International Flight Inspection Symposium
Oklahoma City, OK USA June 2008

Testing of ILS Receivers in a Multipath Propagation Environment

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Introduction

- FI receivers are not dedicated measurement equipment but mostly aviation type *)
- Current Calibration *)
  - generators providing static, non-interfered signals
  - Complex scenarios are excluded
- Improvement of receiver characteristics
  - achieved through use of reproducible interfered RF environment
  - Example: ILS Localizer reception

*) ICAO references, remarks overleaf

Introduction (cont‘d)

*) **ICAO DOC8071** states:

4. FLIGHT INSPECTION RECEIVERS AND RADIO COMMUNICATION EQUIPMENT

4.1 Flight inspection receivers are to be of the highest quality in order to obtain the accuracy required for flight inspection purposes and should provide additional measurement outputs specific to flight inspection [..]

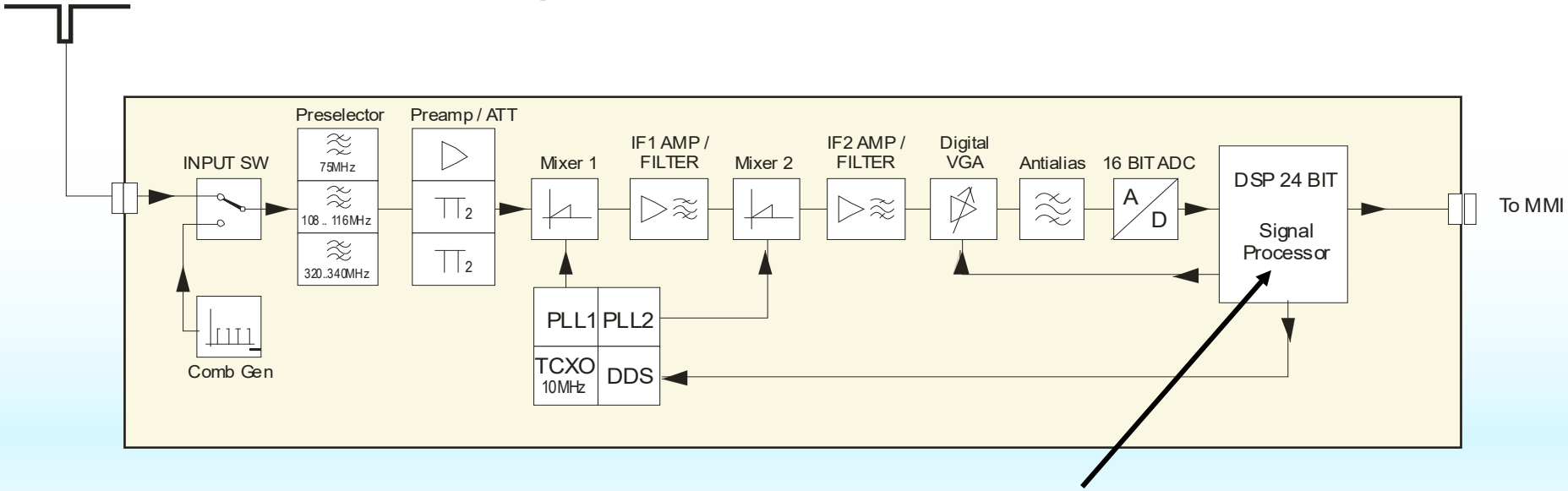
Calibration of test equipment

1.12.10 [..] A test transmitter is connected to the radio frequency (RF) input of the receiver in order to input simulated signals. The receiver output is compared with the nominal signals; deviations are recorded either in a test protocol or in the memory of a computer [..]

Current receiver techniques

Mature Super-Heterodyne Principle in combination with IF A/D sampling

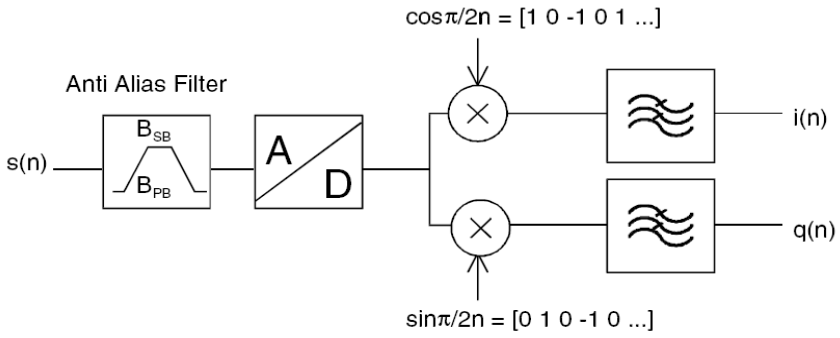
Example: R&S®EVS300



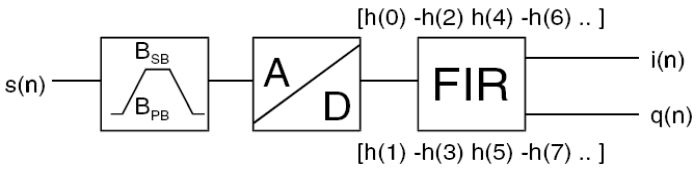
I/Q demodulation and data reduction performed by DSP or FPGA

Current receiver techniques

Digital Down Converter with $f_{IF} = f_S/4$



A



B

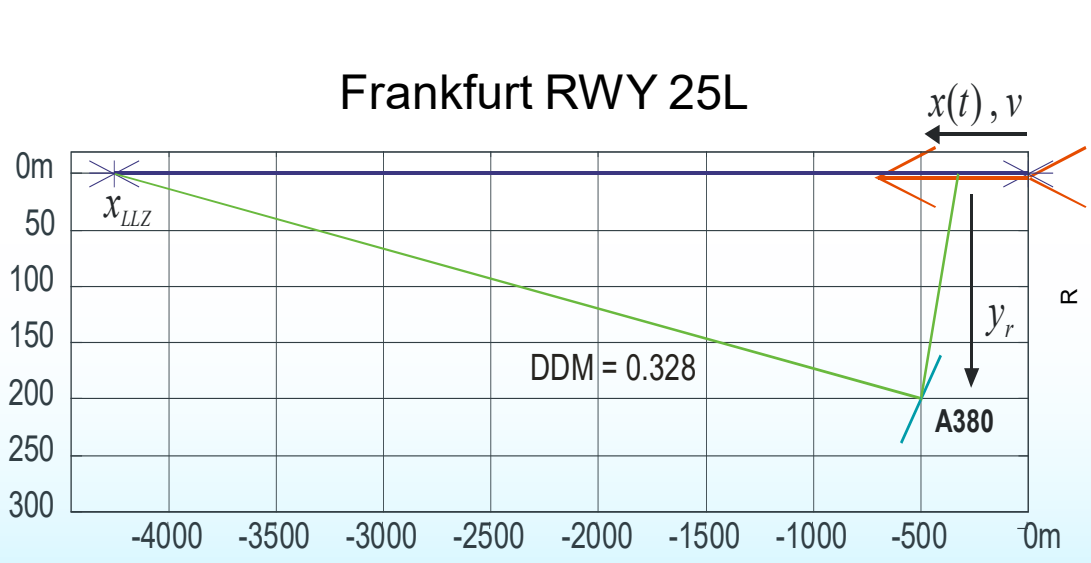
B: IF undersampling at twice the signal bandwidth

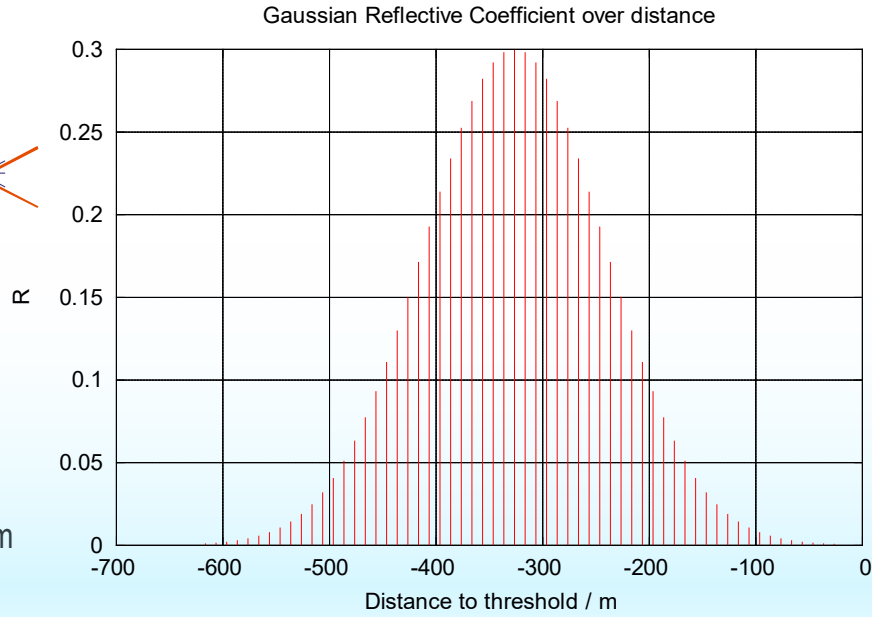
Derivation of Signal-in-Space

- Reference multipath scenario
  - taken from the Frankfurt A380 measurement campaign at a specific position on taxiway S (close to threshold 25L, turn 23°)
  - Derivation of maximum reflection coefficient
- Modelling constraints
  - simple A380 reflection simulation to obtain a roughly realistic interfered signal model - not to replace complex modelling!
  - Patterns of both the LLZ and the receiving antenna are not considered
  - Process of reflection is approximated by Gaussian pulse

Geometry on airport surface

Simplified Reconstruction of A380 tailfin reflection



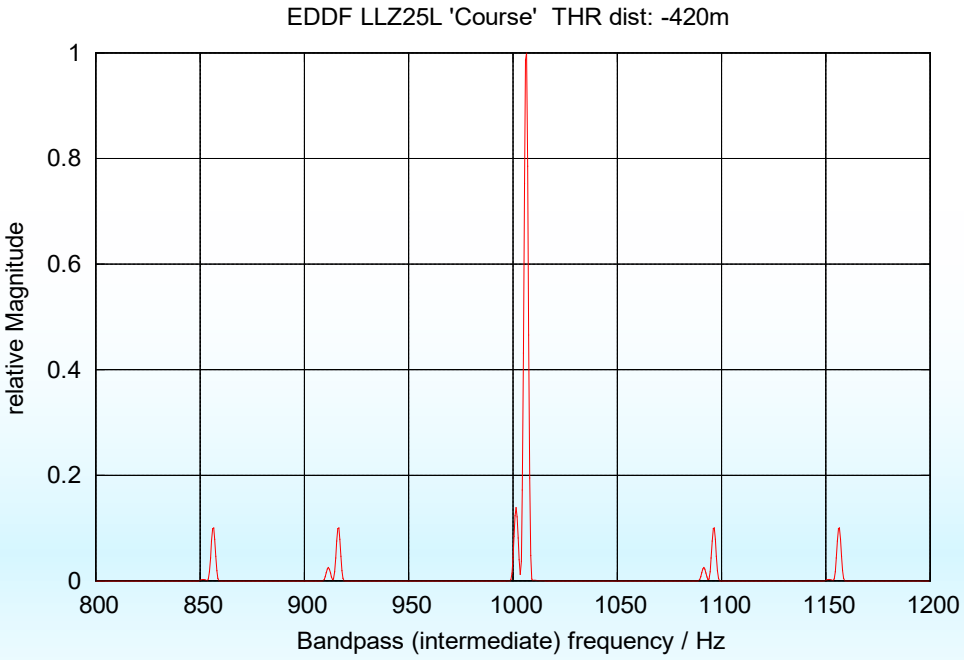


Reflection coefficient approximated by Gaussian pulse

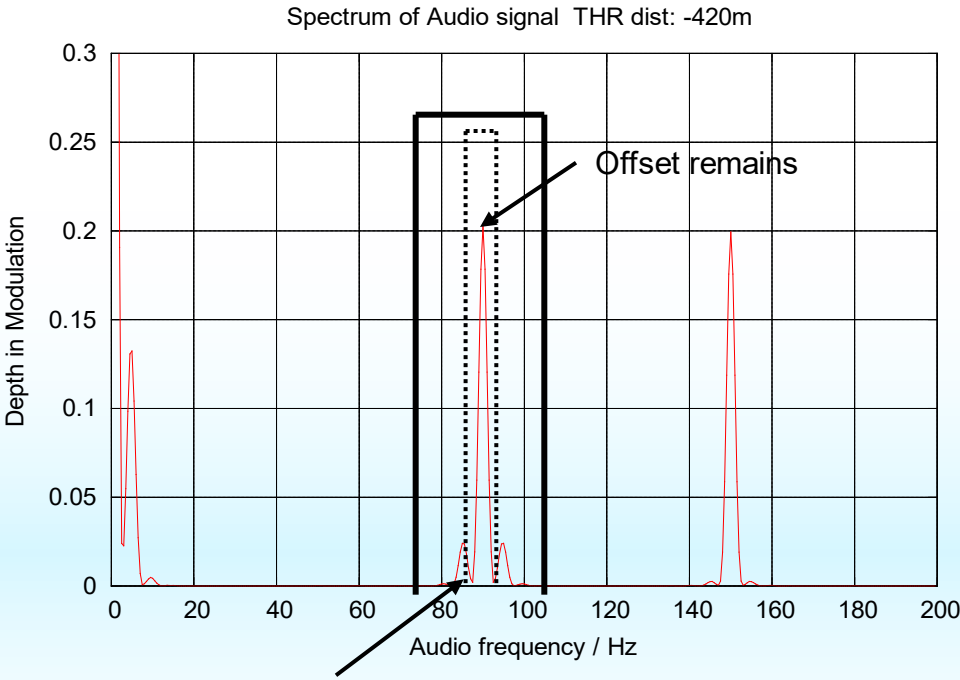
Simulated Signal-in-Space

IF (bandpass) vs. Audio (baseband) absolute spectrum

Transition is non-linear operation



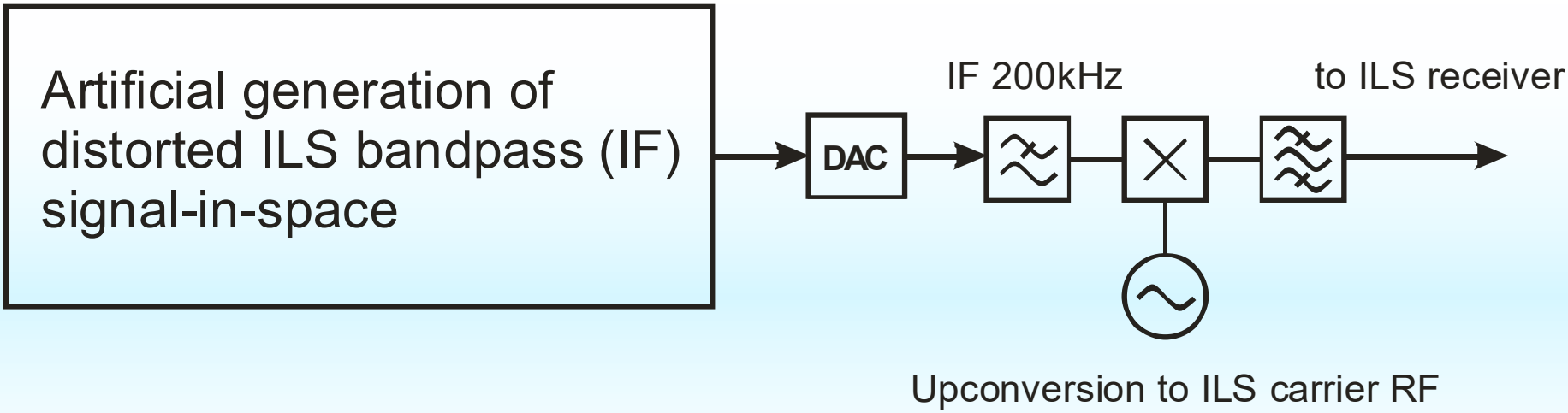
Reflection of carrier and 90Hz sidebands becomes visible



2nd order sidebands causing scallopings when within filter bandwidth

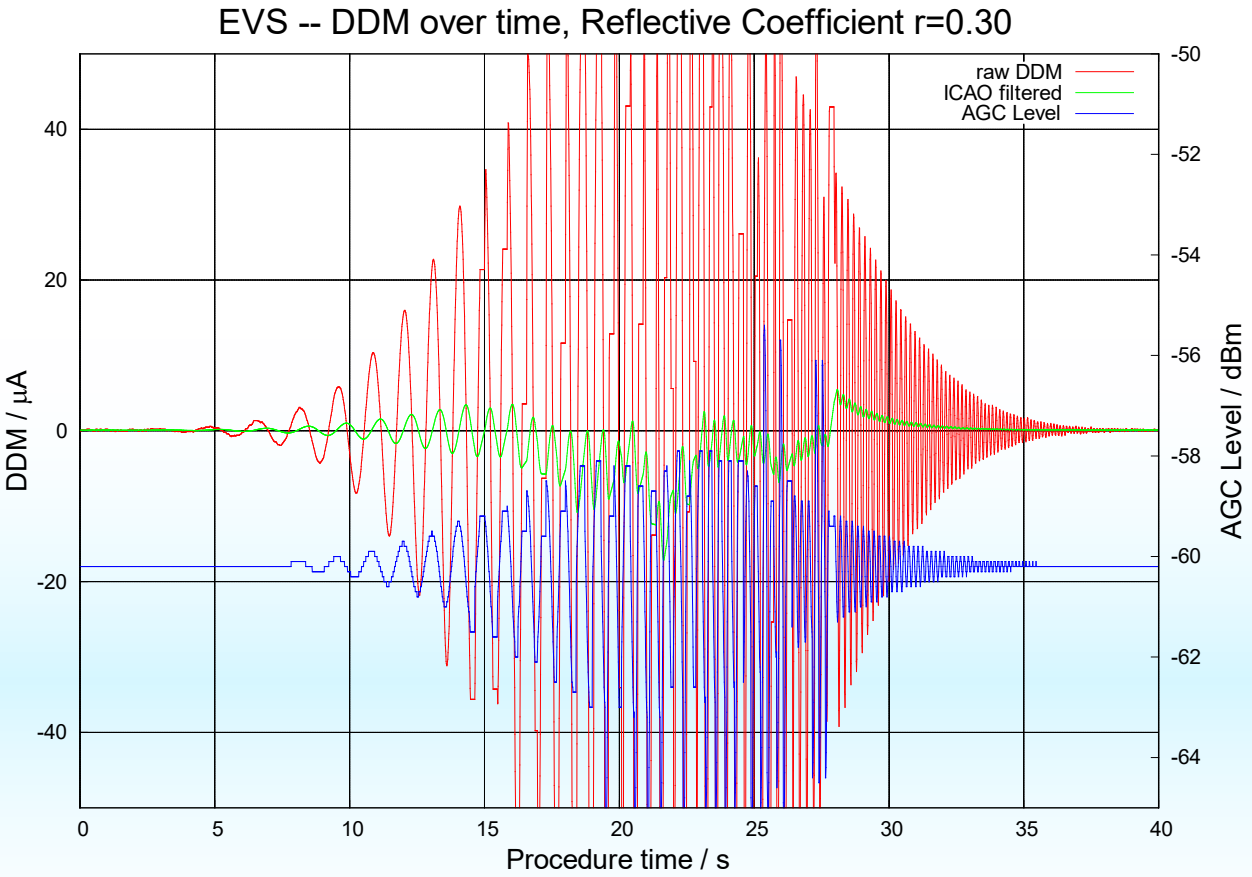
RF signal synthesis

- Arbitrary ILS generator delivers multipath affected RF signal to be fed into real receivers



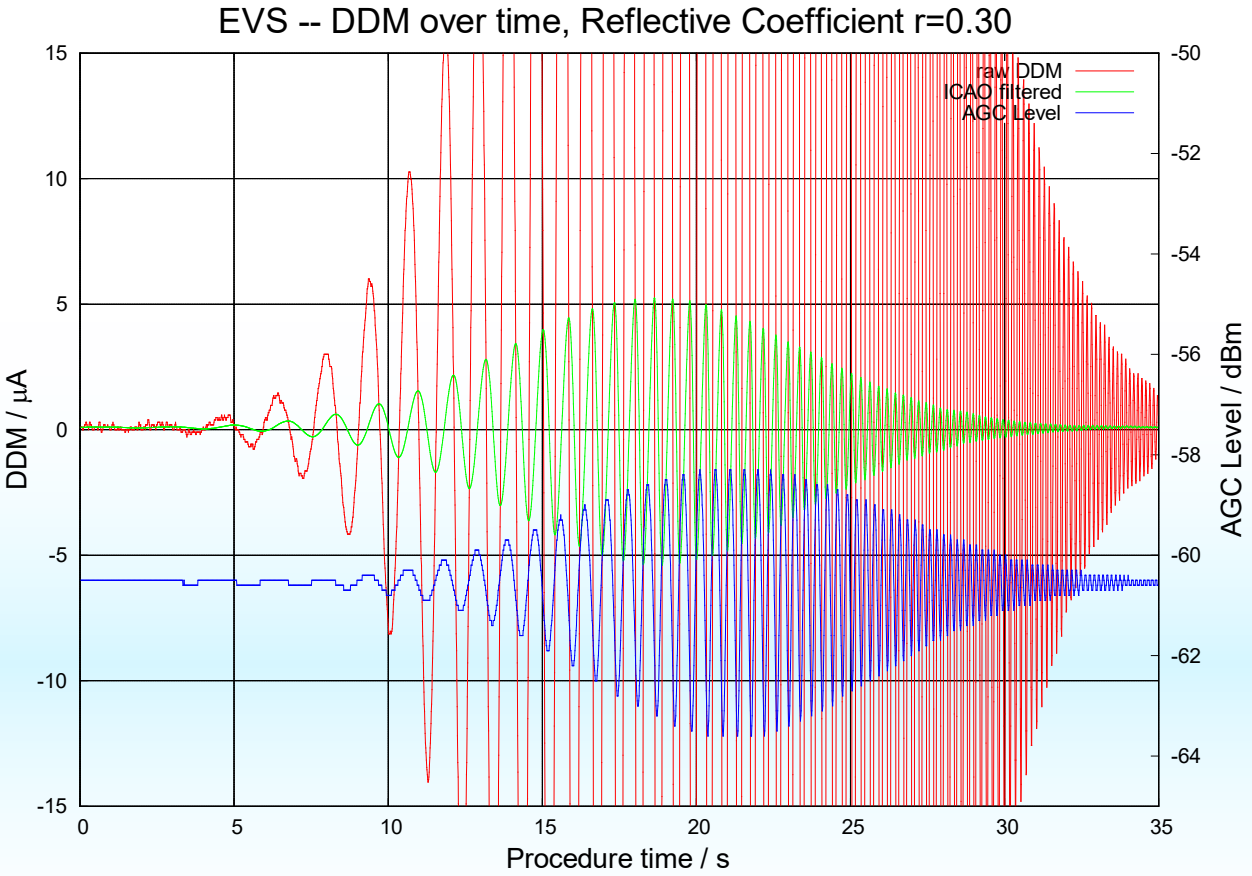
Receiver investigations

Optimizing AGC parameters: Wrong hysteresis



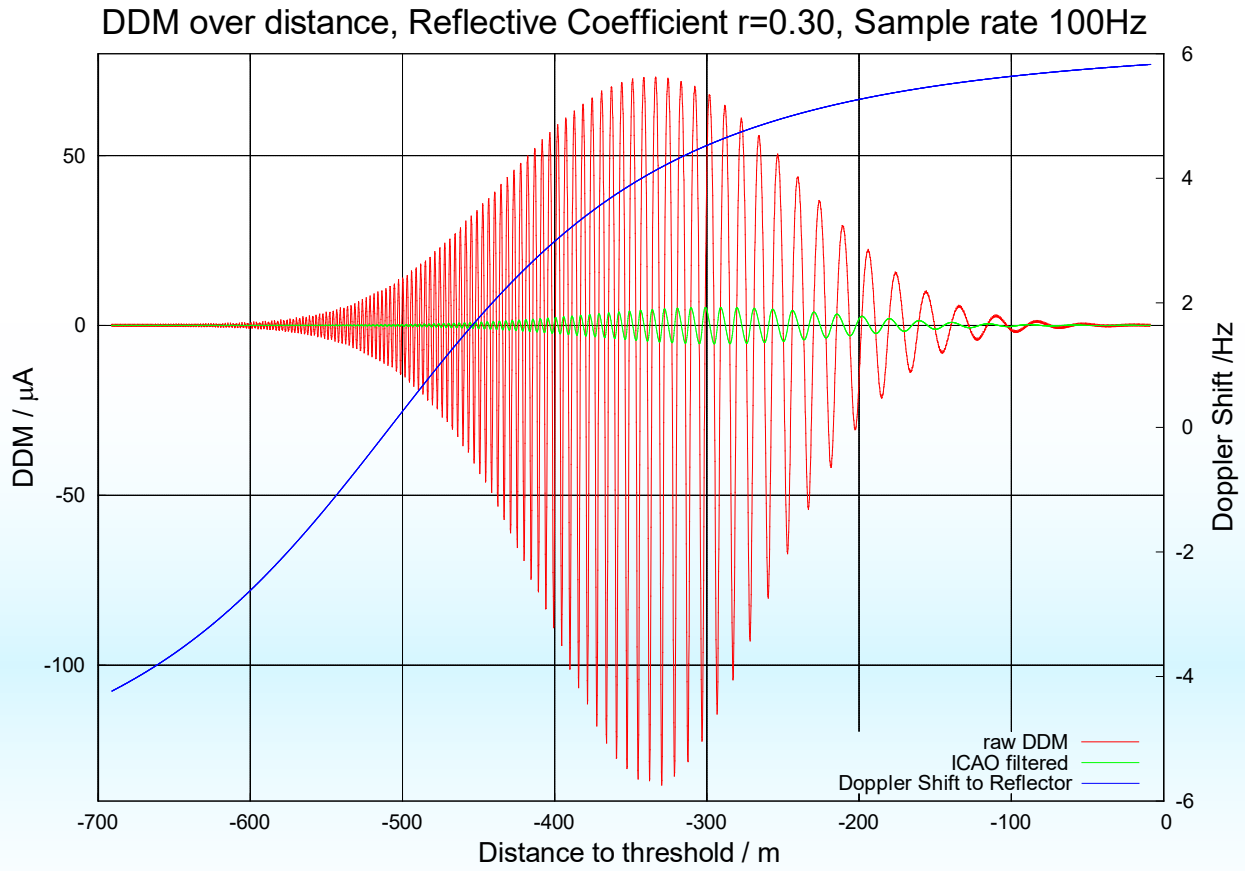
Receiver investigations

Corrected hysteresis



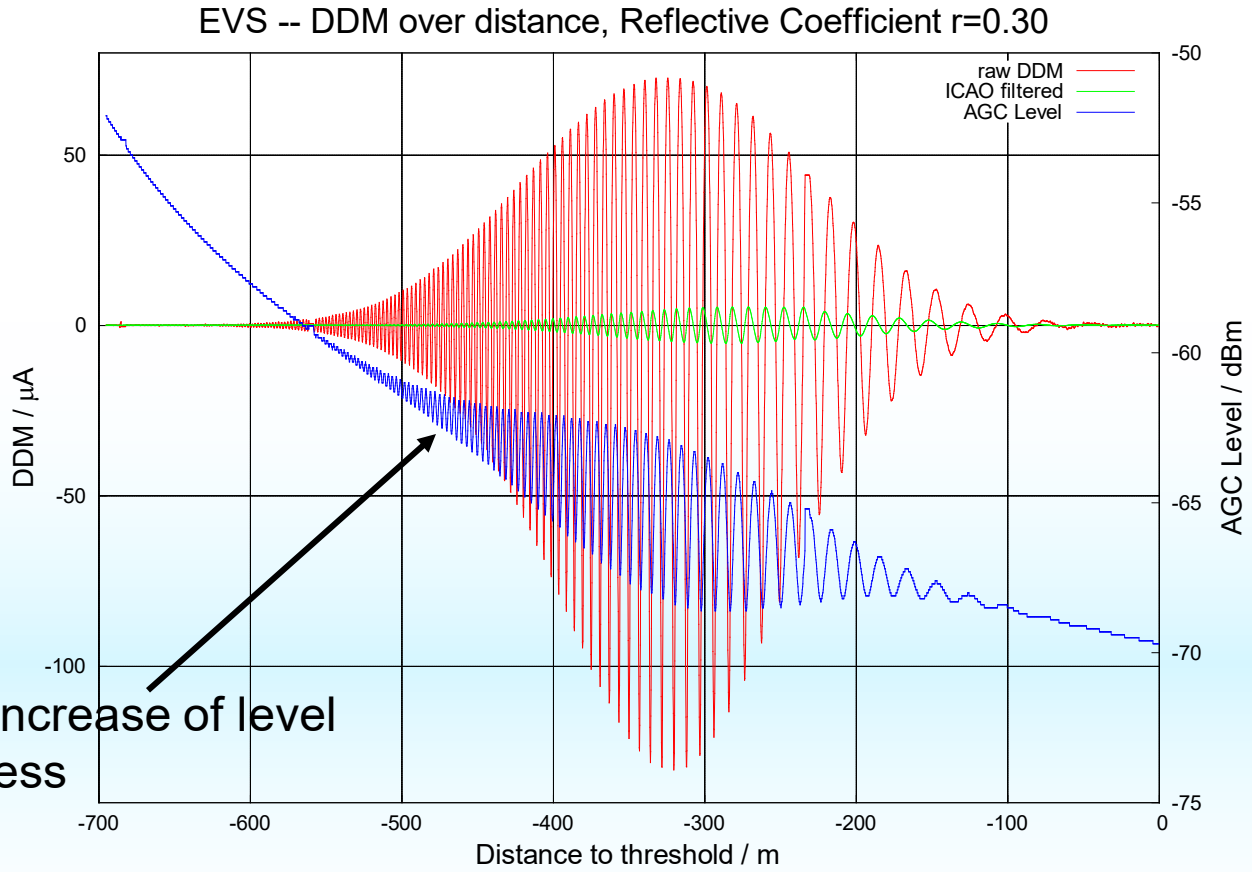
Receiver investigations

Simulated DDM of scattering A380 tailfin at 60km/h



Receiver investigations

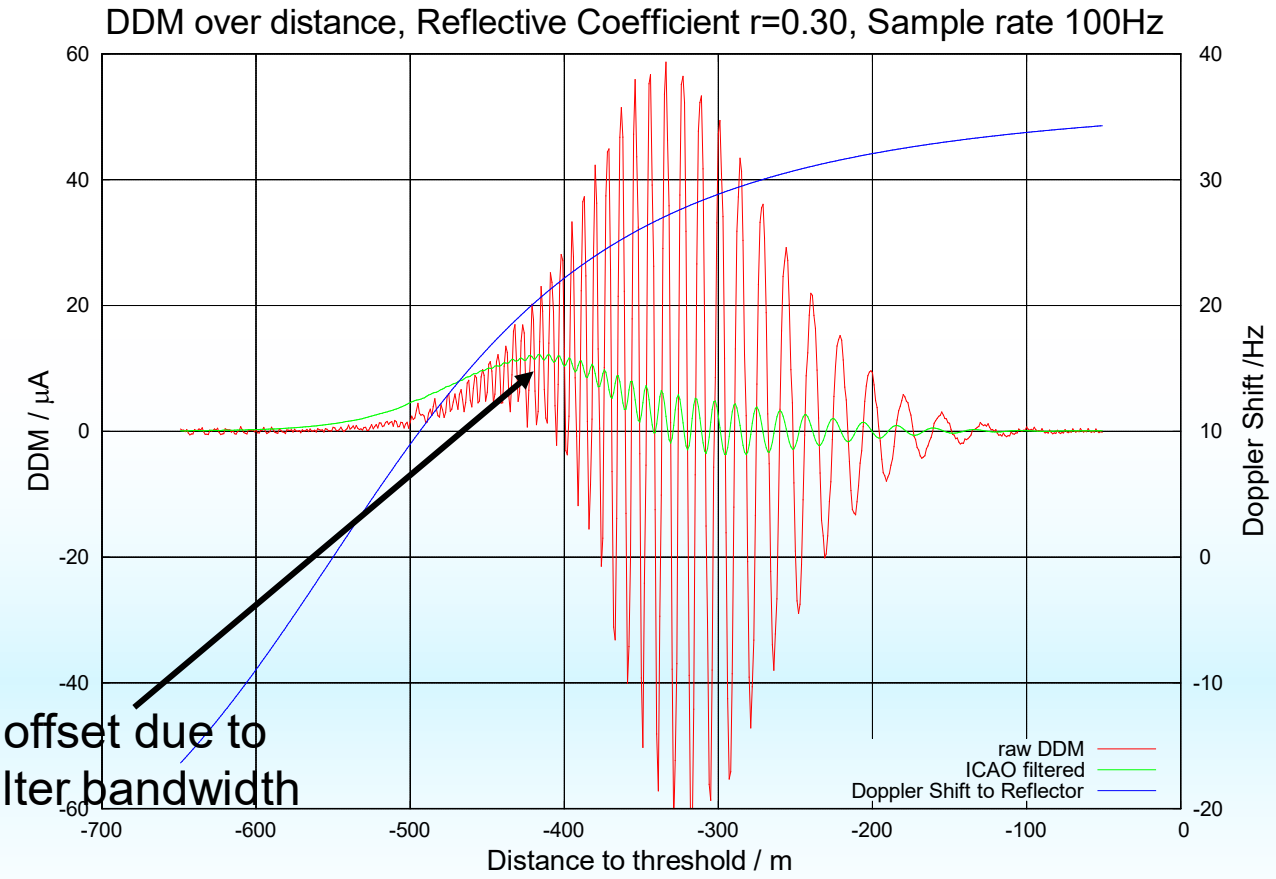
Corresponding DDM of measurement receiver



Selectable increase of level during process

Receiver investigations

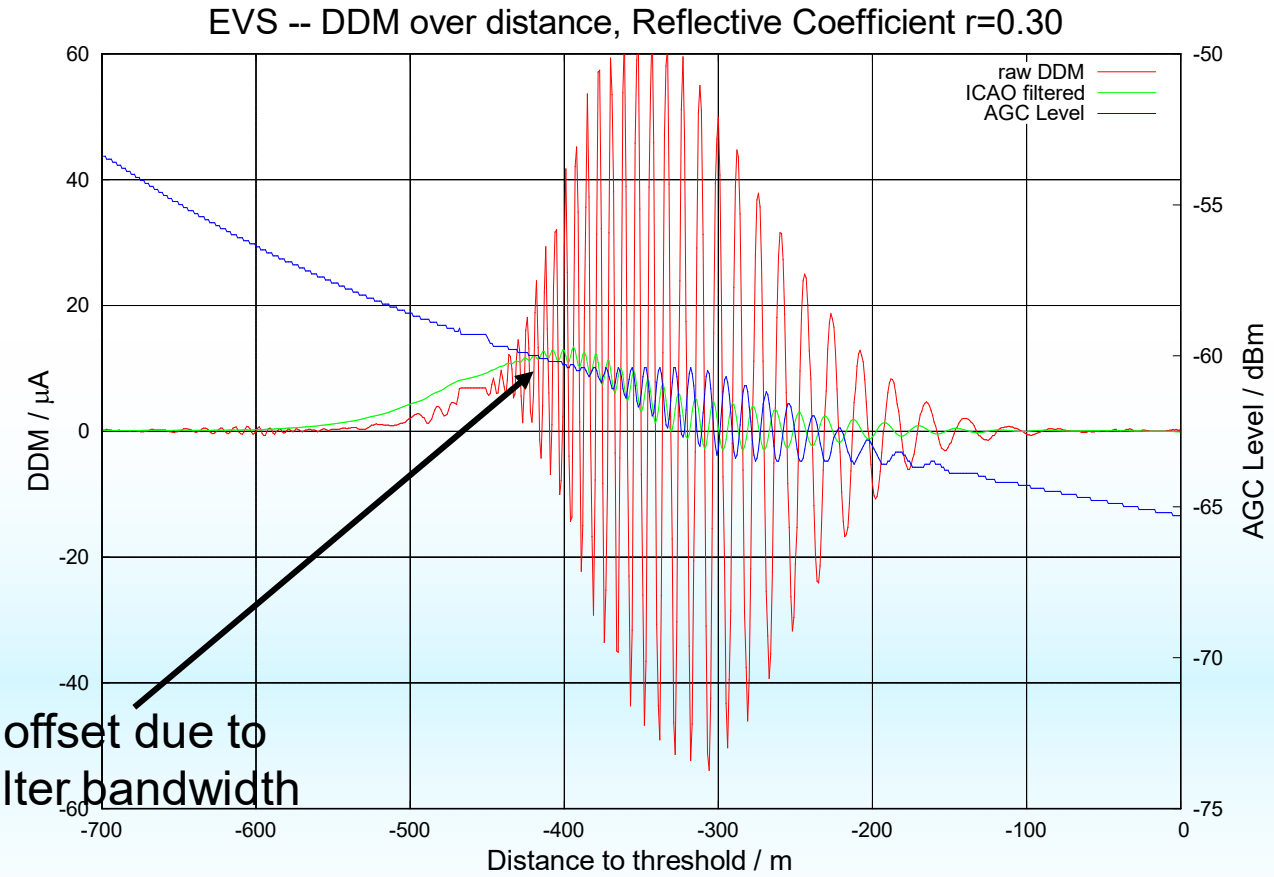
Simulated DDM of scattering A380 tailfin at 360km/h



Significant offset due to sideband filter bandwidth

Receiver investigations

Corresponding DDM of measurement receiver



Significant offset due to sideband filter bandwidth

Conclusions

- Use of approx. real RF signals-in-space
  - is suitable to perform measurements under multipath conditions
  - very useful during receiver design
  - source for bandpass (RF) signal can be converted from complex hybrid computation results
- Accurately designed measurement receivers
  - produce fully comparable results in dynamic conditions (ground or flight inspection)
  - improve safety level of ILS (and other NAVAIDs)