DTTB System Doppler and Flutter Character

- This presentation seeks to explain some of the questions, particularly in the area of dynamic multipath DTTB character.

Some questions are :

(1) What are the mechanics of Flutter ?

(2) What amount of flutter or doppler freq. needs to catered for?

DTTB Transmission

The aspects, mechanics and impact of "Flutter" on DTTB reception

DTTB Transmission
Revisiting "DOPPLER Shift"

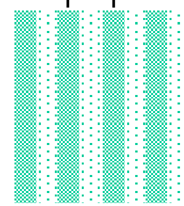
Vt

Whistle (f)

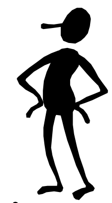
Vs

Decreased period
Hence increased frequency

F= f + f * Vt / Vs



C R C R C R C R



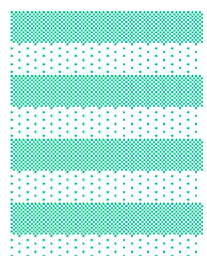
Vto = Vt

Explanation : *While a "compression" of sound is in the air it is followed by another, but closer, aided by the speed of the train.*

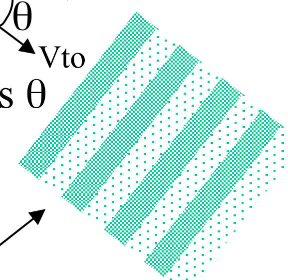
Vt = Speed of train
Vs = Speed of sound (constant)
Vto = Observed speed of train
f = frequency of whistle
F = Observed frequency
C = Compression
R = Rarefaction

θ Vt
Vto

Vto = Vt * cos θ



Vt θ Vto



Period between the "compressions" are partially modified by the speed of the train

Vto = Vt * cos θ

Period between the "compressions" are unmodified by the speed of the train

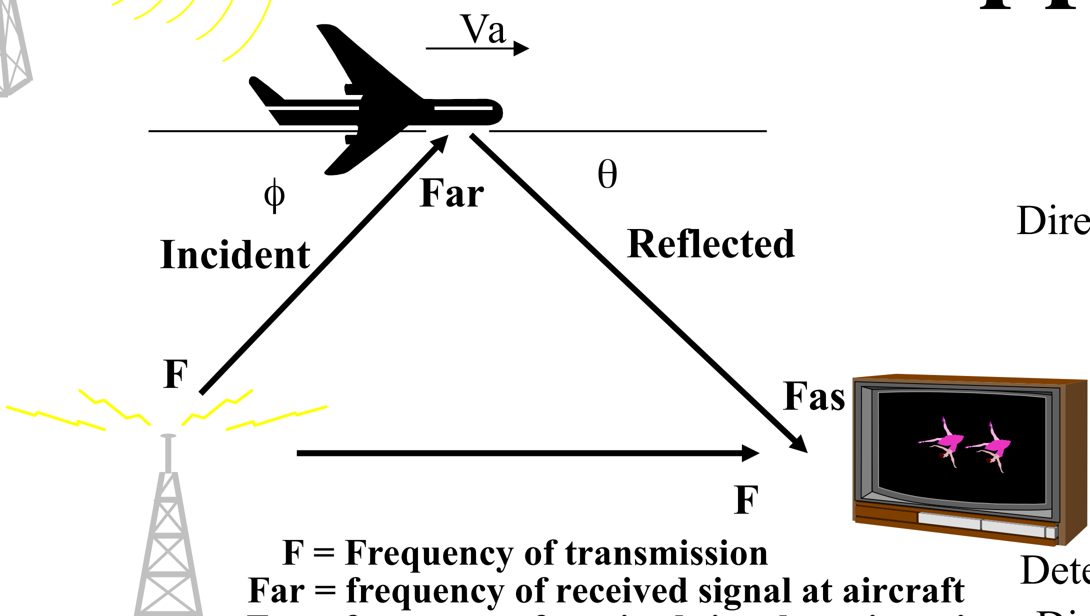
Vto = o

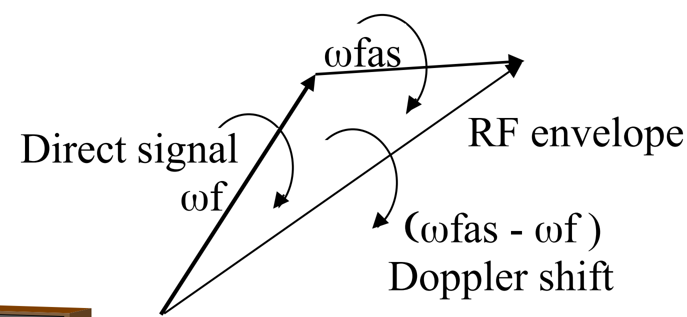
F= f + Cos θ * f * Vt / Vs - for approaching

F= f - Cos θ * f * Vt / Vs - for departing

Doppler shift

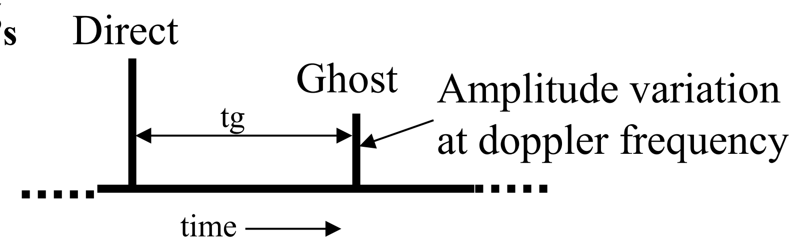
The mechanics of Aircraft Flutter - Doppler Shift





F = Frequency of transmission
Far = frequency of received signal at aircraft
Fas = frequency of received signal, at viewer's TV receiver, sent from aircraft.
Va = Speed of aircraft
c = Speed of light (constant)

Detected video signal :



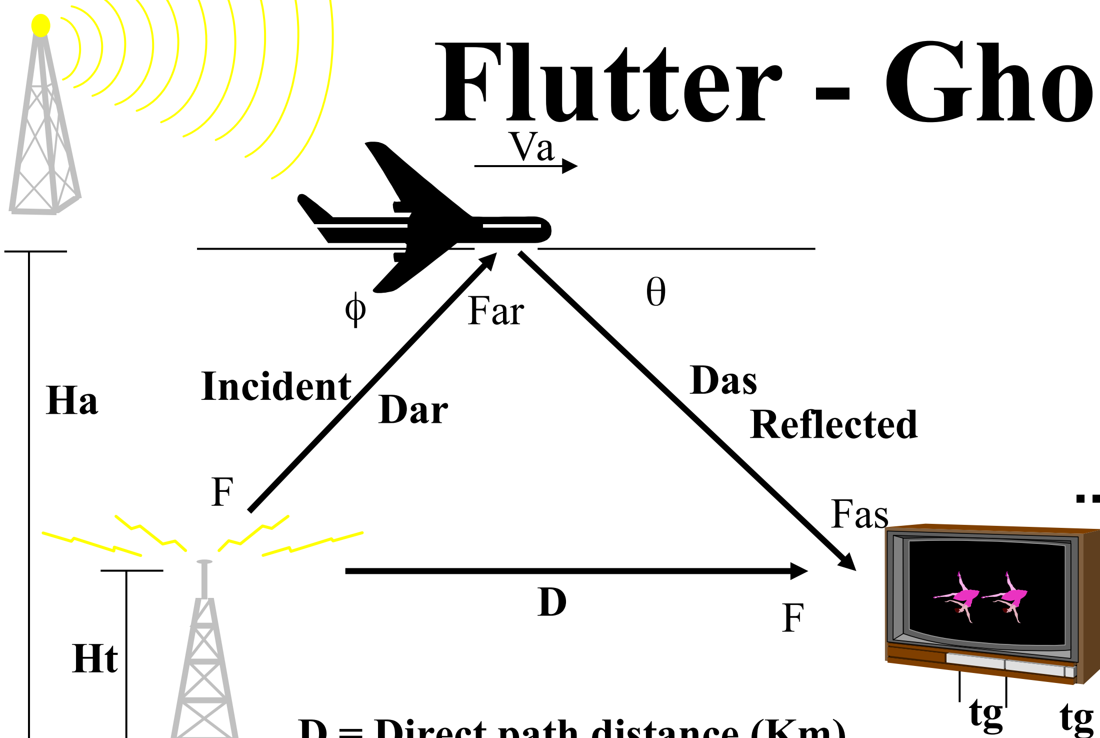
Far = F - F * Cos ϕ * Va / c

Fas = Far + Far * Cos θ * Va / c

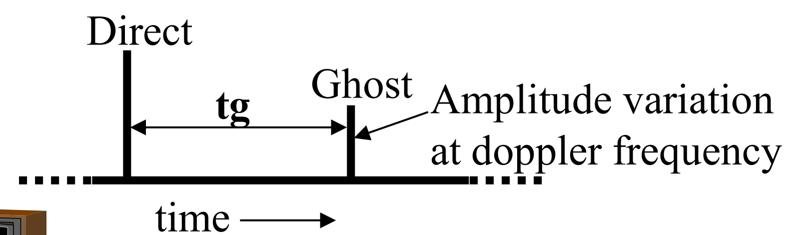
As (F * Cos ϕ * Va / c) <<< F :

Fas = F - F * Cos ϕ * Va / c + F * Cos θ * Va / c
ie : Fas = F + sum of doppler shifts

The mechanics of Aircraft Flutter - Ghost Timing



Detected video signal :



D = Direct path distance (Km)
Dar = Distance fron Tx to aircraft (Km)
Das = distance from aircraft to receiver (Km)
tg = time to ghost from direct signal (uSec)
c = Speed of light = 3 x 10^8 m/sec = 0.3Km / uSec

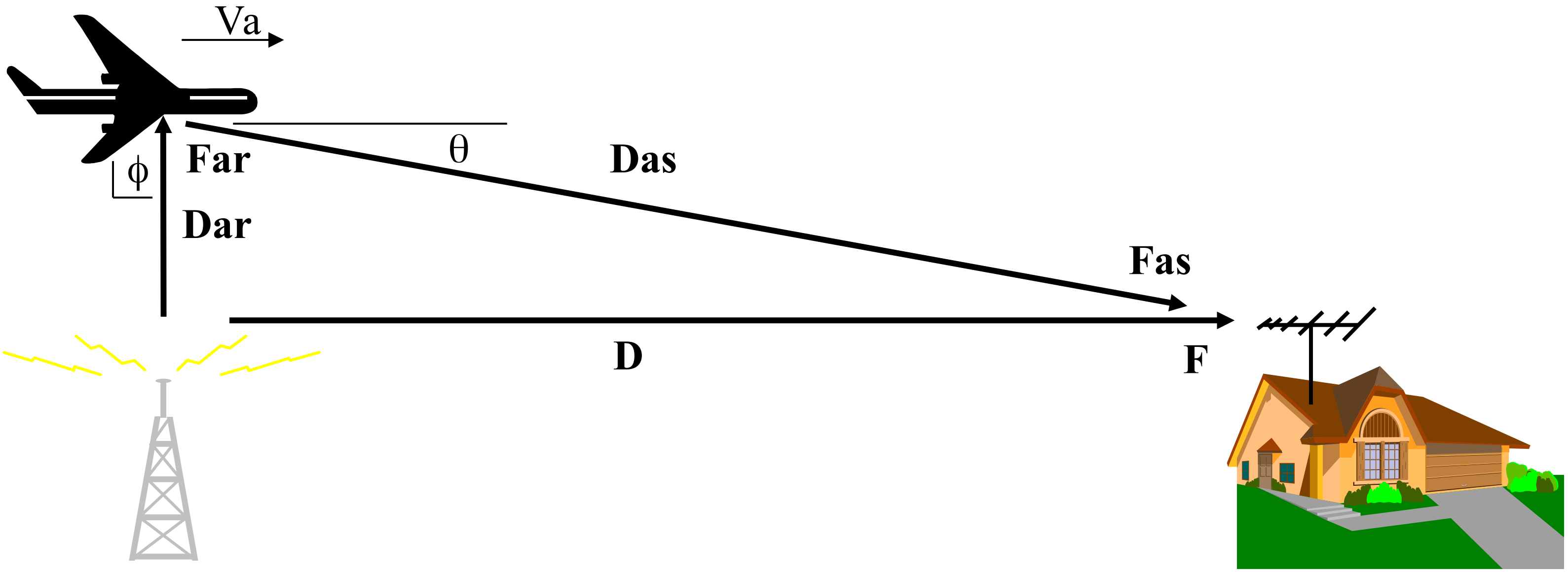
tg = in-direct path delay - direct path delay
= (Dar + Das) / c - D / c
= (Dar + Das - D) / c

Dar = (Ha - Ht) / Sin ϕ
Das = (Ha - Ht) / Sin θ

tg = (Dar + Das - D) / 0.3 uSec

Note : 1. When ϕ = θ there will be maximum reflected signal.
2. As the aircraft path is not obscured by terrain the potential for a large ghost is high.

DTTB Transmission Aircraft Flutter *Scenario 1*



Fas = F - F * Cos ϕ * Va / c + F * Cos θ * Va / c

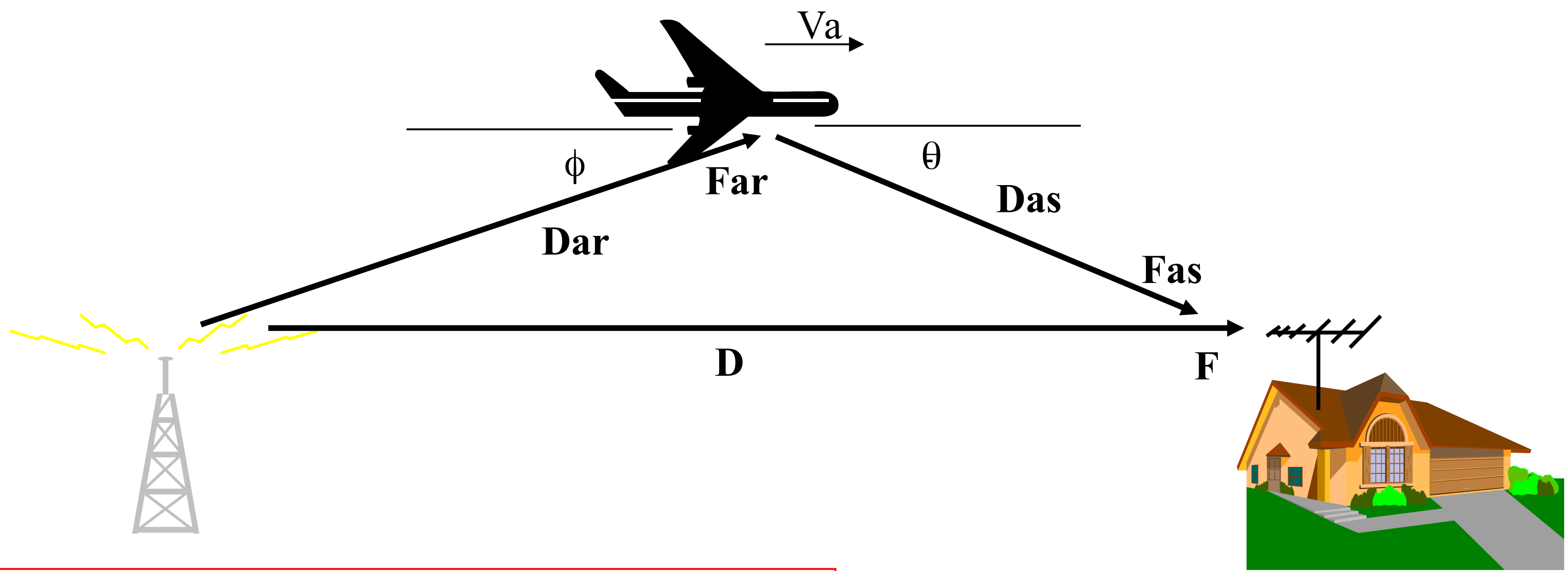
As Cos ϕ = 0 (ϕ = 90 degs.)

Fas = F + F * Cos θ * Va / c

Doppler shift (F * Cos θ * Va / c)

tg = (Dar + Das - D) / 0.3 uSec

DTTB Transmission Aircraft Flutter *Scenario 2*



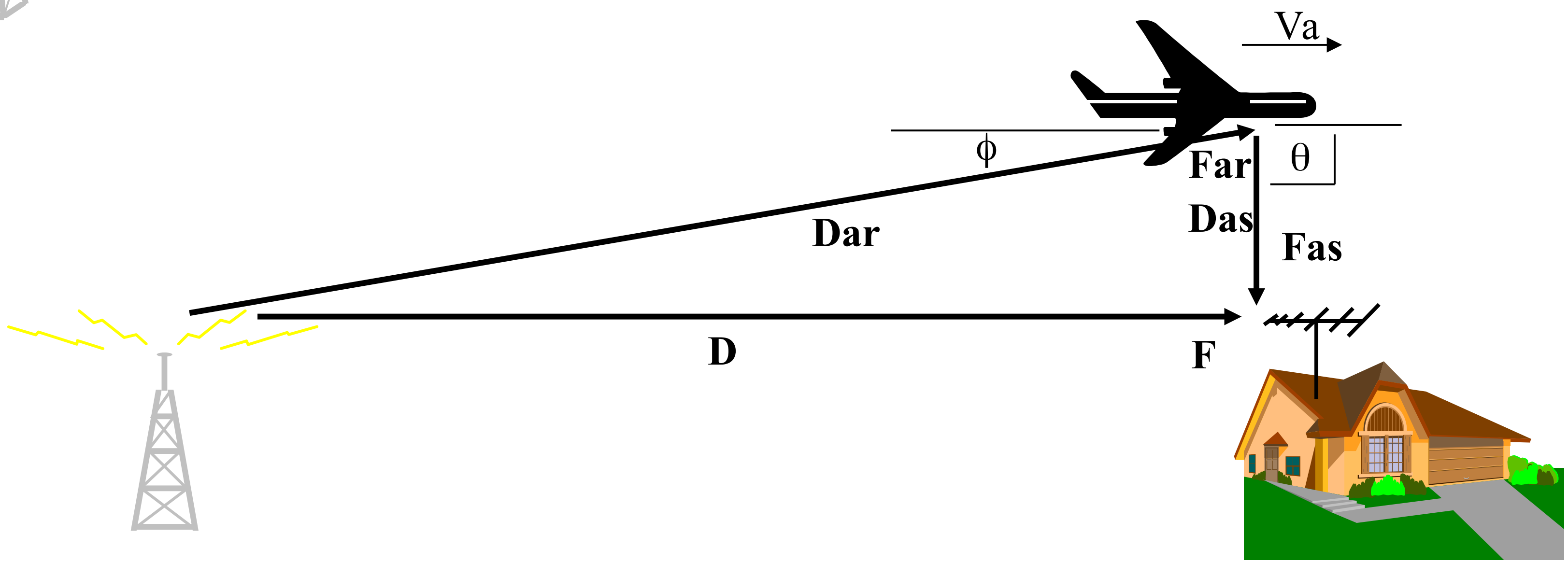
$$Fas = F - \underbrace{F * \cos\phi * Va / c + F * \cos\theta * Va / c}_{\text{Doppler shift}}$$

$$tg = (Dar + Das - D) / 0.3 \text{ uSec}$$

NOTE : There are competing doppler shifts.

If $\phi = \theta$ Fas = F ie There will be no resultant doppler shift

DTTB Transmission
Aircraft Flutter *Scenario 3*



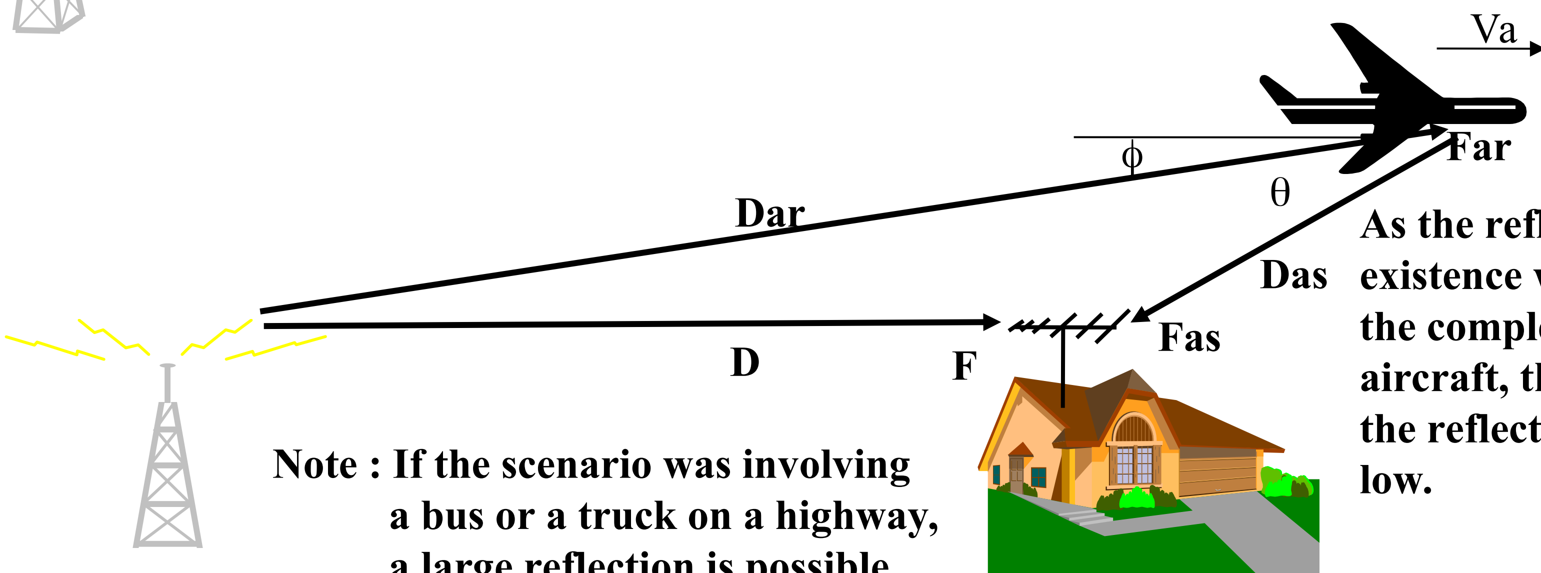
$$Fas = F - F * \cos\phi * Va / c + F * \cos\theta * Va / c$$

As $(F * \cos\theta * Va / c) = 0$ $(\theta = 90 \text{ deg.})$

$$Fas = F - \underbrace{F * \cos\phi * Va / c}_{\text{Doppler shift}}$$

$$tg = (Dar + Das - D) / 0.3 \text{ uSec}$$

DTTB Transmission
Aircraft Flutter *Scenario 4*



As the reflected path's existence will rely upon the complex detail of the aircraft, the magnitude of the reflected signal may be low.

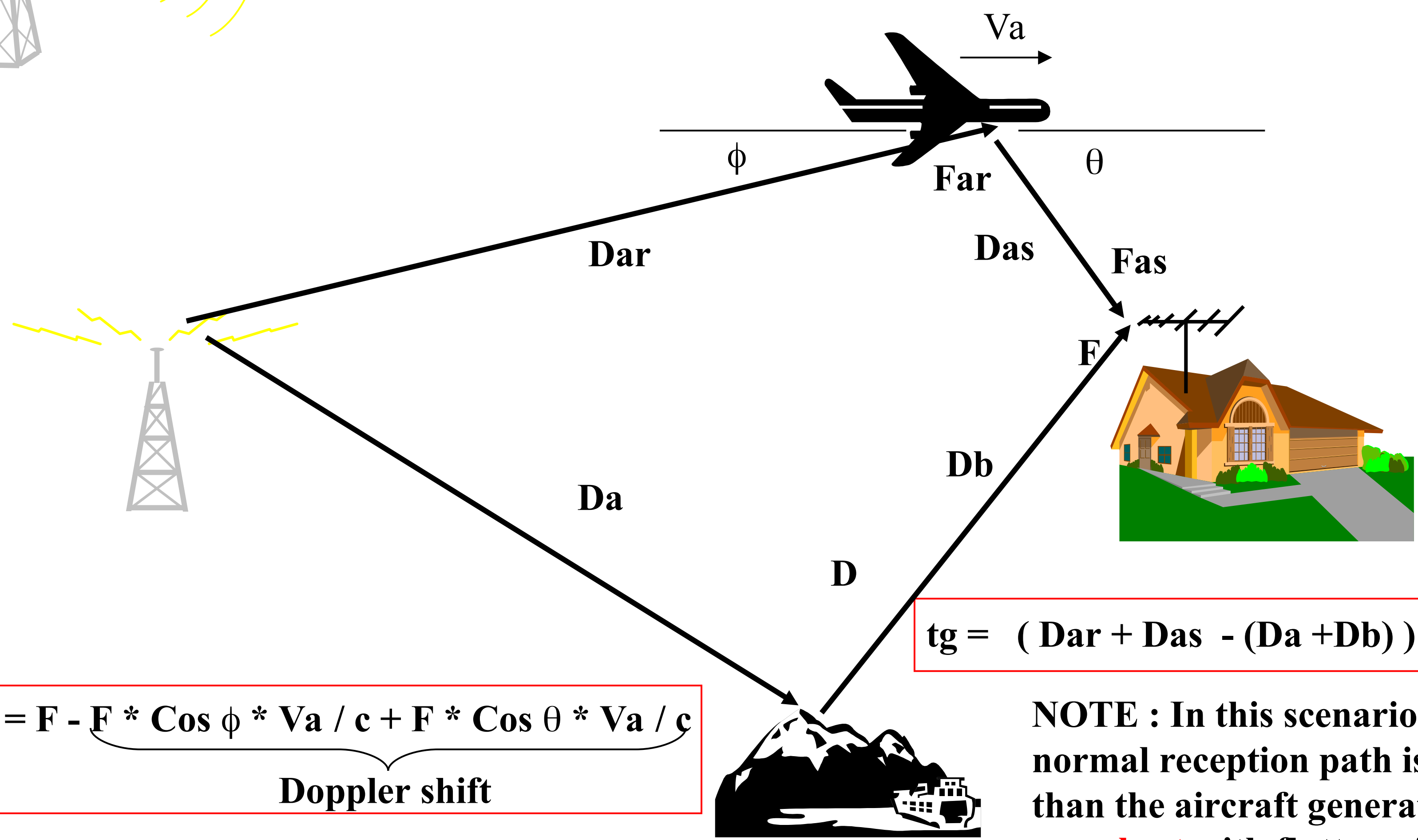
Note : If the scenario was involving a bus or a truck on a highway, a large reflection is possible.

$$Fas = F - \underbrace{F * \cos\phi * Va / c - F * \cos\theta * Va / c}_{\text{Doppler shift}}$$

$$tg = (Dar + Das - D) / 0.3 \ \text{uSec}$$

NOTE : There are adding Doppler shifts

DTTB Transmission
Aircraft Flutter *Scenario 5*



$$tg = (Dar + Das - (Da + Db)) / 0.3 \ uSec$$

$$Fas = F - \underbrace{F * \cos\phi * Va / c + F * \cos\theta * Va / c}_{\text{Doppler shift}}$$

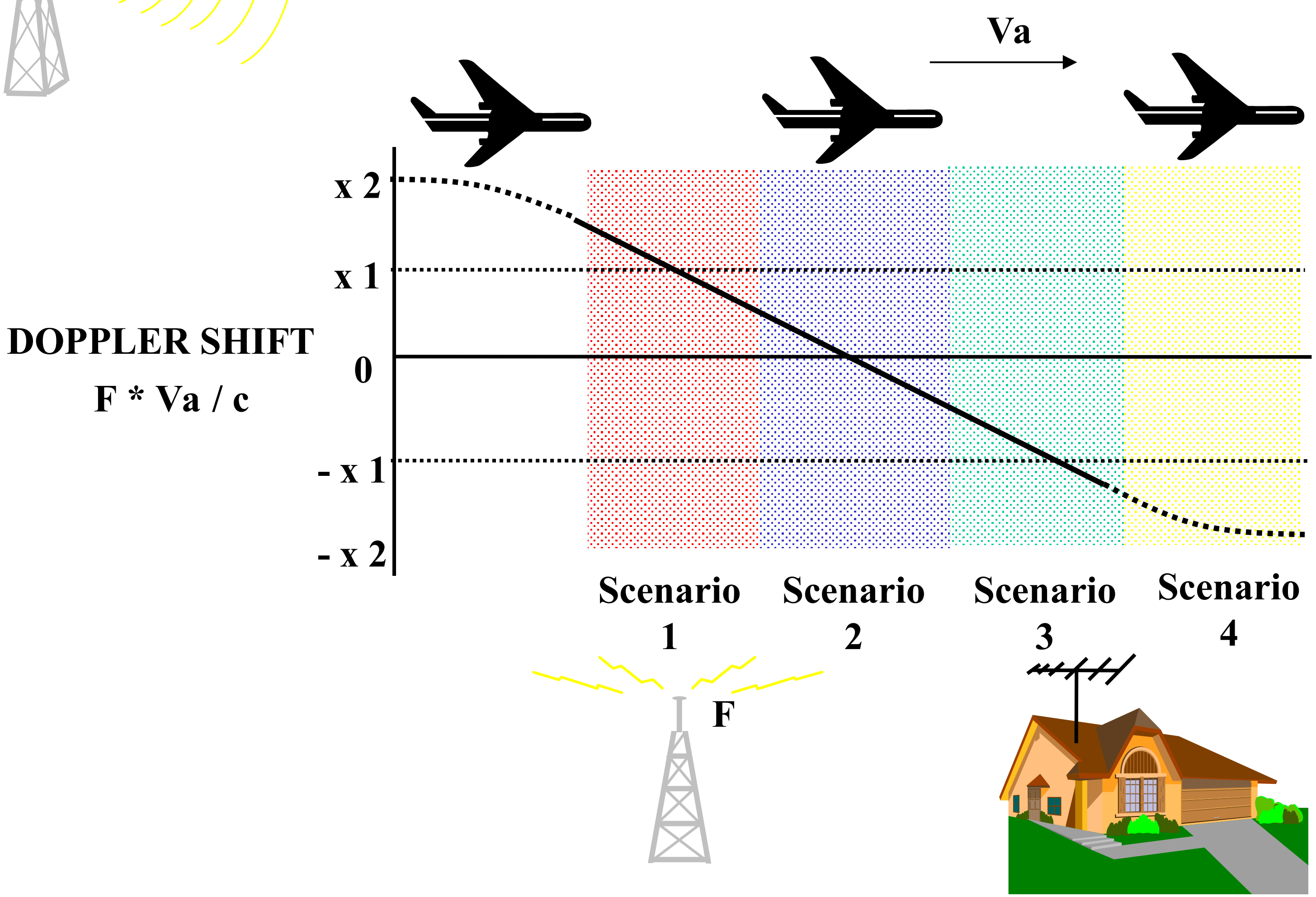
NOTE : In this scenario, when the normal reception path is longer than the aircraft generated path, a pre-ghost with flutter will exist.

Notes on Aircraft Flutter Scenarios

Notes on the Scenarios :

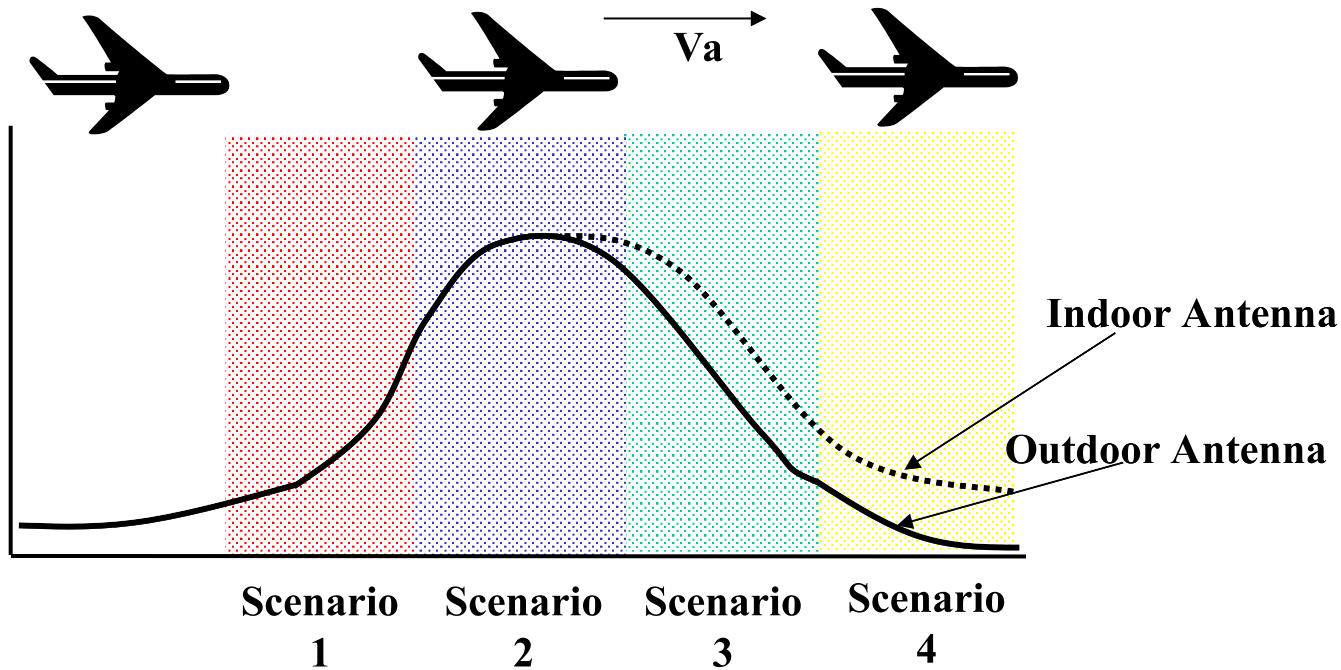
- 3 - D environments will reduce the doppler shifts related to the angle of the aircraft to the 2- D Scenarios shown
- The 2 - D scenarios shown are the worse case
- Maximum reflection is likely to occur when the Incident angle equals the Reflected angle..The doppler shift is then zero.
- The magnitude of the reflections when there is un-equal Incident and Reflected angle will depend upon the complex shape of the aircraft or vehicle, gain (front ,side and rear) of the receive antenna.
- The magnitudes of the reflections from the aircraft have the potential of being high compared to the terrain obstructed and ground cluttered direct path.

DTTB Transmission
Aircraft Doppler Summary



Note : Scenario 5 is all above but with a Pre - ghost.

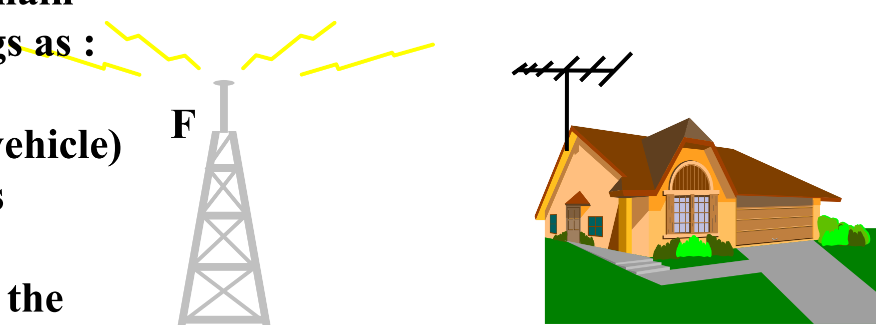
Ghost Amplitude Variation of Aircraft Flutter



This curve is an example of the possible level variations of the ghost with the position of the plane and hence with time.

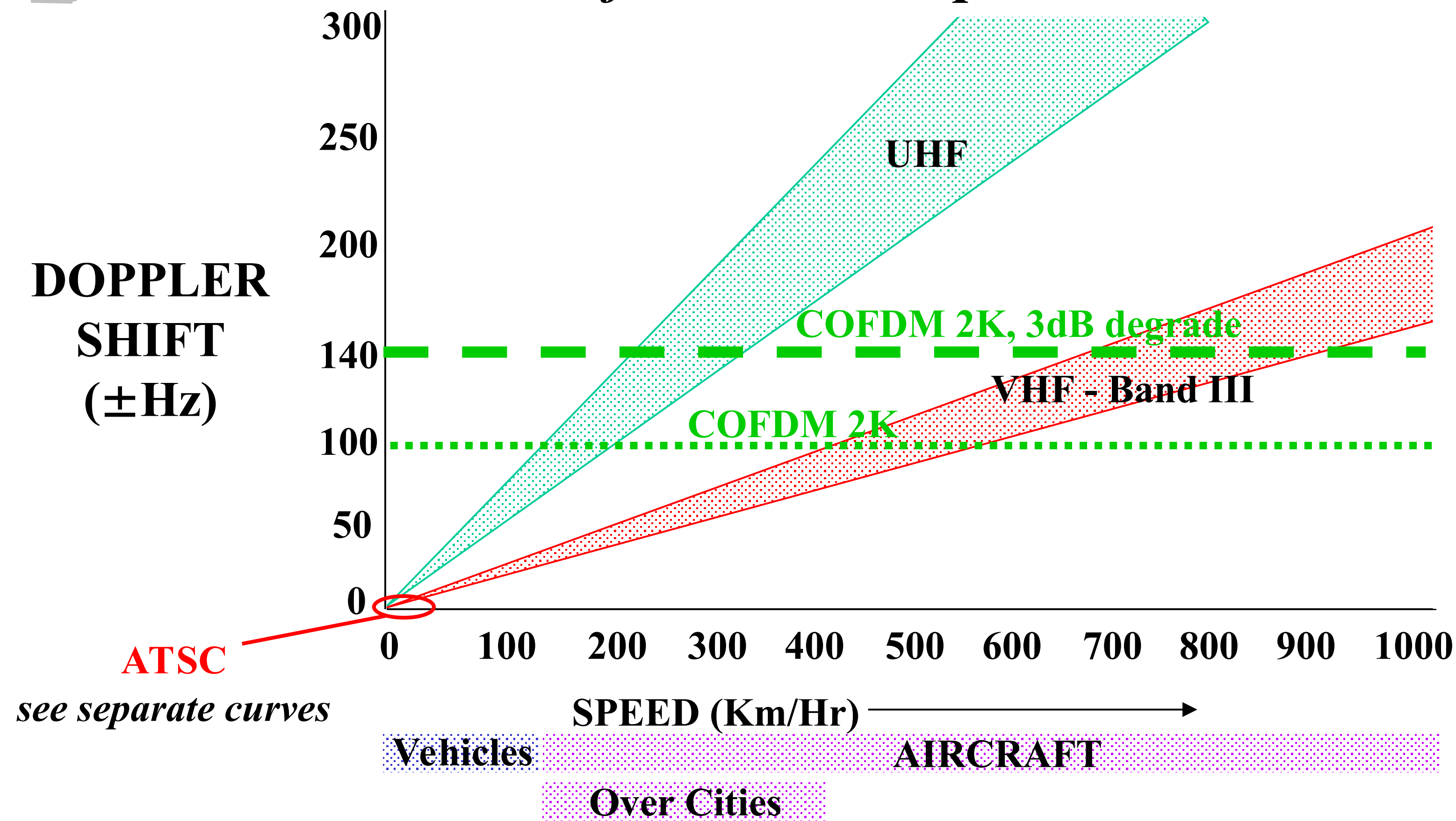
The amplitude relationship with respect to the main direct path with time is influenced by such things as :

- **height of aircraft**
- **reflection efficiency from aircraft (or vehicle) related to incident and reflected angles**
- **receive antenna characteristics**
- **the extent of the terrain obstruction of the main direct path.**



DTTB Systems Doppler Performance Limits

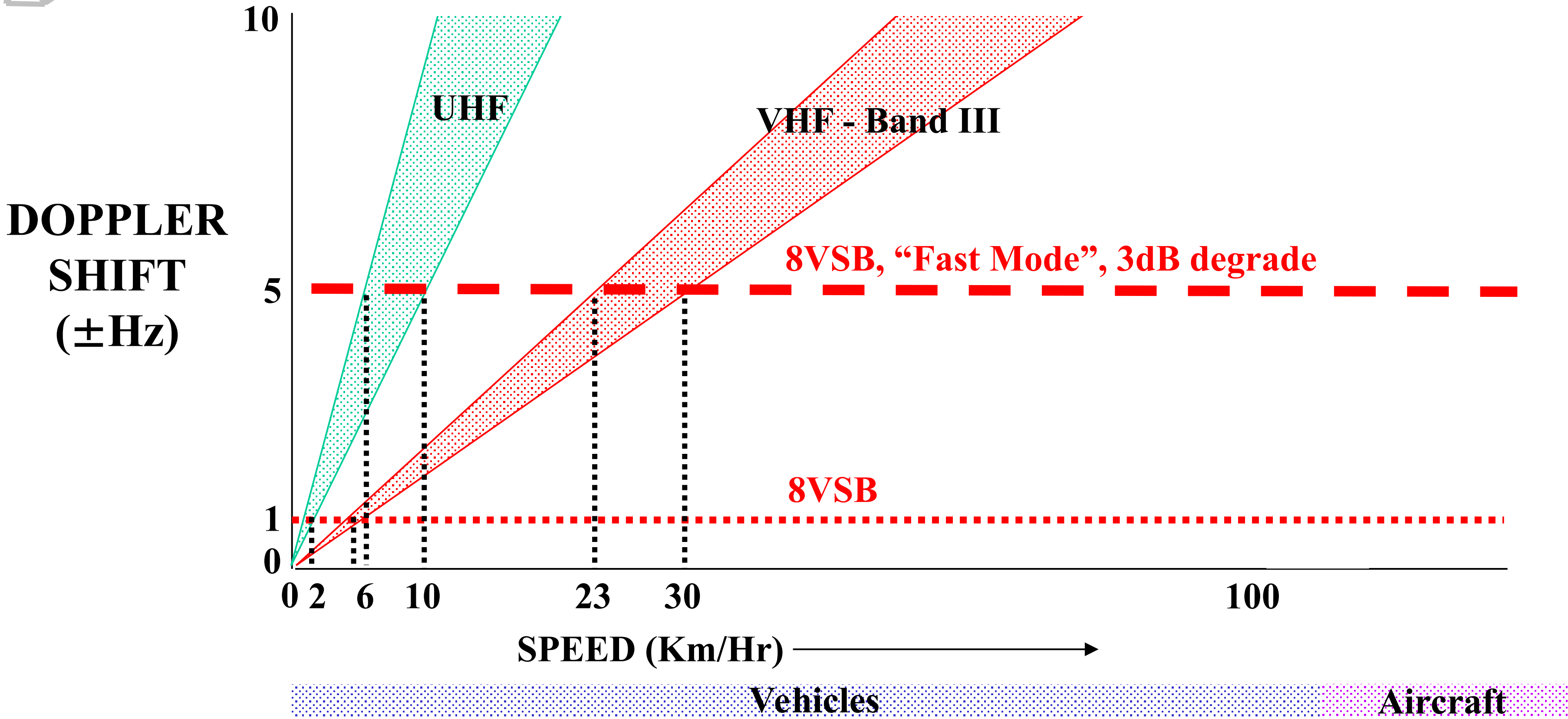
for current implementations



COFDM implementations will inherently handle post and pre-ghosts equally within the selected guard interval.

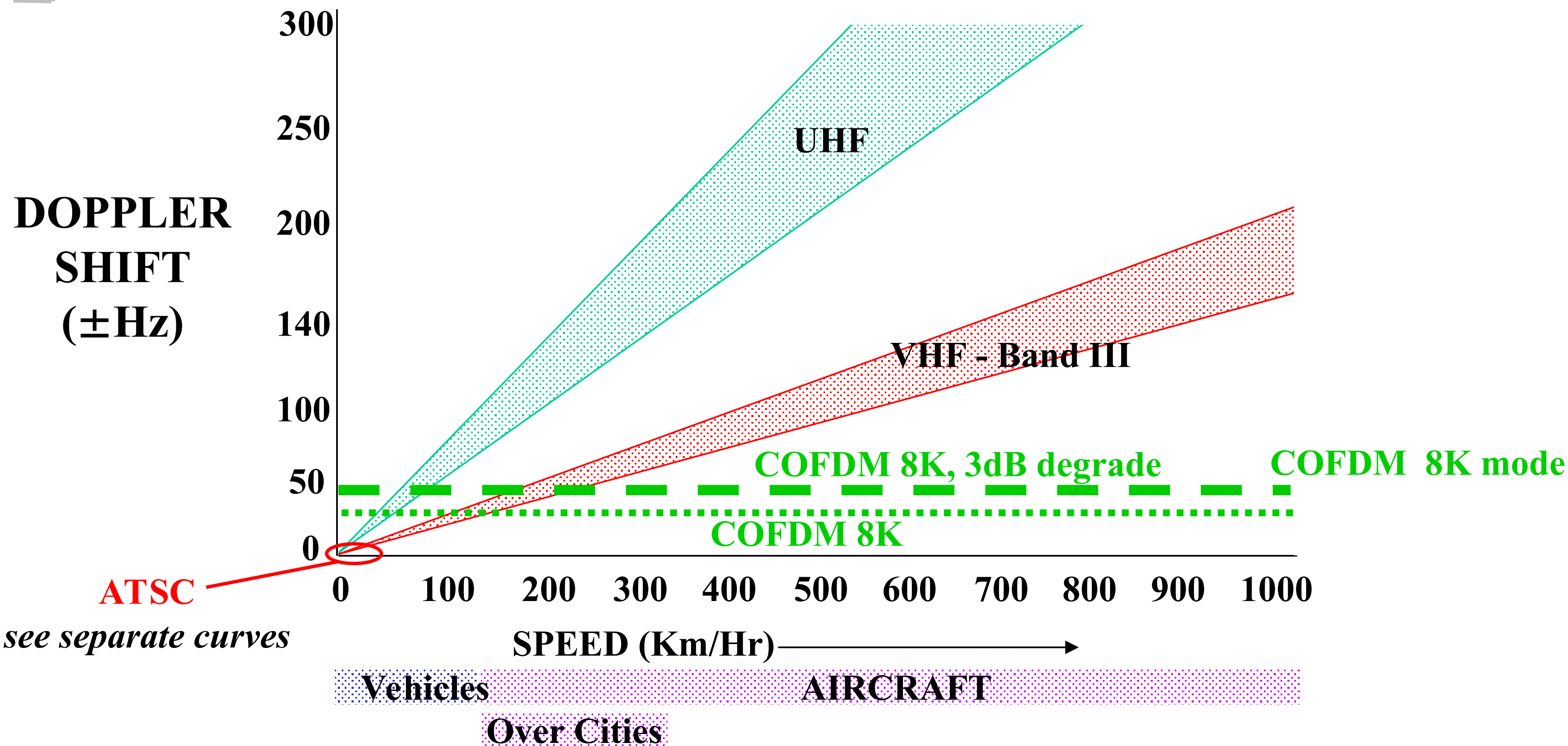
ATSC 8-VSB Doppler Performance Limits

for current implementations



8VSB implementations of equalisers are likely to cater for post ghosts up to 30 uSec and pre-ghosts up to 3 uSec <u>only</u>.

DVB-T COFDM 8K Doppler Performance Limits



COFDM implementations will inherently handle post and pre-ghosts equally within the selected guard interval.

Doppler Performance Outcomes

Outcome from scenarios :

- **When the Doppler shift is maximum the amplitude of the ghost is low.**
- **When the amplitude is maximum the Doppler shift of the ghost is low.**
- **Up to full Doppler shift with the amplitudes in the range that will affect the DTTB systems (>-15dB echo) may be common.**

DTTB Systems
Doppler Shift Range

Doppler shift range :

- **Up to 160 to 250Hz doppler shift will be experienced over the UHF band.**
- **Up to 55 to 75Hz doppler shift will be experienced over the VHF band.**
- **Up to 20 and 70Hz doppler shift will be experienced from vehicles in urban areas in the VHF and UHF bands respectfully.**

DTTB Transmission Aircraft Flutter Behaviour

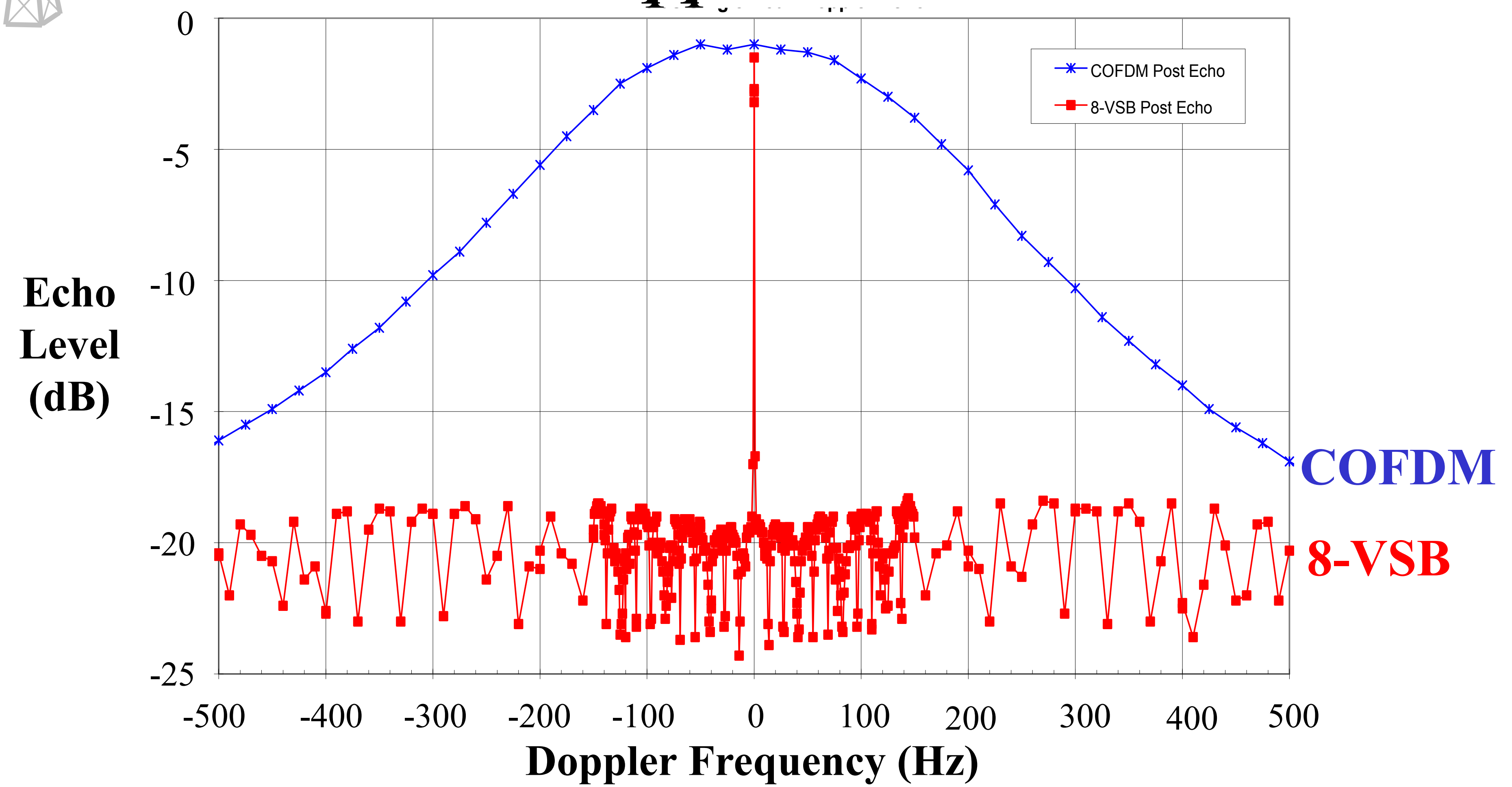
DTTB system performance :

- The **COFDM 2K** system will allow up to **300Hz** doppler shift
- The **COFDM 8K** system may allow up to **75Hz** doppler shift
- The **8VSB** system may allow up to **5Hz** doppler shift

before the picture and the sound is interrupted.

DTTB system Laboratory Doppler Tests

Doppler Echo



8VSB standard mode (1Hz nom.) Fast mode - not shown (5Hz nom.)

Aircraft Flutter & Doppler Perfomance Conclusion

DTTB system performance :

- **The COFDM 2K system is OK for VHF and UHF reception conditions.**
- **The COFDM 8K system is OK for VHF reception conditions.**
- **The 8VSB system is highly susceptible to any flutter from either Aircraft or vehicles.**

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