Excellent DF-Sensors
for strategic and tactical EW-Systems

Olaf Lukas, Rohde & Schwarz, Munich,
Radiomonitoring & Radiolocation Division

at the **Aardvark Roost**

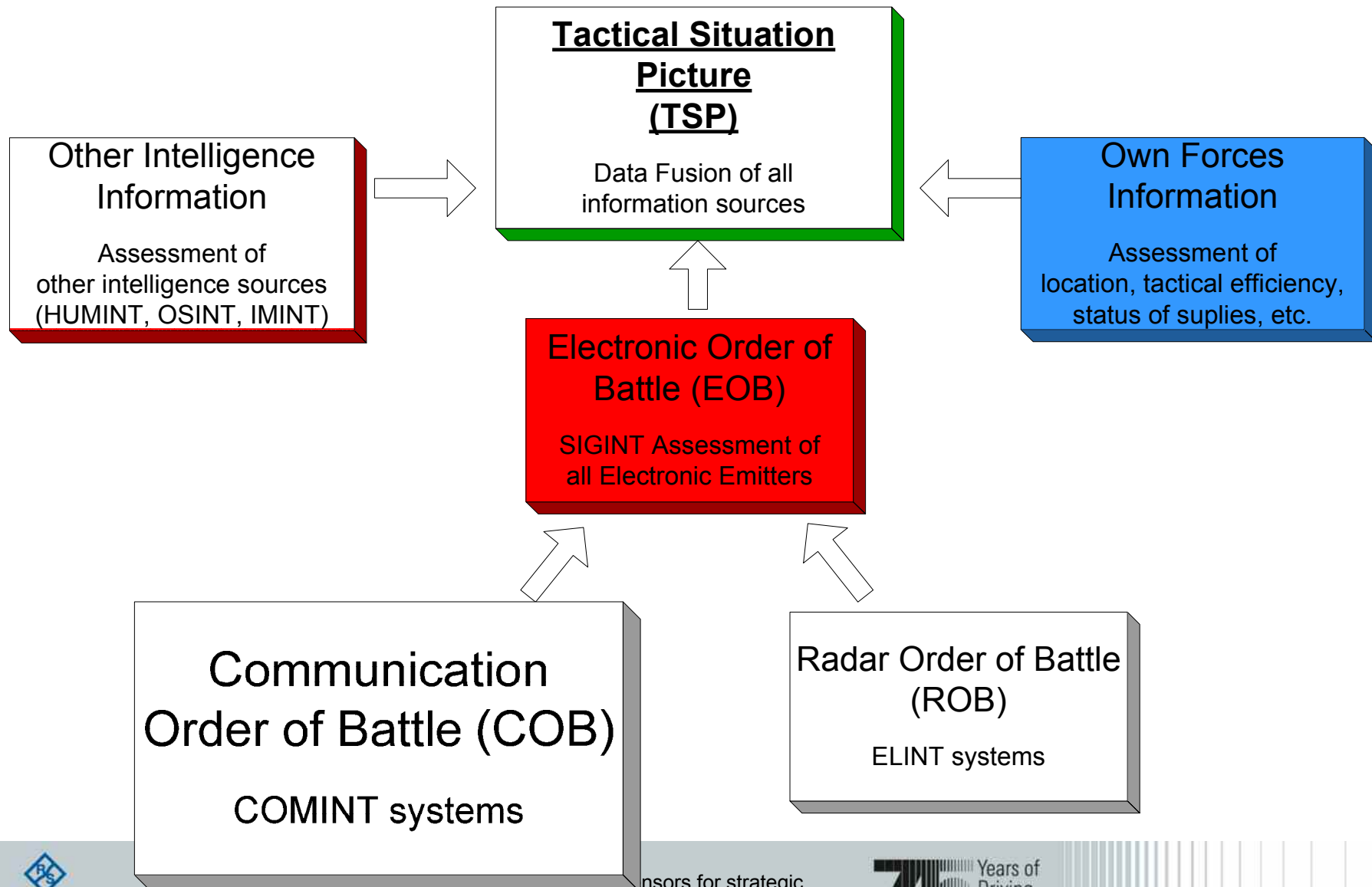Pretoria, SA, 2009-08-25 (14:30 – 15:10)

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Sensors in SIGINT /SpectrumMonitoring

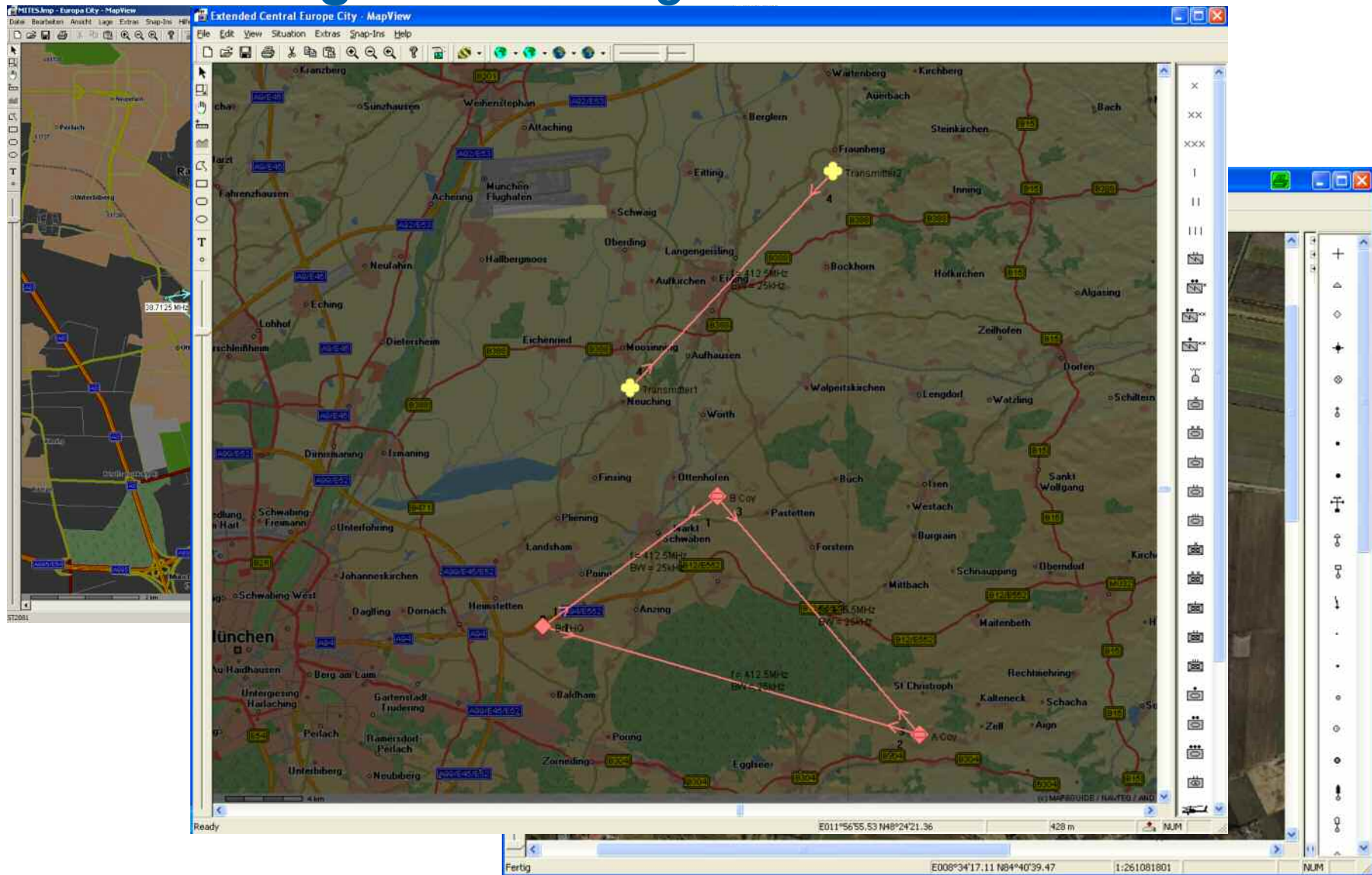I **Detect –and DF- strong and weak signals in HF-VHF-UHF**

I **Give a good precision/resolution in F, t and azimuth (location)**

I **Can deliver metadata ("quality", probability)**

I **Help to distinguish wanted / unwanted target emitters**

I **See "everything" without delivering "too much"**

- I scans, bandwidth/wideband, filtering
- I sensitivity, accuracy, speed
- I characteristics, cooperation with signal analysis
- I automatisms, synchronous/asynchronous and easy/expert-GUI
- I calibration, compensation, combination
- I Quasi-parallel on many channels (e.g. ATC)

I **Are more than just DFs as they go to land + air + sea**

I **Are robust against "unfriendly environment"**

I **What if … (too) many signals? Blanking? Multi-user?**

I **Have special modes for *spread signals, FH and TDMA, …***

Low Price

# Commander: „Give me the Tactical Situation"

Tactical Situation Picture (TSP)

Data Fusion of all information sources

Other Intelligence Information

Assessment of other intelligence sources (HUMINT, OSINT, IMINT)

Own Forces Information

Assessment of location, tactical efficiency, status of suplies, etc.

Electronic Order of Battle (EOB)

SIGINT Assessment of all Electronic Emitters

Communication Order of Battle (COB)

COMINT systems

Radar Order of Battle (ROB)

ELINT systems

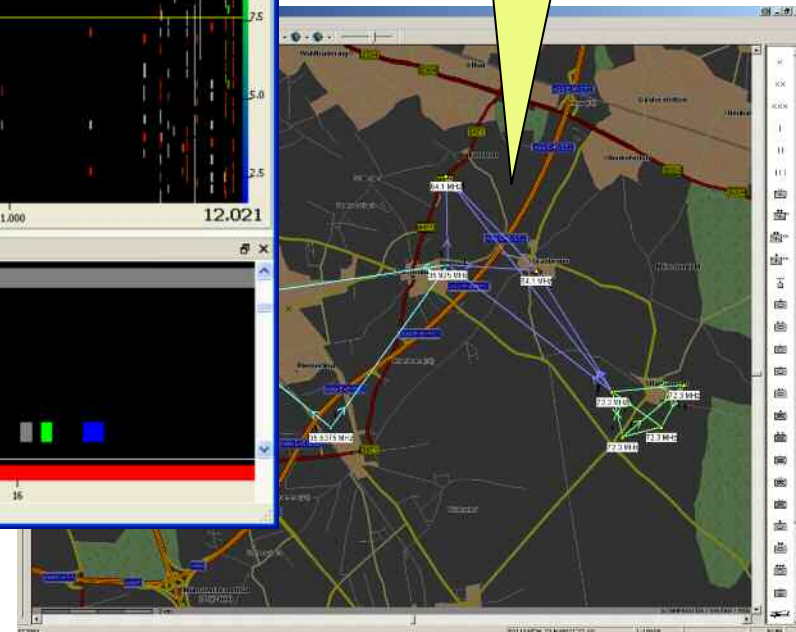# An difficult **goal**: Building a **COB** … from **nets**

Pre-requisit: building **nets** from **emitters**

In:
many transmitters
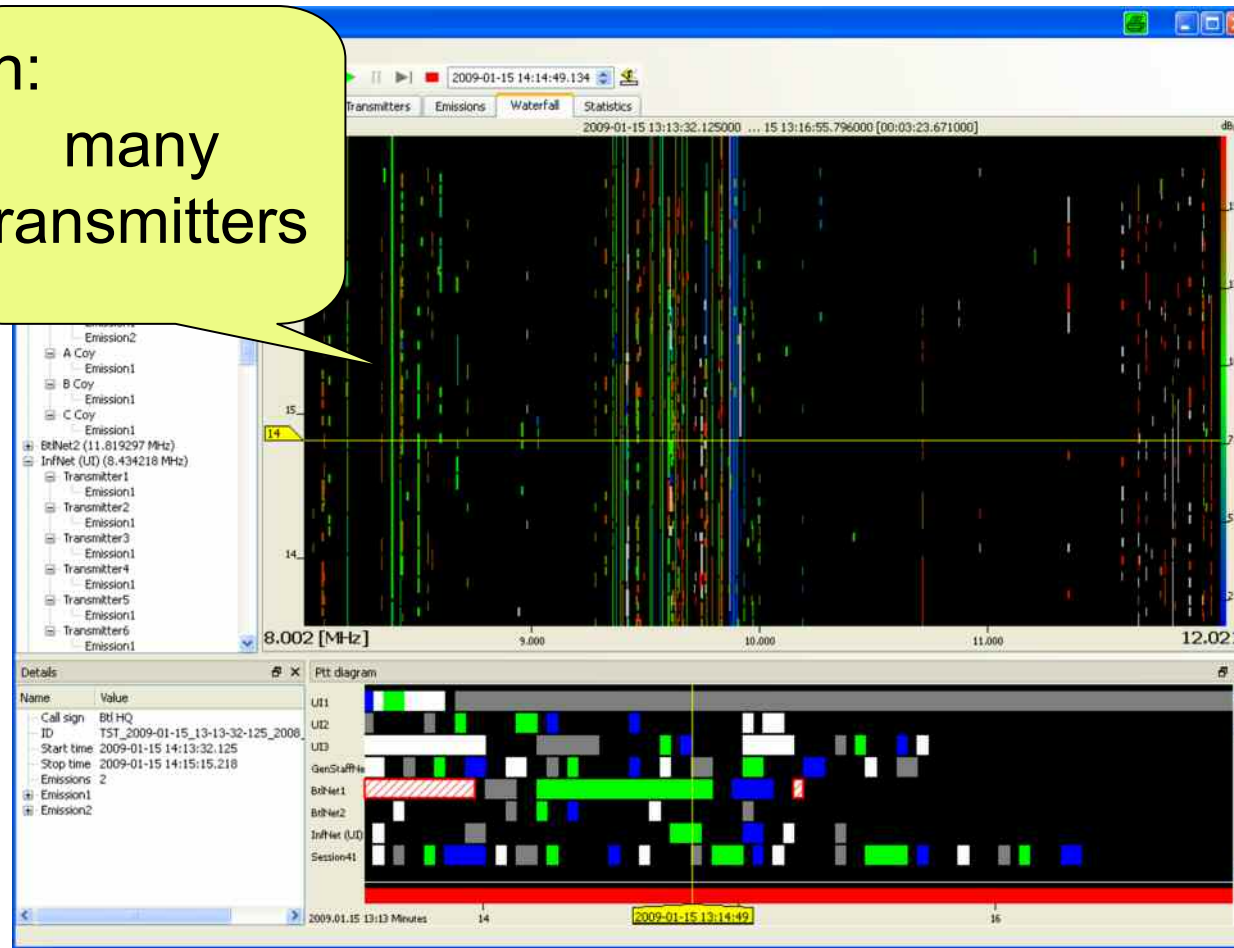
Out:
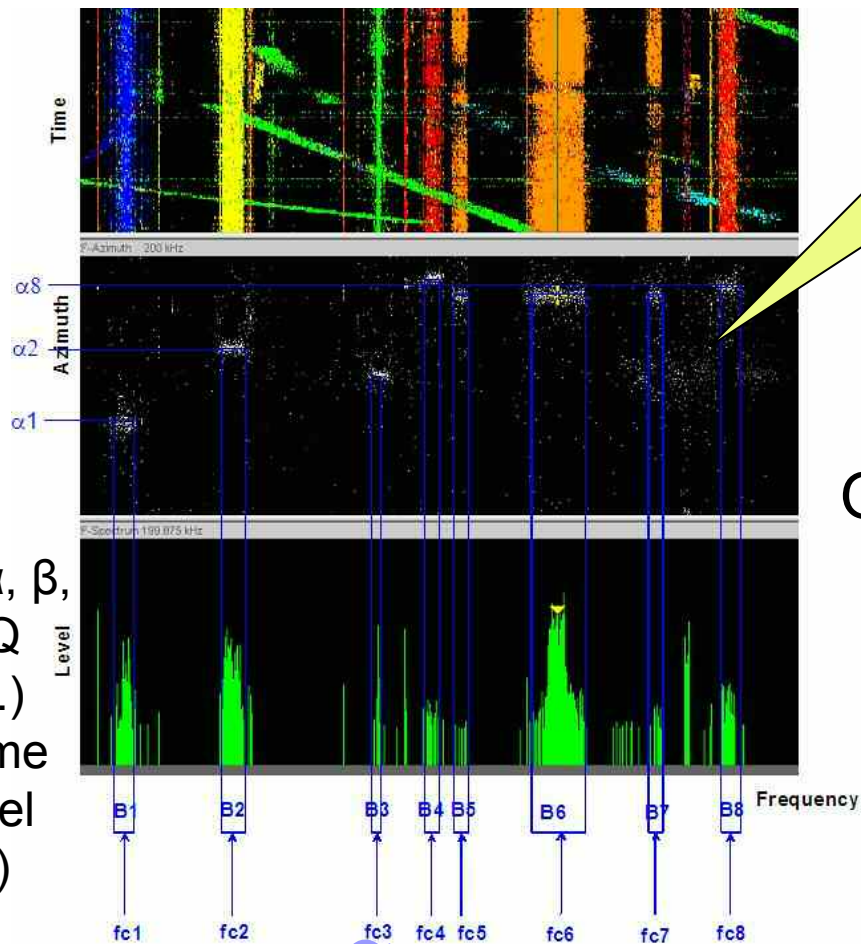specific nets

Needed: building **emitters** from **emissions**

In:
many emissions

Out:
different transmitters

Inputs
instantaneous f, t, α, β, Q averaged f, t, α, Q (on-time, length, tol.) own Posn, north, time client for this channel (history f, t, α, β, Q)

(raw measurements)

Outputs
emitter(s) at f, t, α, β, Q „character"-class additional params

Pre-Classifier

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From very small to big

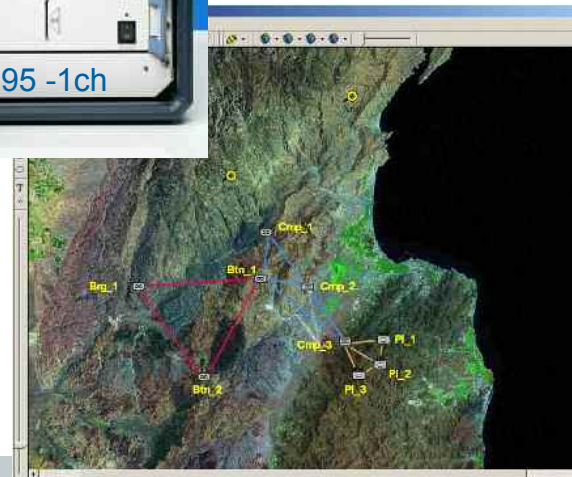PR100+HE300 – 1ch homing

DDF395 -2ch

DDF255 -1ch

DDF195 -1ch

DDF04E-3ch
DDF06A -3ch

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…and a lot of DF-antennas

ADD011SR

ADD075

ADD070/070M

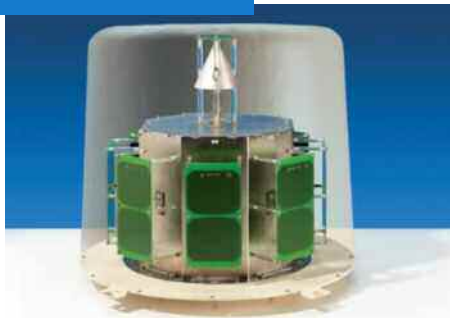ADD050SR

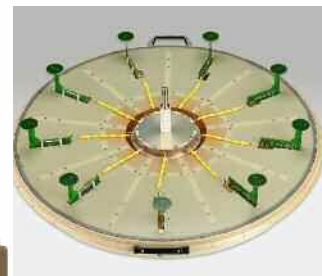ADD090S

ADD253 (xxx)

ADD197

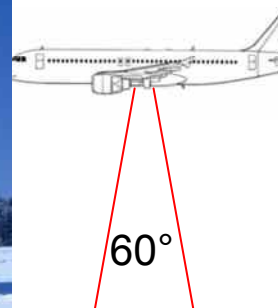ADD15x
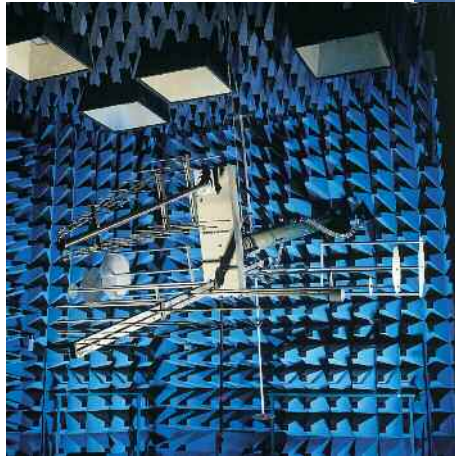
ADD050

ADD070

ADD170

ADD215

ADD153SR

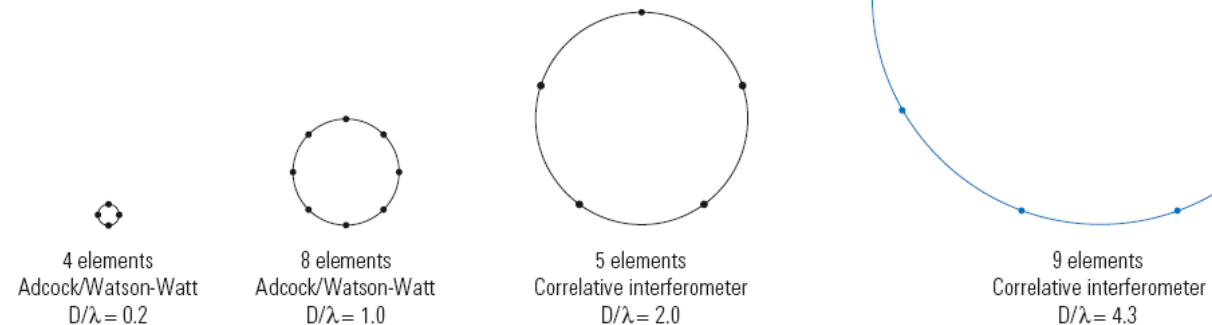ADD295

Environmental influences (excellent to ok)

60°

Environmental influences (bad to worst)

Multi-Element DF Antennas:
Accurate results even with 50% reflections -?

Frequency example	Accuracy of R&S®DDF255/ADD253 (9 el.; with 50% reflections)	Accuracy of a 5 element DF antenna (with 50% reflections)
160 MHz	20° RMS	21° RMS
300 MHz	12° RMS	12° RMS
460 MHz	8° RMS	95° RMS
900 MHz	4° RMS	150° RMS
1500 MHz	9° RMS	110° RMS
3000 MHz	6° RMS	160° RMS

4 elements
Adcock/Watson-Watt
$D/\lambda = 0.2$

8 elements
Adcock/Watson-Watt
$D/\lambda = 1.0$

5 elements
Correlative interferometer
$D/\lambda = 2.0$

9 elements
Correlative interferometer
$D/\lambda = 4.3$

Maximum permissible diameter of the DF antenna relative to the wavelength for unambiguous DF results for up to 50% of environmental reflections
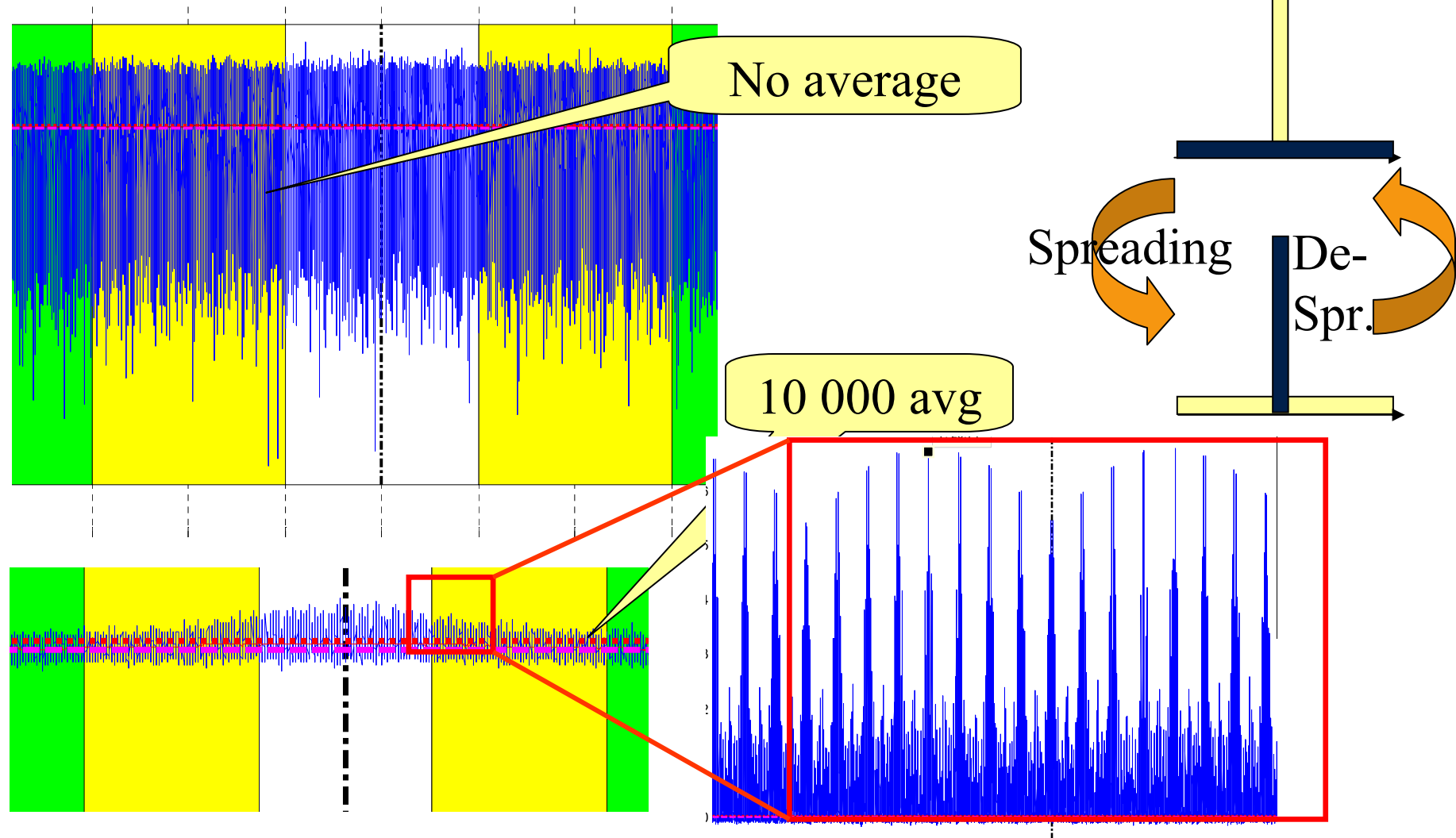
Even though the receive signal consist 50% of reflections DDF®255 gives a reasonable accuracy. DF antennas with just 5 elements will show wild bearings at most frequencies.

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Flexibility in the digital domain:
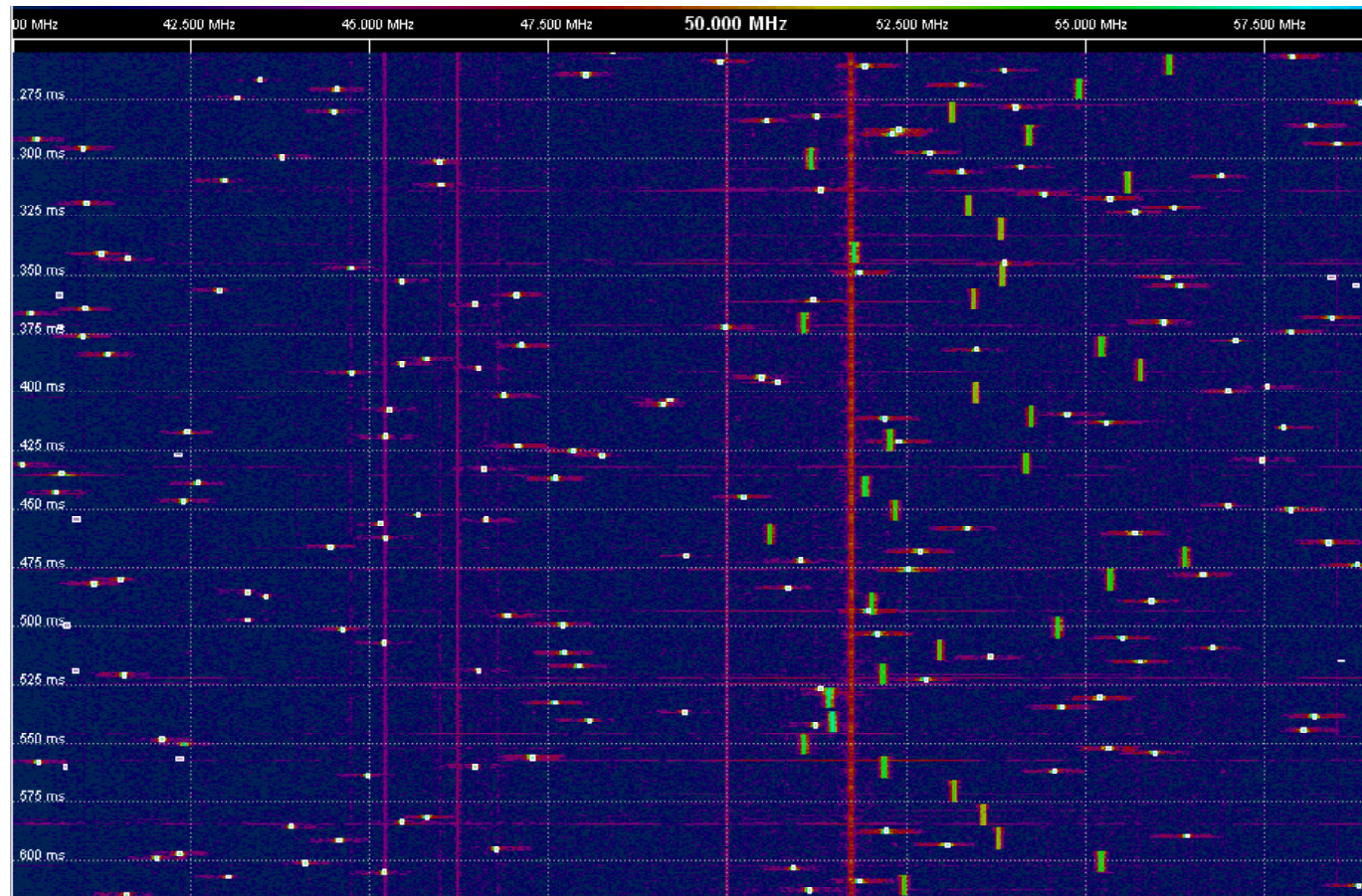# DF methods / Preprocessing of raw data
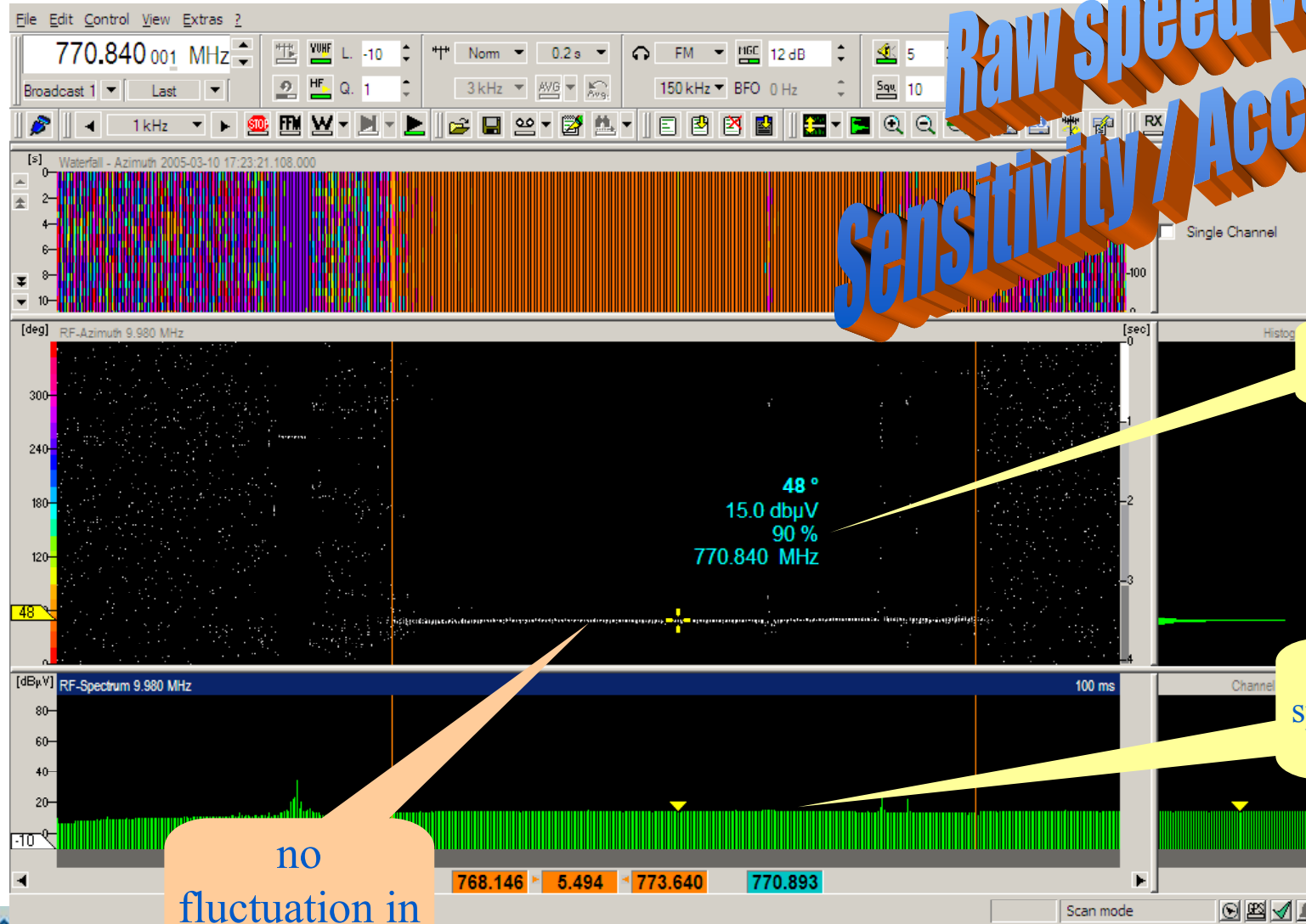
DSSS and averaging – an example

No average

Spreading

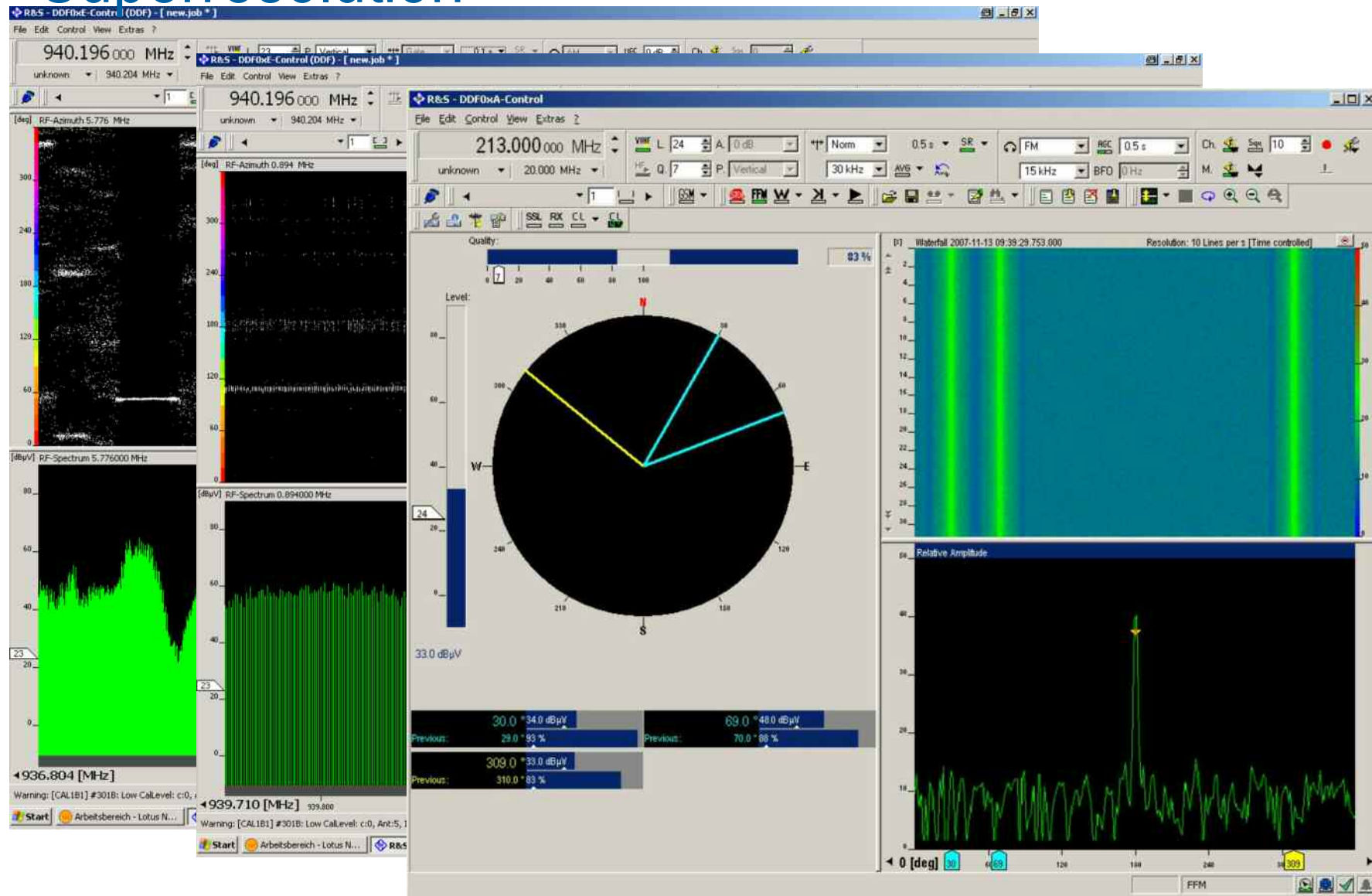De-Spr.

10 000 avg

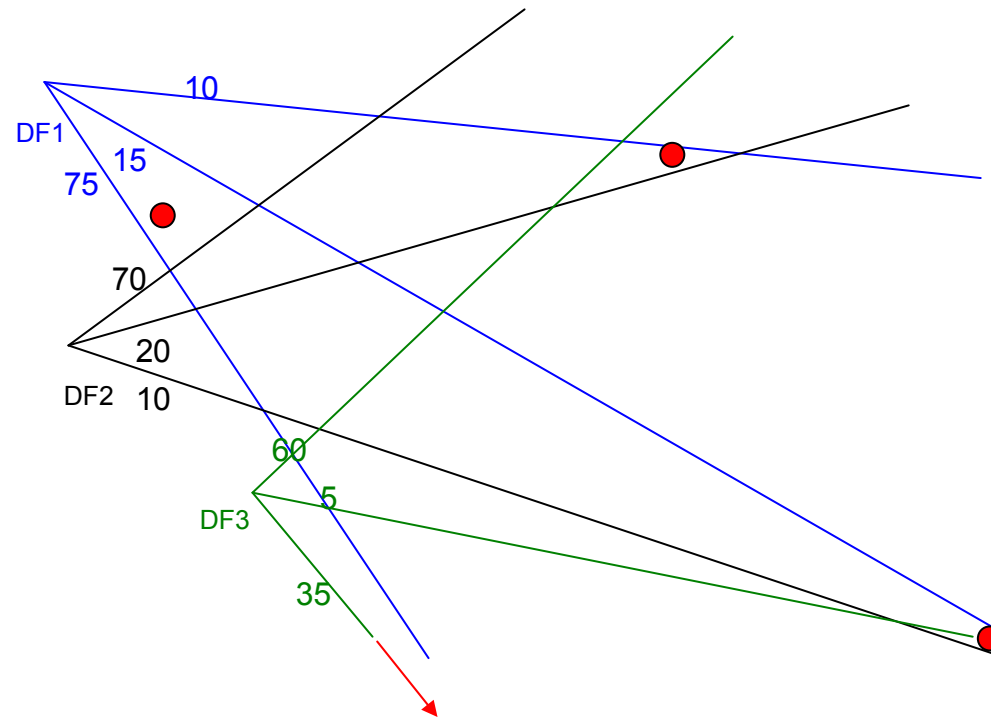$S/N = -29dB$!!

DF on Frequency agile signals

- **10 MHz bw stare @<500μs (20kHz)**
- **Stepmode 10 MHz @<1ms per step**
- **Independent of occupancy**
- **Automatic preprocessing**
- **Automatic choice of antenna and DF-algorithm**
- **System support**

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Superresolution

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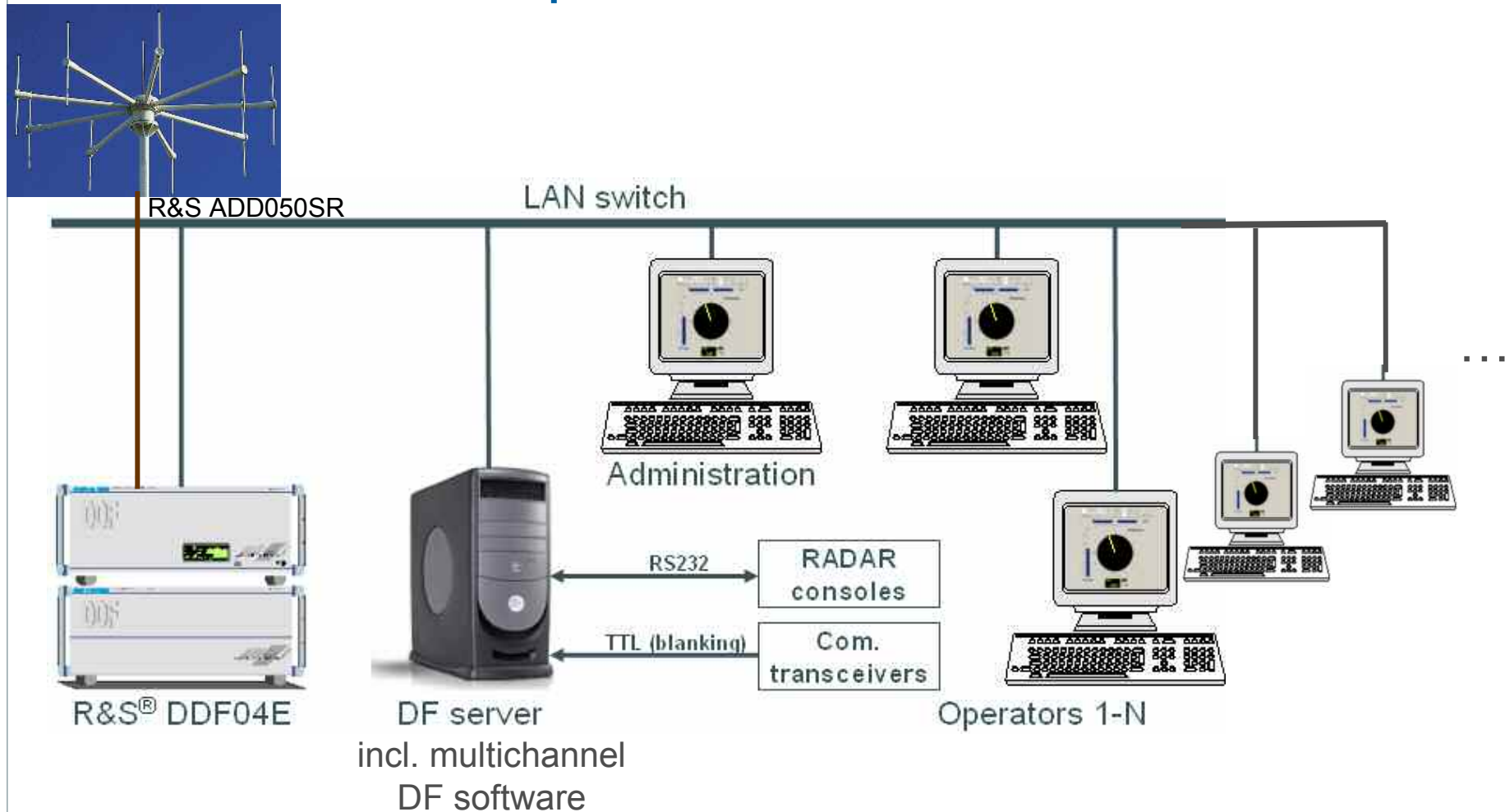Years of
Driving
Innovation

Superresolution just Science?

Location, DF and TDOA
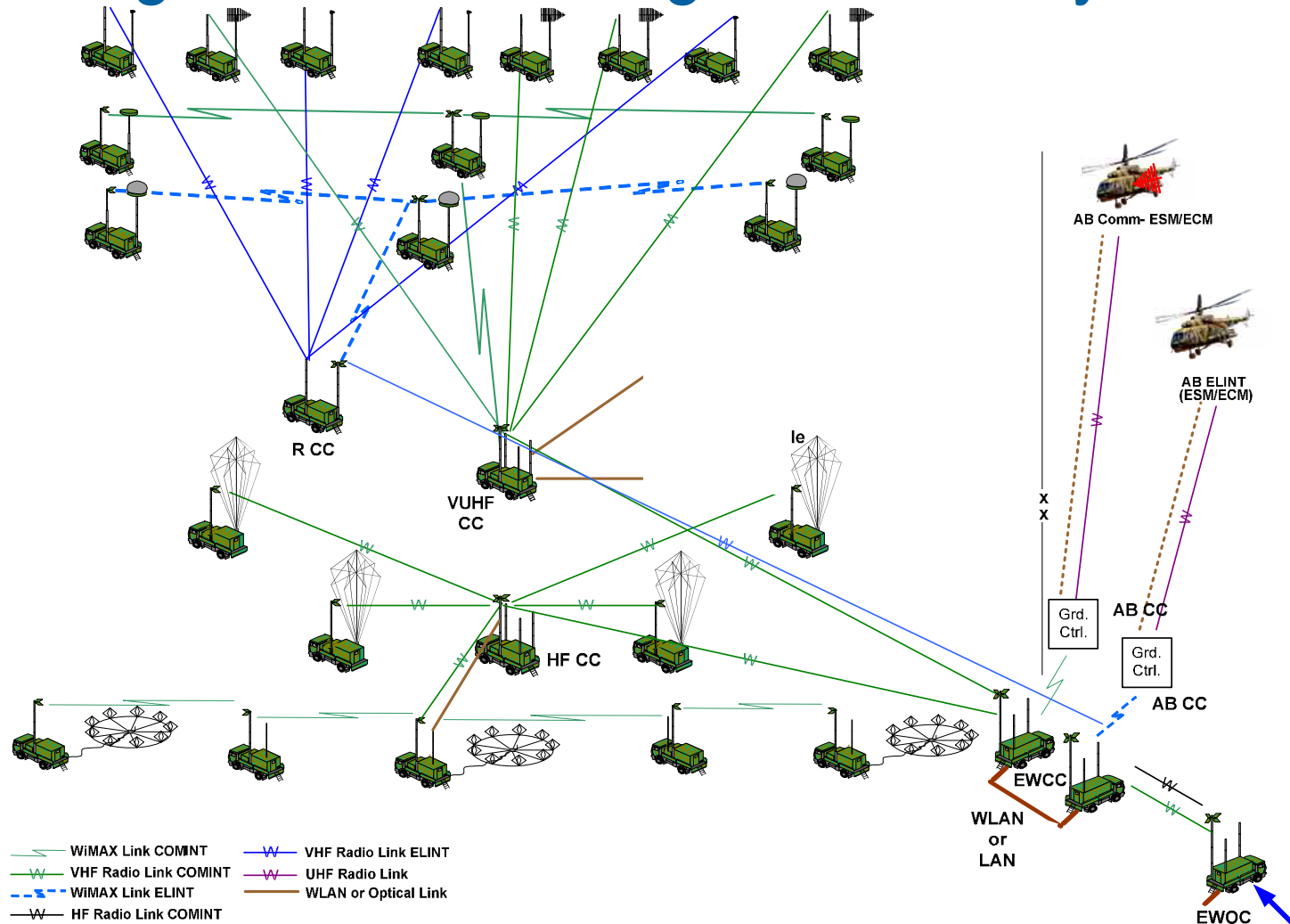
I **TDOA alone can be quite accurate and attractive with signals of wide bandwidth or repetitive pulses**

   I For continuous emissions that means (*4):
   `TDOA_location_accuracy = lightspeed / bandwidth*2`
   e.g. **25kHz => 6,0 km**; 200 kHz => 750m; but 1 kHz => 150 km

I **Minimum number of stations is with DF 2 (to 3), with TDOA 3 (to4)**
   TDOA stations can be simpler; antenna and receiver must be good

I **With pure TDOA no**

   I homing or running fix,

   I single station (ship, aircraft,…)

   I silent mode (must exchange much data to correlate, co-location problem)

   I short time reaction strategy (must exchange and correlate to get result)

   I universal (i.e. signal independent   location capacity)

Multi-User Example *Air Trafic Control*

Integration into "integrated C4I-systems"

Legend		
WiMAX Link COMINT	VHF Radio Link ELINT	
VHF Radio Link COMINT	UHF Radio Link	
WiMAX Link ELINT	WLAN or Optical Link	
HF Radio Link COMINT		

Labels visible in diagram: R CC, VUHF CC, Ie, HF CC, AB Comm- ESM/ECM, AB ELINT (ESM/ECM), AB CC, Grd. Ctrl., EWCC, WLAN or LAN, EWOC
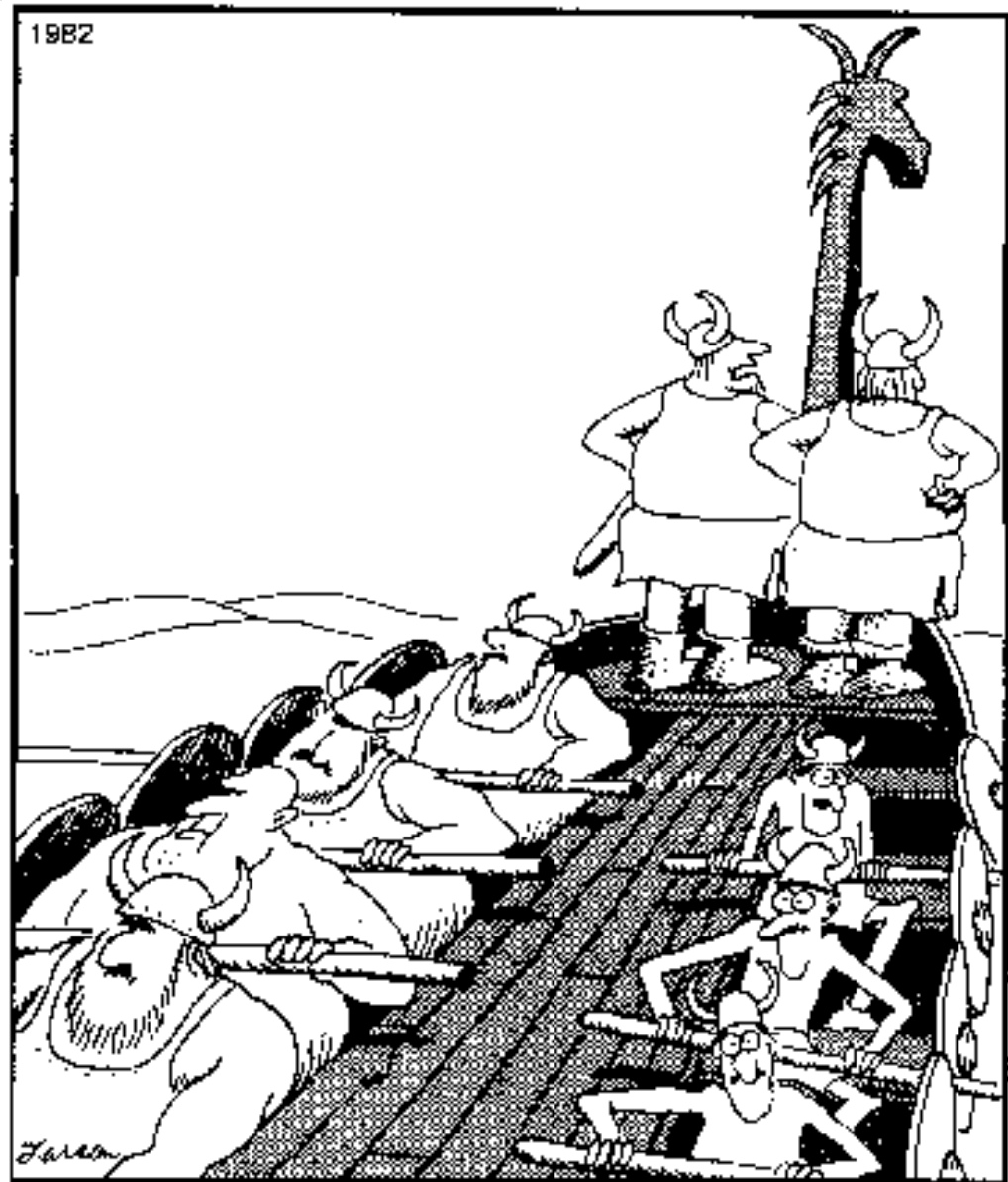
2008-05-24 / 8VTE-RJ

DF - Extras

- One model with **Interference-Canceller** for co-located transmitters
- Correlation based **correction** for ship's structures (►HF)
- Several models with quasi **parallel DF** for 2 (4) channels
- Single channel, wideband and scan-modes –also with intelligent averaging and/or GPS **syncronisation**
- Signal **classifier** & raw-data **recording** available
- GUI software, **remote control** and automatic **location** systems (single- /multiuser) available
- GSM / **TDMA** mode (500µs, synchronized to downlink)
- Special **superresolution** mode, **SSL-mode** (HF)
- **DDFs and ADDs available for 0.3 to 6000 MHz** (monitoring max. 0.01 .. 26 500 MHz), **Watson-Watt & Correlation.**

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It's all about balance…

Thank you!

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