Federal Aviation Administration

Memorandum

Date: OCT 19 2010

To: Chas. Frederic Anderson, Manager, National Aeronautical Navigation Services, AJW-37

From: Leslie H. Smith, Manager, Flight Technologies and Procedures Division, AFS-400

Subject: Harmonized Flight Instrument Procedure Design Calculations

We received many questions reference to the official standard design airspeeds (V_{KIAS}) and formulas for determining true airspeed (V_{KTAS}), assumed tailwind (V_{KTW}), turn radius (R), and bank angles (ϕ). The current documents for RNAV and RNP SAAAR contain differing information since they were written at different times and the standard has evolved over time. The following table and formulae are the current standard for determining V_{KIAS}, V_{KTAS}, V_{KTW}, R, and ϕ for all instrument procedure design: conventional and performance based navigation (PBN).

1. Apply the following airspeed table:

Indicated Airspeed (Knots)						
Segment		Indicated Airspeed by Aircraft Category (CAT)				
		A	B	C	D	E**
Above 10,000 feet						
Feeder, Initial, Intermediate, Missed Approach, Departure		180	250	300	300	350
At/Below 10,000 feet						
Feeder, Initial, Intermediate		150	250			310
Final		90	120	140	165	250
Missed Approach (MA) Departure		110	150	240	265	310
Minimum Airspeed Restriction						
Minimum Airspeed Restriction*	Initial	110	140	210	210	310*
	Intermediate	110	140	180	180	310*
	Missed, Departure	100	130	165	185	310*
	Final	NA	NA	NA	NA	250

* The minimum speed restriction values are for use to reduce turn radius. Only one speed restriction per approach segment is allowed and the fastest airspeed appropriate for the highest speed category of aircraft serviced by the approach procedure must be used to determine the speed. AFS-400 or appropriate military authority approval is required when more than one speed restriction is required for a particular approach segment (e.g. initial, intermediate, missed approach). AFS-400 or appropriate military authority approval is also required for missed approach airspeed restrictions when used for other than obstacle/terrain avoidance requirements. **Publish a chart note indicating the maximum or minimum Catergory E airspeed as appropriate.

2. Use Order 8260.54A, formula 2-3a, for True Airspeed calculation.

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Pseudo Code:
start
Remark:  Calculate true airspeed (V_KTAS) in knots per hour
(1)    input V_KIAS is indicated airspeed
             alt is the highest expected altitude in the operation
(2)    V_KTAS=round((V_KIAS*171233*sqrt(303-0.00198*alt))/
                    (288-0.00198*alt)^2.628,0)
Remark:  303 is the value for ISA at MSL (15°C) on the Kelvin scale
         (288K=0°C,+15°C=303K)
end
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3. Use Order 8260.54A, formula 2-3b, for Tailwind calculation.

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Pseudo Code:
start
Remark:  Calculate tailwind component (V_KTW) in knots per hour
(1)    input alt is the highest expected altitude in the operation
             apt_elev is the airport elevation of record
(2)    if (alt-apt_elev)≤2000 then
             V_KTW=30
       else
             V_KTW=round(0.00198*alt+47,0)
       end if
end
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4. Use Order 8260.54A, formula 2-3c, for turn radius calculation for all except use 18° for optimum bank angle (ϕ) for all categories below 19,500 and 5° for 19,500 and above.

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Pseudo Code:
start
Remark:  Calculate turn radius (R) in nautical miles
(1)    input V_KTAS is the result of formula 2-3a above
             alt is the highest expected altitude in the operation
             apt_elev is the airport elevation of record
             ϕ is the effective turn bank angle
             β is magnitude of heading change in degrees}
Remark:  First, determine ground speed in knots per hour (V_ground)
(2)    if alt>19,500 then
             V_ground=round(min(570,0.9941*alt/100+287),0)
       end if
       if alt≥10,000 and alt≤19,500 then
             if (V_KTAS+V_KTW)>500 then
                   V_ground=500
             else
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                    Vground= VKTAS+VKTW
              end if
        end if
        if alt<10,000 then
              Vground= VKTAS+VKTW
        end if
(3)     R=round(Vground^2/(tan(ϕ*pi/180)*68625.4),2)
        If R*tan(β/2*pi/180)>20 then
              R=20/tan(β/2*pi/180)
        end if

end
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5. Use Order 8260.54A, formula 2-8, for RF Bank Angle calculation.

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Pseudo Code:
start
Remark:  Calculate bank angle (ϕ) in degrees given radius in NM, VKTAS
         and VKTW in knots per hour
(1)     input alt is the highest expected altitude in the operation
              aptelev is the airport elevation of record
              VKTAS is the result of formula 2-3a above
              VKTW is the value from formula 2-3b above
              R is the given turn radius
Remark:  First, determine ground speed in knots per hour (Vground)
(2)     if alt>19,500 then
              Vground=round(min(570,0.9941*alt/100+287),0)
        end if
        if alt≥10,000 and alt≤19,500 then
              if (VKTAS+VKTW)>500 then
                    Vground=500
              else
                    Vground= VKTAS+VKTW
              end if
        end if
        if alt<10,000 then
              Vground= VKTAS+VKTW
        end if
(3)     ϕ=round(atan(Vground^2/(R*68625.4))*180/pi,0)
end
```

If you have any questions, please contact Mr. Harry Hodges, Manager, Flight Procedure Standards Branch, AFS-420, at (405) 954-4164.