FUTURE SENSOR COMBAT

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2016-10-11

THEME

- In the future, the risk of transmitting must be weighed against the benefits

- How do we remain silent ***and*** gather information at low risk?

- Which technologies will support less obtrusive acquisition?

TRENDSPOTTING

- Today,
  - sensor functions are wired into hardware
  - a sensor function is executed by one aircraft
  - superiority associated with better sensor parameters
  - deterministic performance of sensors feeds the Air Picture data base
  - EW concerns mostly radars and seekers

- Tomorrow,
  - sensor functions independent of RF hardware
  - a sensor function may be realized by several aircraft
  - superiority associated with the *probability* that the recognized Air Picture > the adversary´s Air Picture
  - opportunism and statistics will increasingly characterize the AP´s completion
  - EW moves into the C2/COM domain

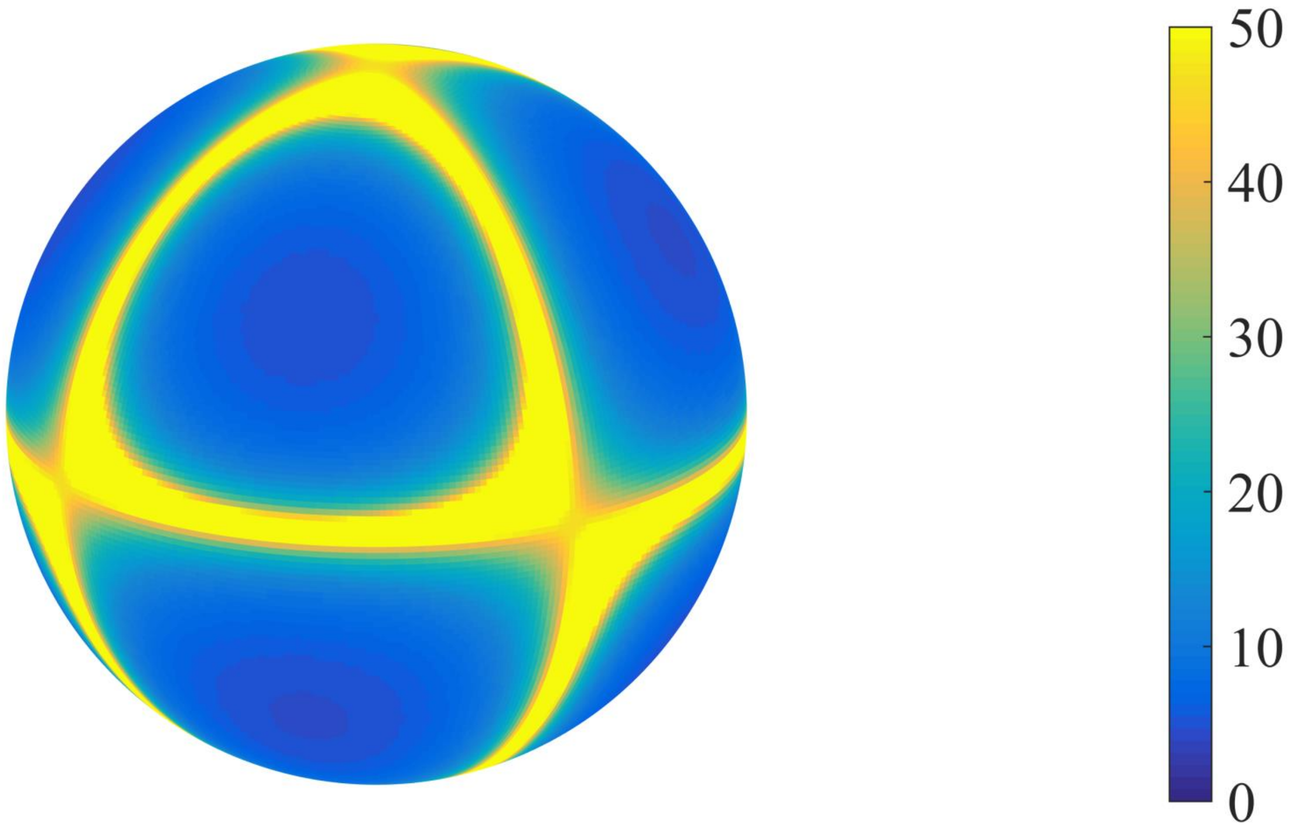
COMMUNICATIONS AND LINKS

- Radar usage restrictions => increased reliance on communications
  - For sharing and merging incomplete sets of air pictures.
- Broadcast COM systems
  - Simple, low cost => attracts integration
  - Well-proliferated in interoperable architectures => costly to change.
- Exploit this weakness!

COM ACQUISTION

- Intercept distance > the intra-communication distance
  - Difficult for enemy to jam listeners without deteriorating own link or revealing jammer
- Method:
  - Several aircraft record potential emissions.
  - At request, filtered recordings are stored, exchanged and matched.
  - Position and velocity of the emitter is estimated.
- The errors depend on
  - own formation
  - pos and time accuracy
  - the incident direction of the received signal.

COM ACQUISTION



The radial distance error as a function of incidence directions. Given are: the number of listening aircraft, their nominal positions, and errors in own position and time.

COM JAMMING

- Broadcast COM systems are susceptible to jamming
  - From all directions
  - Rigid protocols invite to jamming
- Jamming may be efficient at distances > the intra-communication distance
- Cognitive-radio responses to jamming should be expected in the future

DIRECTIVE LINKS

- We must prevent adversaries from
  - detecting
  - positioning
  - identifying
  - jamming

  ... our own communications.

- First: today´s standard methods should still be usable

- In addition: an RF link over a narrow beam with low sidelobes
  - The signal in other directions is suppressed by at least 20 dB.
  - Enough for preventing detection in most situations

DIRECTIVE LINKS

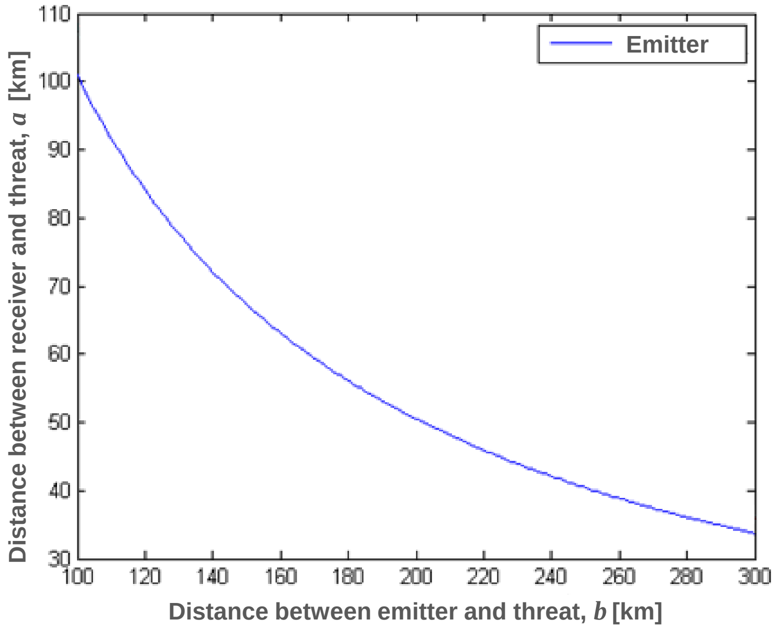
- Order-of-magnitude parameters of a Ku-band link
  - Link haul distance 10^2 km
  - Array 10^2 elements
  - Data rate air picture, a/c status, nav/pos, C2, ID
  - Polarisation two, simultaneous superposition
  - No of digital channels TBD
- Directive link requirements close to ESM/ECM req's
  - Supplier shifts expected
- Electronics components mature by 2020
- ITAR issues likely to emerge, own design capability needed

PASSIVE RADAR

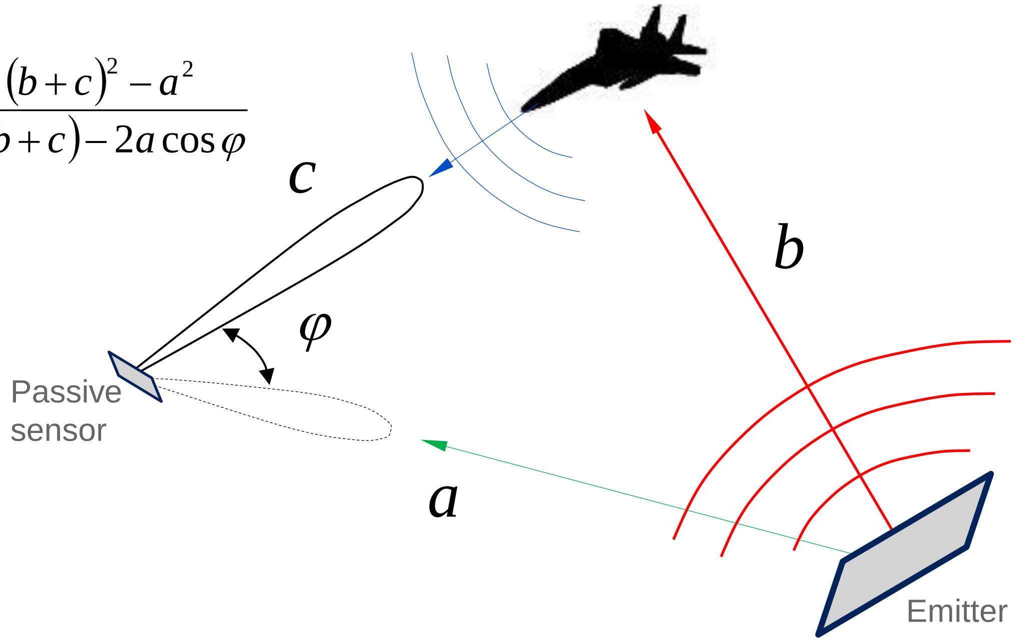
- Safe for forward deployed aircraft
- Made viable with modern AESA technology

1. AEW-band transmitter
   - Receiver candidate a: Medium-sized platform with downscaled AEW antenna
   - Receiver candidate b: Fighter with AEW-band capability on receive
2. ISR-band transmitter
   - Receiver candidate a: Medium-sized platform with X-band antenna
   - Receiver candidate b: Fighter radar

PASSIVE RADAR



$$c = \frac{(b+c)^2 - a^2}{2(b+c) - 2a\cos\varphi}$$



- Useful when the Air Picture is depleted
- But not a disruptive game changer
  - Latencies, range, accuracy....

IDENTIFICATION

- IFF emissions simple to detect
  - Wide or omni lobes, not LPI
- Add new method
  - Narrow interrogation lobe => higher frequencies
  - Determine incidence, respond in narrow lobe
  - Use power adaptation, spread-spectrum and other LPI techniques
- Holy grail: adversaries don´t notice being interrogated
- Drawback: neutral a/c cannot respond

PNT
Position, Navigation, Time

- Critical issue for all sensor functions
- SATNAV has some 15 ns, 20 m accuracy
  - Accurate enough for long-range engagement
- But SATNAV can not be relied upon in a conflict
  - Not even asymmetric
- Rapid development of jammer concepts
  - But too slow for air-to-air scenarios
- Air-launched decoys more suitable
  - Small payload, power available
  - Cheap, carried in numbers
  - Enter scene when needed, $M > 0.8$

PNT
Accuracy

- Std quartz clocks:
  - 10^{-8} => 360 μs after 1 hour mission
  - Far too inaccurate for COM acquisition
- Timing need:
  - Clock stability of $5 \cdot 10^{-11}$ <=> 200 ns error after 1 hour
  - Note: depends on sensor formation and weapons properties
- Position need:
  - Std: 1.8 km after 1 hour mission
  - Relative error should be reduced to < 100 m
  - Again: formation and weapons dependent

MISSILE DATA LINKS

- Main reasons for side-looking radars (SLR)
  - SAR/GMTI
  - Missile data link support during evasion
- F-22
  - SLR postponed to "beyond Increment 3.2" ...
- T-50
  - SLR AESA presented, hatch exists
- But:
  - Efficient (= 180°) evasion not supported by side-looking AESA
  - kill ratio increases if link is maintained during evasion
- Conclusions:
  - Backwards-looking radar needed, or
  - Link handover

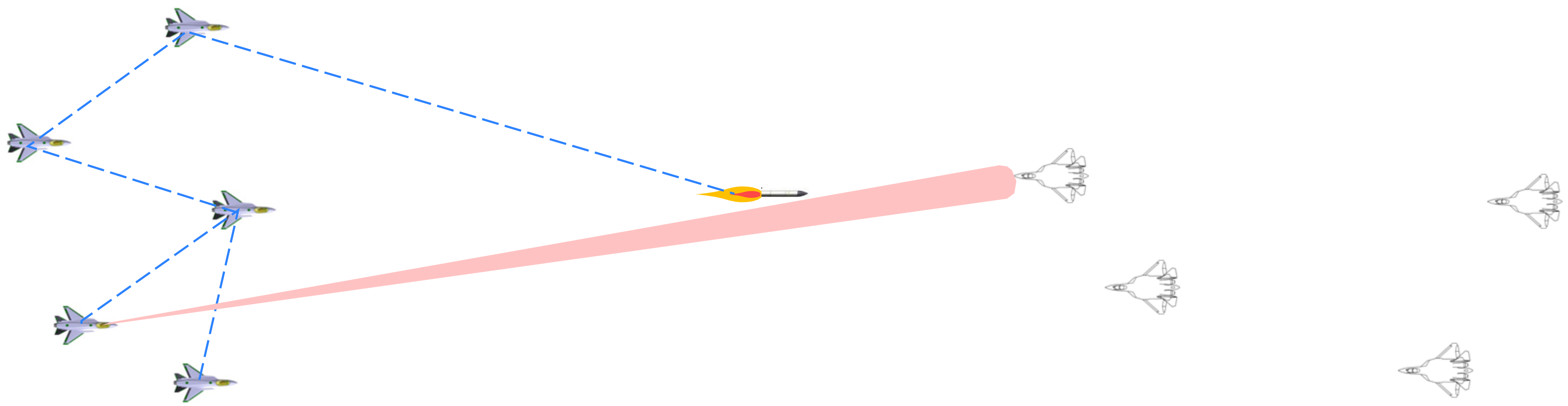
MISSILE DATA LINKS

- Backwards looking link/radar?
  - Spine-tails candidate location, but
    - LR target tracking difficult
    - Competition: RWR, COM array, chute, APU, tailhook
    - Associated with two-engine aircraft

- Hand-over?
  - Requires planning
    - Link, target tracking or both? To one or two? Recursive hand-over?
  - Sensitive
    - Launch inhibited if the other a/c is not in place
    - The other a/c might have to evade, too.
  - Rigid, not robust

MISSILE DATA LINKS

- Hand-over to the network?
  - Missile is given the air picture + target designation
  - All aircraft contribute: to air picture & as contact node candidates
  - In line with unmanned companion development



FIGHTER RADAR

- The front-end is entirely devoted to radar
- Result:
  - Other functions bereft of aperture area in the front sector
  - Front-end occupied by an increasingly silent, multi-M$ antenna
- The front-end aperture must support other functions
  - ESM, ECM, jamming, COM, links, passive radar
- Balanced approach
  - Extend the requirement specification, include *some* functions
  - Remaining functions easier to integrate

RF ARCHITECTURE

- Functional transparency
  - RF hardware
  - Common avionics computer platform
- Low-level service layers, for all sensor functions
- Management Process handles sensor execution requests from, *e.g.:*
  - Air Picture Completion,Threat Assessment processes
  - Network Connectivity Upholding process
- Patch where needed
  - ECCM, DRFM require fast responses, etc
- Supports functional growth and customer adaptation
- Emulates standard/legacy sensor functions