RED RADIALS

MAX PERFORMANCE MANOEUVERING BRIEF

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INTRODUCTION

This document is to discuss how to get the best out of your aeroplane in terms of max performance with application in the RR BFM environment. It is not exhaustive discussion but provides a common reference for all RR pilots. The document is based on the YAK52 and Nanchang. Both aircraft have similar performance though we have a range of engine powers from 285Hp through to 400hp with 360hp being the most common. In addition various props also affect performance.

In general terms the YAK52 is superior in Roll but inferior in ROC, Acceleration and particularly in slow speed handling. The YAK52 has an exclusive use of negative G and higher Vne than the Chang. Though the Chang will get to its Vne a lot quicker than the YAK. The YAK G limit 7G is greater than the Chang limit at 6G. (Though both based on similar Nzw).

AIRCRAFT LIMITS

Any discussion of Max performance manoeuvring requires discussion of aircraft and engine limitations. Recall that Rolling G reduces aircraft limits to around 2/3 of symmetrical G limits. With this in mind the RR limits have been chosen at +4/-1G.

With respect Engine limits they all apply though from a perf point of view all discussion is based on Max Continuous power (855/82%). It is imperative that usual engine monitoring is undertaken throughout the Max performance and BFM sequences. By its inherent nature high power and slow airspeed will result in CHT issues for the YAK52 and Oil temp issues for the Chang.

AIM OF MAX PERF MANV

So what do we mean by Max performance ?
Rate Of Climb (ROC)
ROC of climb is determined by Specific excess power (Ps). This in turn determines sustained turn performance. Now we all know our Best climb speed. This (for our purposes) is based on max rate of climb and therefore represents the best speed for Ps. It therefore also gives you close to the best speed for sustained turn performance. That is your best Turn rate without losing speed.... i.e the best speed to achieve maximum sustained G in level flight. Which at the levels we fly will be a modest 2-2.5G. Any more G and you will lose speed.

TURN PERFORMANCE

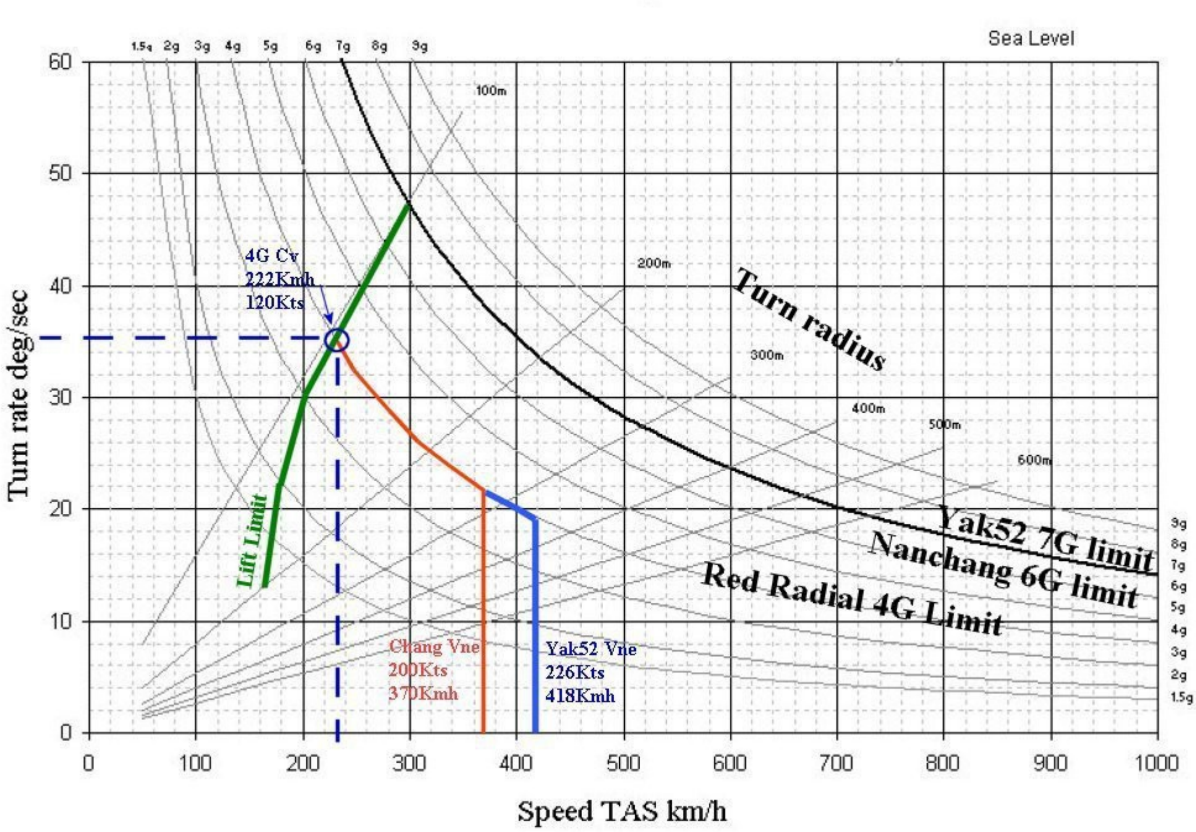
First up lets discuss the stall. Its important to understand that a wing does not stall at a speed it stalls at a specific AOA. We use speed as a means to reference this AOA since we don't have an AOA gauge. The speed we refer to is Power off 1G Stall speed. Stall speed will significantly reduce with higher power settings. For this discussion we will be referring to the 1G power off stall speed.

There are 2 types of turn Instantaneous and Sustained

INSTANTAENOUS

This is the maximum rate min radius you can achieve right now. It occurs at the lift limit. In other words to achieve it you smoothly pull to the lift limit … that is the first indication of Buzz. Unless you are descending you will loose airspeed. However regardless of speed riding the lift limit/buzz will give you your best rate at that speed. An interesting feature of flying the lift limit is that Turn radius is essentially constant regardless of speed. Turn rate however dramatically changes with speed whilst riding the lift limit. As IAS increases on the lift limit so does G and as a consequence so does your turn rate. There comes a point that as you ride the lift limit you will eventually reach your G limit (4G RR). This point represents the best turn rate you can achieve in your aeroplane. This is known as Instantaneous Corner Velocity or Cv. … It is a need to know speed. In addition your Cv for actual aircraft g limit is also a need to know speed … because at any speed higher than this an indiscriminate snatch on the poll will result in you exceeding your actual G limit.

Lets look at this on a Fan plot. This is a graph that is essentially a Vn diagram overlayed over a turn radius/G grid.

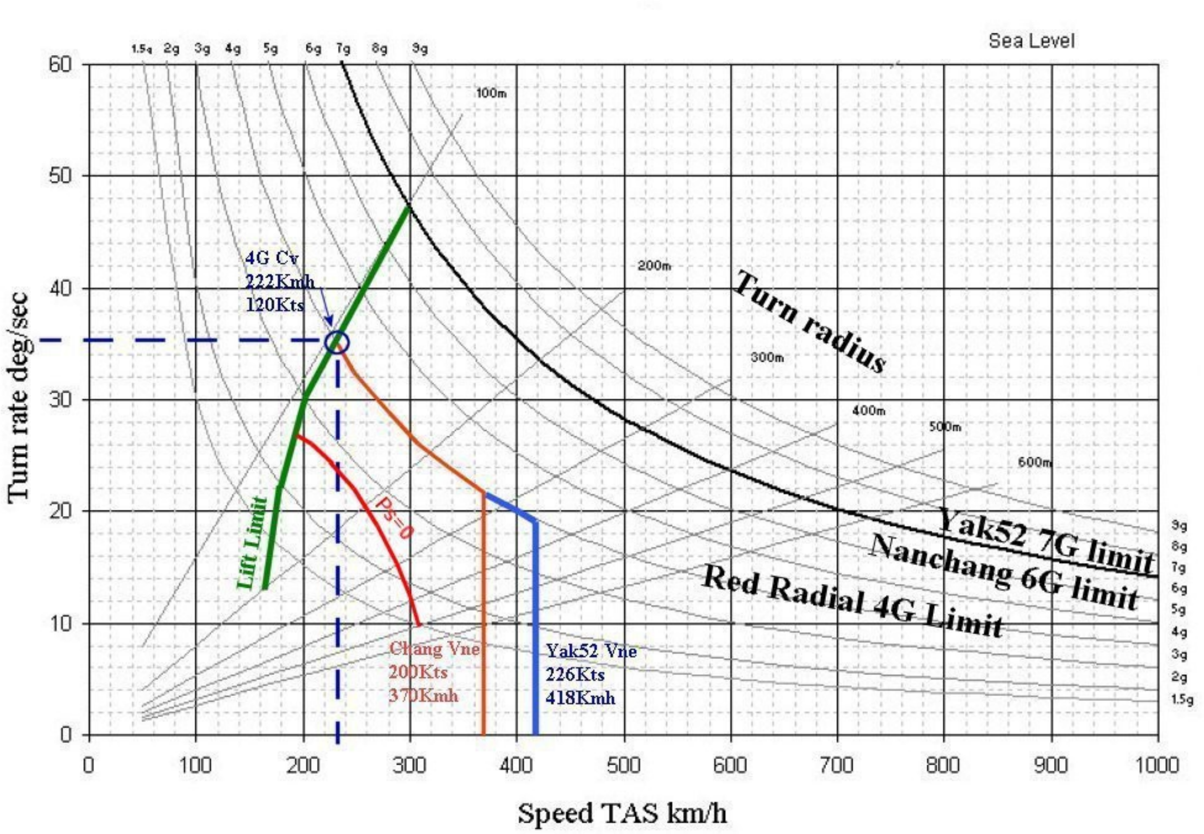


As you can see we have plotted the the flight envelope on the chart. The left edge represents the lift limit. The top of the chart is the G limit. Whilst the right hand chart is Vne. Inside the boundary represents the legal/RR flight envelope. Turn rate is the Y axis, TAS the X axis with G and turn radius lines the grid.

Looking at the left hand edge of the chart you can see the Lift limit. Note that as TAS increases both G and Turn rate increase whilst turn radius is essentially constant. The intersection of the lift limit and G limit defines Corner velocity ...i.e Cv 4G is 122 kts (222kmh) and Cv 7G is 162kts (300kmh). Chang 6G Cv 150Kts (278kmh). Also reading off the chart we can see that 4G Cv we are generating 35.5 degrees sec rate with a turn radius of just 110m. So immediately it becomes evident that with these values two aircraft manoeuvring against each other are going to be close ….. very close !

SUSTAINED TURN

The sustained turn is all about excess power Ps = V(T-D)/W. Ps to all intensive purposes represents instantaneous available ROC or (with a bit of maths) your instantaneous avail 1G acceleration rate. So essentially you want max power minimum weight at the highest speed achievable. The aim being to be able to sustain the best rate of turn without energy loss (Speed or height). Essentially we are using this to determine a speed to fly that will give us this performance. Assuming we are at this speed we are at limit performance ….i.e. Ps=0. It is possible to plot the Ps=0 boundary on the fan plot as well. It would look something like this:



The curve (red) I have drawn is very approximate as the data for the YAK52/Chang hasn't yet been obtained. The shape of this Ps=0 contour is very different for jet aircraft. In the piston engine case the ps=0 line is limited by the lift limit line. The Best speed for sustained turn performance will occur (for a piston engine aeroplane at the intersection of the lift limit line with the Ps=0 contour. In our approximate example this occurs at 96kts (175kmh)..... very close to the best ROC speed. Though we have used simplified data in this document it stands to reason the Chang will have slightly better sustained turn performance to the YAK.

So how do we apply all this ? First up know you 2 Cv speeds if you want to achieve your best turn rate then you need to do be at this speed on the lift limit and descending as required (that is a specific nose attitude below the horizon) to maintain this speed and also maintain the G. If faster than this speed then you need to reduce to it using nose position (since power is fixed). Its important to anticipate arrival at the speed and use bank to control nose position. Knowledge of and using canopy cues of the ideal nose position is essential. This will allow you to achieve an approximate nose position every time to give you the performance you are trying to achieve.

If you cant descend (i.e. at low altitude) then you are looking at a sustained level turn this will be achieved at the Ps = 0 speed.

RATE v RADUIS

As we can see that radius remains constant at the lift limit. However turn rate increases as speed and G increase on the lift limit. In general manoeuvring in BFM rate is the important factor.... since radius is essentially constant. You cant pull any more than the lift limit, regardless of speed radius remains constant whilst rate and G increase.

If not on the lift limit then radius will vary dramatically with speed. This is an academic consideration when specifically trying to achieve a specific turn radius.

AIRCRAFT HANDLING

Now that we are armed with the basic info lets now put this into practice in how we achieve this theory in the aeroplane.

Be aware that as IAS and power changes then so does the rudder requirement for balanced flight. In most cases we will be at a constant high power setting. Recall we are countering both Torque P factor and slipstream. As IAS decreases and AOA increase P factor increases, As IAS decreases slipstream effects increase. This means as IAS reduces progressively more LEFT rudder is required. At high power settings and very low IAS (like below 1G power off stall speeds) you may actually run out of rudder. Be aware that in any lift limit manoeuvring there is the chance of departure particularly if you are not balanced. In most occasions you should feel this coming as the aircraft will show a reluctance to keep turning the way you are going. A small reduction in back pressure will in most cases keep things going the way you want. If the aircraft departs then immediately centralise controls, if recovery is not immediate set the throttle to IDLE. If recovery does not occur then follow you aircraft's spin recovery technique.

To achieve max performance you need minimum drag. Not being balanced increases drag … keep the aeroplane balanced.

BUFFET/BUZZ

As we get to the stall aerodynamic buffet is felt. This represents the Lift limit. The Buffet in the Chang is more pronounced. Ideally you should be able to feel the degree of buffet. This is not easy in the YAK with its thin almost symmetrical aerofoil. The Chang on the other hand has a a fairly large degree of buffet feel. The place you want to be is right on the first indication of Buffet … ideally so subtle that it actually should be described as a “Buzz”. Once at this point your stick position is virtually constant as IAS and G change as you ride the lift line (AOA is constant).

This can be practised by rolling into a a turn (say about 50degrees of bank) at 100kias. Smoothly increase back pressure until the first tickle of buffet is felt, now holding constant stick position increase the bank slightly allowing the nose attitude to drop slightly holding on the buzz. Then reverse the process by reducing bank allowing the nose to rise still whilst holding on the buzz. Use rudder as required to keep the aircraft balanced. Things to note are that though speed changed backstick position was relatively constant. The aim of this exercise is that you develop the ability to fly the aircraft accurately on the buzz at any airspeed and attitude without fear of departing.

CLIMB
Use of the vertical especially max rate climbing is an essential part of BFM. Max rate climb is achieved at one airspeed. That is the speed quoted in the flight manual as your climb speed. This is a convenient speed as it also happens to be your best sustained turn speed. It typically occurs at 1.32Vimd.

Max Angle climbs will be achieved at a slightly slower speed. Recall that Max angle occurs at best lift Drag … very close to Vimd. So essentially will occur at your best glide speed. A typical application for Max Angle climb is in the horizontal scissors were you are trying to limit your forward travel and generate turning room in the vertical … esp for the aeroplane with better power to weight.

DRAG MINIMISATION
Drag is in most cases detrimental to performance so its important to know how to minimise it. First up keep the aircraft balanced, get your feet working and develop a feel for approximate pedal position versus airspeed.

UNLOAD FOR SPEED
Recall that Total drag comprises both Form/Profile drag and Lift dependent drag. If you are not producing lift you are not producing lift dependant drag. A quick way to reduce drag is to unload the aircraft to 0G (caution Changs oil pressure). At 0G lift dependant drag is zero. You know you are at zero G (or close to it) when you are light in the seat. Assuming altitude permits anytime you want knots then unloading is the most efficient way to do it. You can of course unload in any attitude.

ROLL
by nature of its design the YAK rolls a lot faster than the Chang. This allows the YAK to position its lift vector more rapidly than the Chang. A smart Chang driver shouldn't stay in a rolling scissors with a YAK:) however the Chang (because of Washout) has significantly better slow speed roll control than the YAK. So a smart YAK driver needs to be careful in a horizontal scissors with a Chang :) . Roll rates also vary with IAS. Max Roll rates will occur in 130kts (240kmh) area. Rudder can be used to increase roll rates significantly but does require a little finesse. In addition an unloaded aeroplane (0G not negative G) will also roll faster than one under G.

FLAP
Given the Chang and Yak only have an up or down position the flap is generally a straight out drag device. There is no advantage in deploying flap in terms of improving max performance. (Its prohibited by RR ROC anyway)

FLICK MANOEUVERS
Though the YAK52 is capable of flick manoeuvres as long as speed limits are adhered to there is no real tactical application of them. They are not considered in a tactical sense as a maximum performance manoeuvre. They are not permitted in any RR activity.

KNOWLWDGE AND TECHNIQUE

With a basic understanding of the principals and open discussion with fellow pilots and practice will allow you to get the best out of your aeroplane. The aim to become proficient in max perf handling on your own. Then once you start in the BFM environment you need to instinctively apply these methods

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