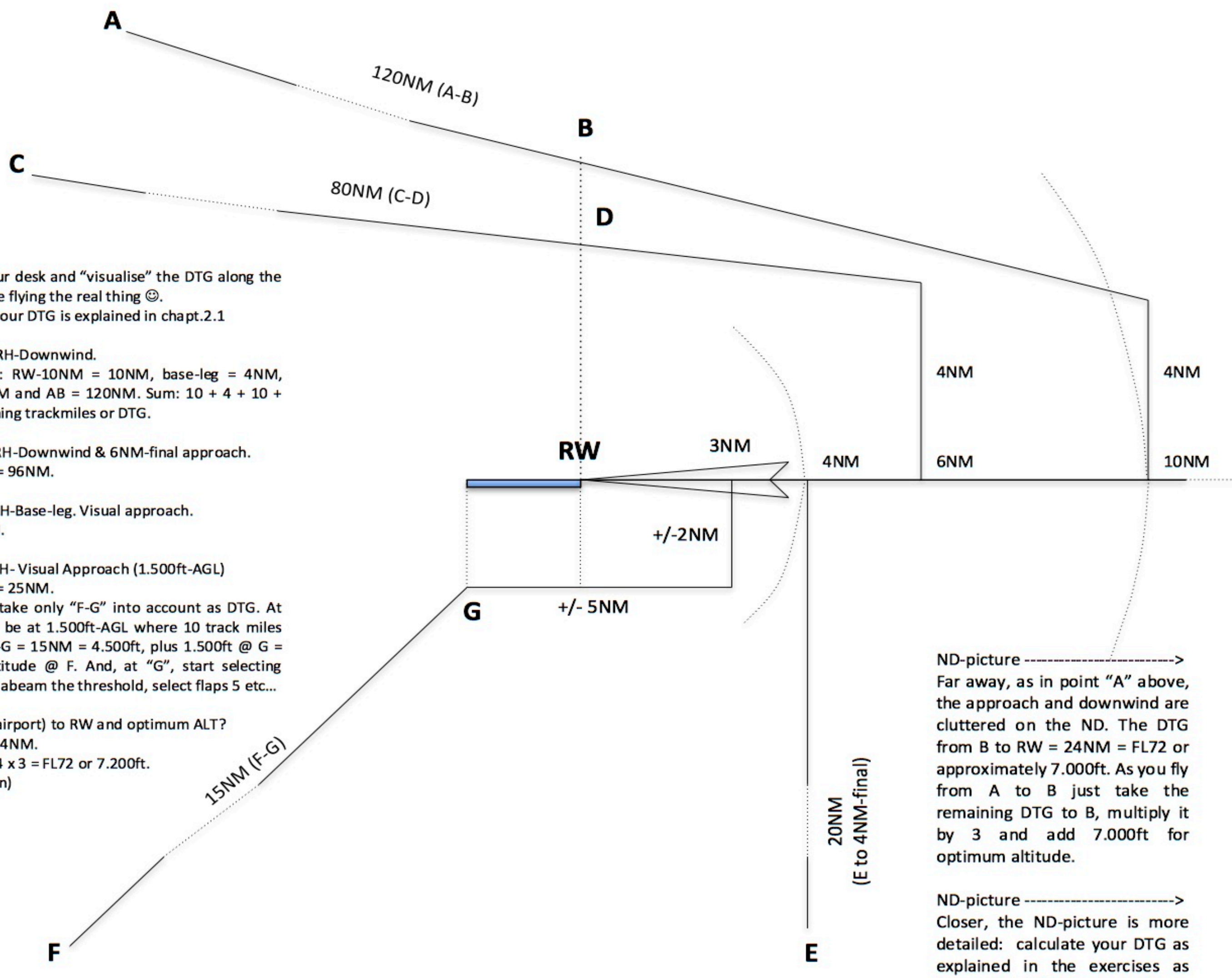
Chapter 10: Annexes

10.1 B737-800W Basic Simplified Descent Management: Cadets



10.2 DTG – “Distance To Go” or Remaining Track Miles Visualization-Exercises

DTG – “Distance To Go” or Remaining Track Miles Visualization-Exercises



Exercises:
Position this paper “flat” on your desk and “visualise” the DTG along the route as if you would actually be flying the real thing ☺.
The way to calculate/estimate your DTG is explained in chapt.2.1

Question: DTG from A to RW? RH-Downwind.
Answer: Counting backwards: RW-10NM = 10NM, base-leg = 4NM, base-leg to B = 10NM and AB = 120NM. Sum: 10 + 4 + 10 + 120 = 144NM remaining trackmiles or DTG.

Question: DTG from C to RW? RH-Downwind & 6NM-final approach.
Answer: DTG = 6 + 4 + 6 + 80 = 96NM.

Question: DTG from E to RW? LH-Base-leg. Visual approach.
Answer: DTG = 4 + 20 = 24NM.

Question: DTG from F to RW? LH- Visual Approach (1.500ft-AGL)
Answer: DTG = 3 + 2 + 5 + 15 = 25NM.
An easier way is to take only “F-G” into account as DTG. At point G you have to be at 1.500ft-AGL where 10 track miles are remaining. So, F-G = 15NM = 4.500ft, plus 1.500ft @ G = 6.000ft optimum altitude @ F. And, at “G”, start selecting flaps and level flight, abeam the threshold, select flaps 5 etc...

Question: DTG from B (abeam airport) to RW and optimum ALT?
Answer: DTG = 10 + 4 + 10 = 24NM.
Optimum altitude: 24 x 3 = FL72 or 7.200ft.
(Simplified calculation)

ND-picture ------------------------->
Far away, as in point “A” above, the approach and downwind are cluttered on the ND. The DTG from B to RW = 24NM = FL72 or approximately 7.000ft. As you fly from A to B just take the remaining DTG to B, multiply it by 3 and add 7.000ft for optimum altitude.

ND-picture ------------------------->
Closer, the ND-picture is more detailed: calculate your DTG as explained in the exercises as from point “B” & in chapt.2.1

Appendix: Abbreviations

- AAL: Above Airport Level
- AGL: Above Ground Level
- ALT: Altitude
- A/P: Auto Pilot
- APP: Approach
- APT: Airport
- ASAP: As Soon As Possible
- ATIS: Automatic Terminal Information Service
- Capt.: Captain
- C/B: Circuit Breaker
- CDA: Continuous Descent Approach
- CDU: Control Display Unit
- CFIT: Controlled Flight Into Terrain
- CHG: Change
- C/O: change over
- CO2: Carbon Dioxide
- CRZ: Cruise
- CWS P: Control Wheel Steering Pitch
- DES: Descent
- DEV: Deviation
- DTG: Distance To Go (remaining track miles)
- F15: Flaps 15, F40 = Flaps 40 etc…
- FAF: Final Approach Fix
- FF: Fuel Flow
- FL: Flight Level
- F/O: First Officer
- FPM: Feet Per Minute
- ft: Feet (1ft = 0,3048m)
- FCOM: Flight Crew Operations Manual (Boeing)
- FCTM: Flight Crew Training Manual (Boeing)
- FMC: Flight Management Computer
- GA: Go Around
- GCA: Ground-Controlled Approach
- GOP: Good Operating Practice
- GPWS: Ground Proximity Warning System
- GS: Ground Speed
- HWC: Head Wind Component
- IAF: Initial Approach Fix
- ILS: Instrument Landing System
- IMC: Instrument Meteorological Conditions
- INTV: Intervention
- ISA: International Standard Atmosphere
- KIAS: Knots Indicated Air Speed
- KTS: Knots: nautical miles per hour. (1,852km/h)
- LDGF: Landing Fuel
- LH: Left Hand
- LVL: Level
- M: Mach
- MCP: Mode Control Panel
- MEA: Minimum Enroute Altitude

- Mmo: Maximum Mach Operating speed.
- MORA: Minimum Off Route Altitude
- MSA: Minimum Safe/Sector Altitude
- ND: Navigation Display
- NPA: Non Precision Approach.
- NM: Nautical Miles
- PAPI: Precision Approach Path Indicator.
- Pax: Passengers
- PF: Pilot Flying
- PFD: Primary Flight Display
- PM: Pilot Monitoring
- PNF: Pilot Non Flying
- RAAS: Runway Awareness and Advisory System
- RH: Right Hand
- ROD: Rate Of Descent
- RTE: Route
- SA: Situational Awareness
- SB: Speed Brake
- SL: Sea Level
- SOP: Standard Operating Procedure
- SPD: Speed
- SPD INTV: Speed Intervention
- STAR: Standard Arrival Route
- STD: Standard
- SRA: Surveillance Radar Approach.
- TAI: Thermal Anti Ice
- TAS: True Airspeed
- T/D: Top of Descent
- T.E.M.: Threat and Error Management
- TOD: Top Of Descent
- TS: Thunder storm
- TWC: Tail Wind Component
- UP-SPD: Up Speed. Vman-clean, min-drag-speed.
- VMC: Visual Meteorological Conditions
- Vmo: Maximum Operating limit speed.
- Vref.: Reference speed
- vs: Versus
- V/S: Vertical Speed
- Zzzz: Zzzzleeping Captain ☺, do not disturb!!!
