Distributed radar on multiple airborne platforms – challenges and solutions

Swedish Aerospace Technology Congress
2025-10-14/15

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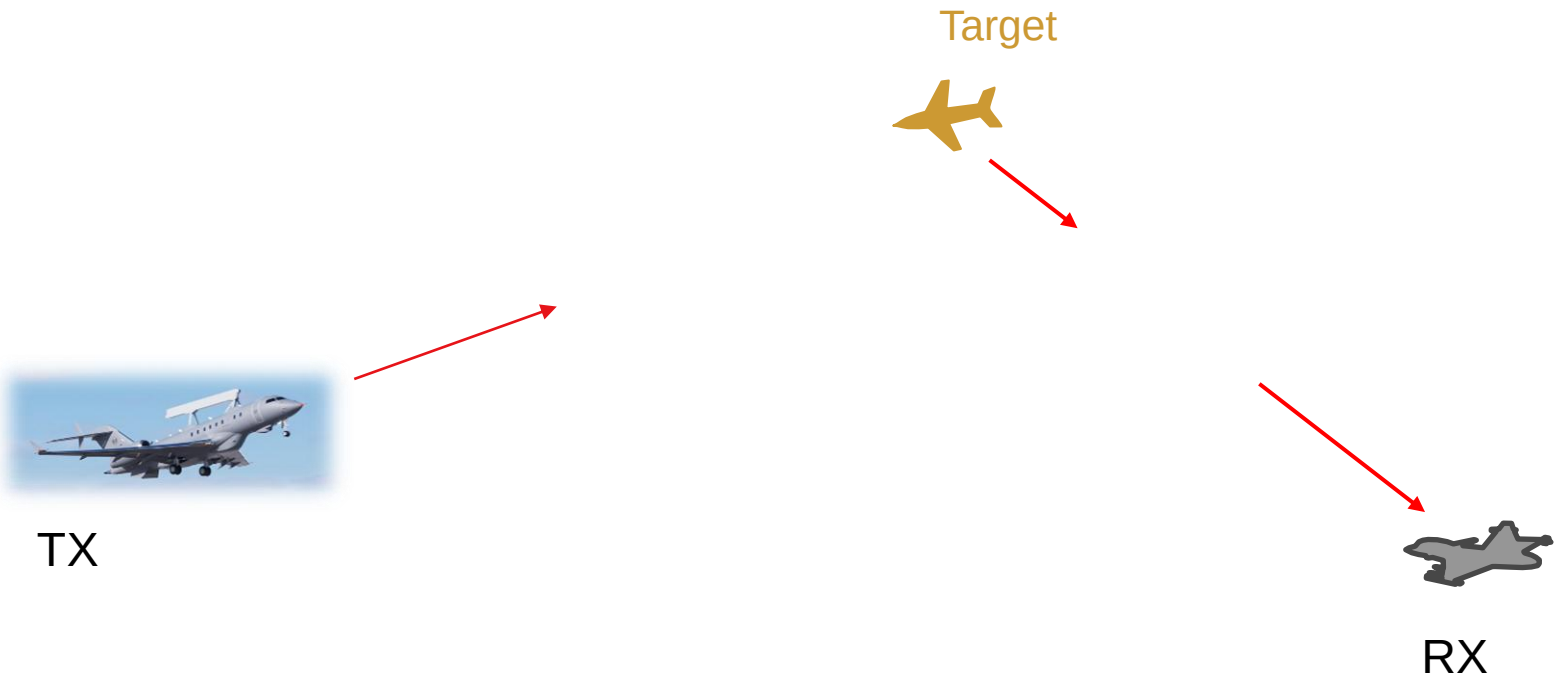
Tomas McKelvey (Chalmers)

Funding by Swedish Innovation Agency (Vinnova through NFFP7 and NFFP8 programs) and Saab.

Why?

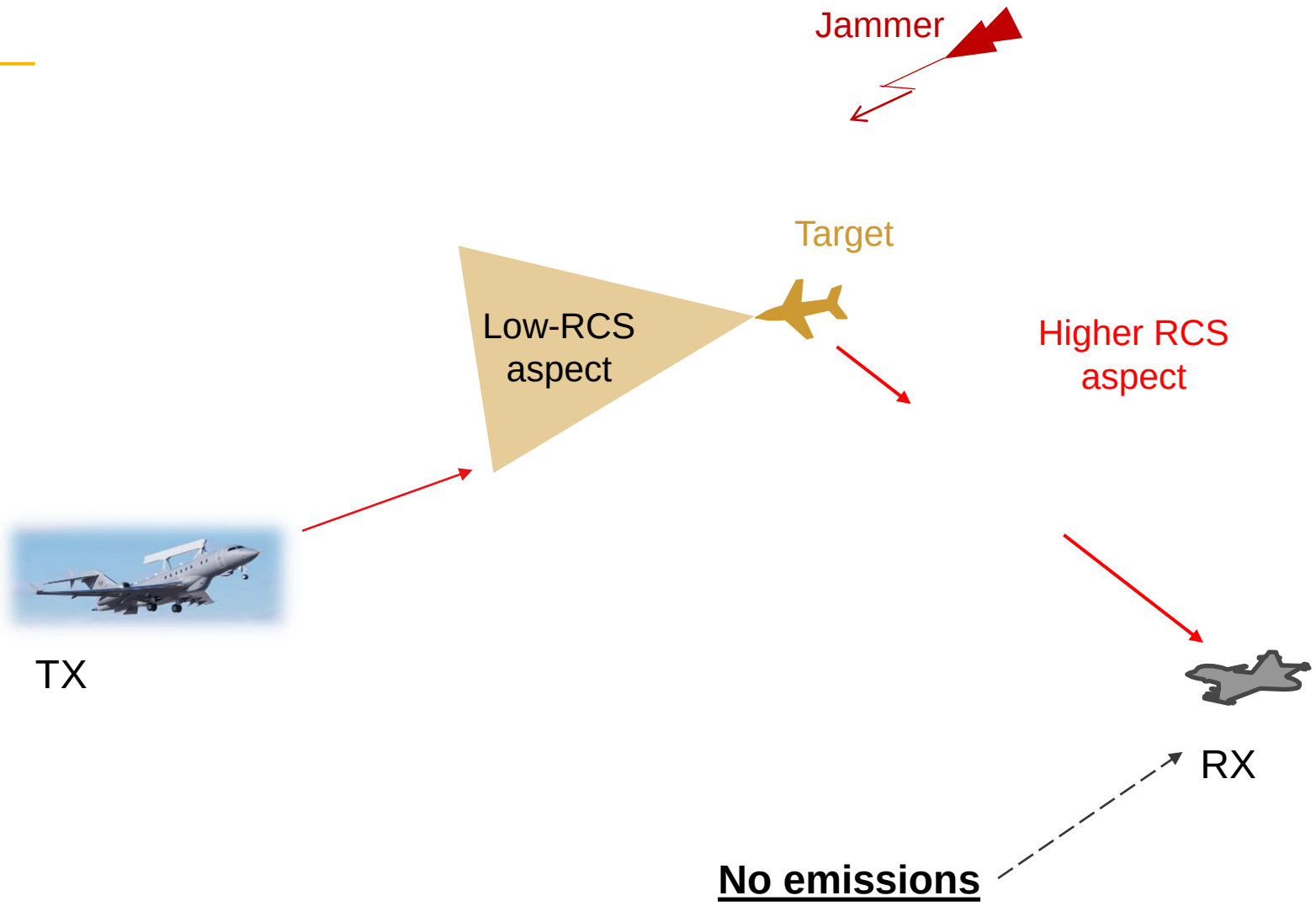


Why?

A. Combat stealthy & low-RCS threats

B. Jamming threats primarily directed towards transmitter

C. Covert operation for receiver platform



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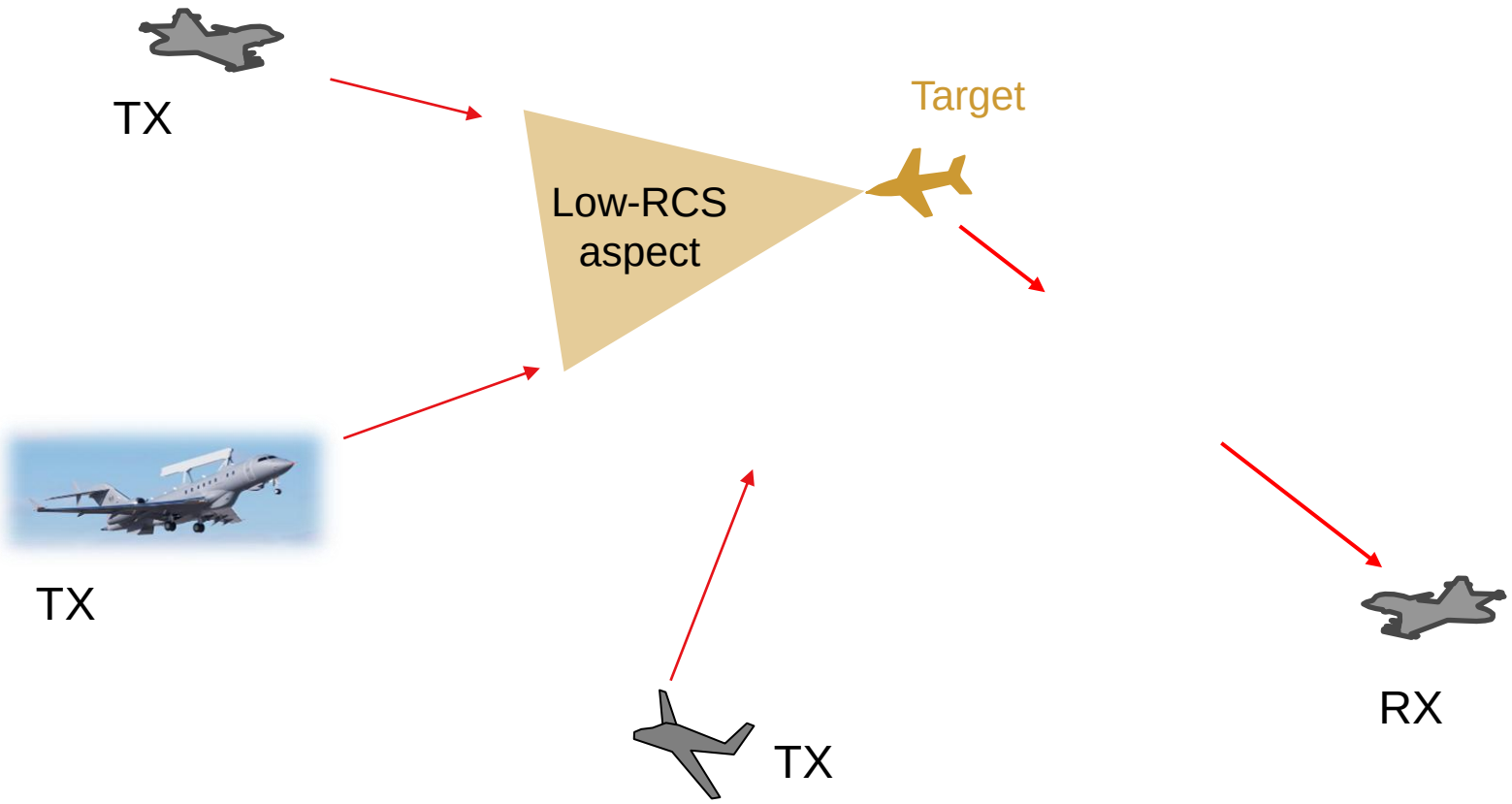
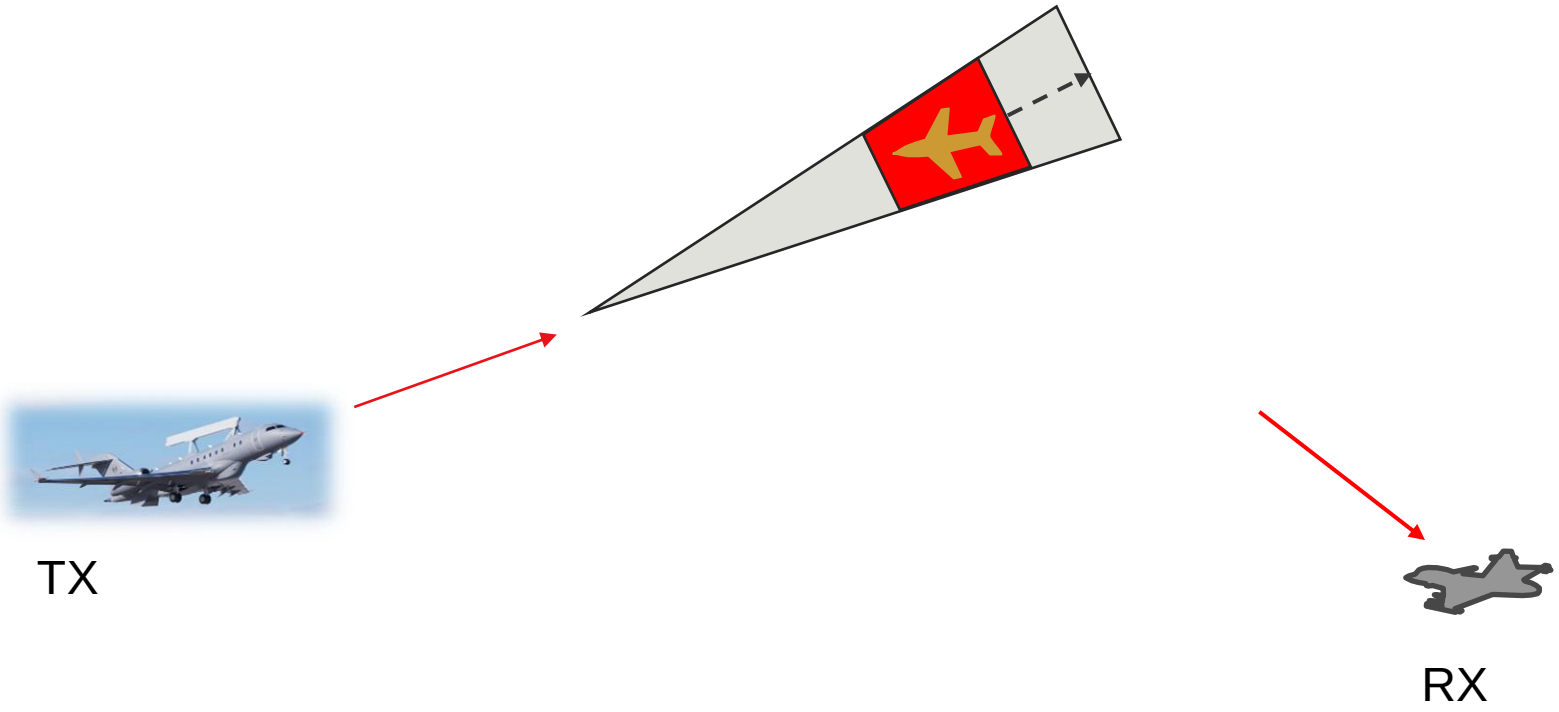


Bistatic Airborne Radar



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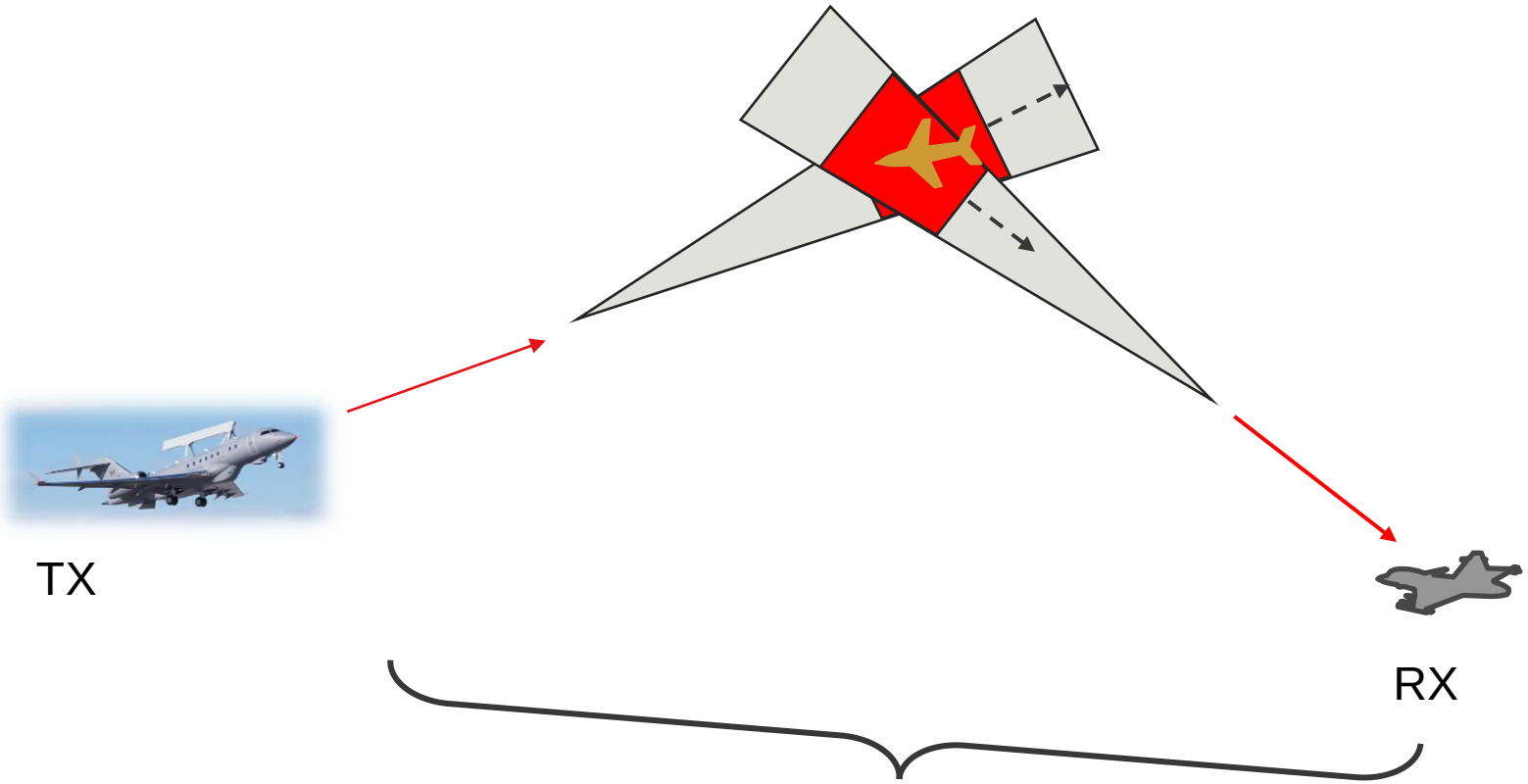
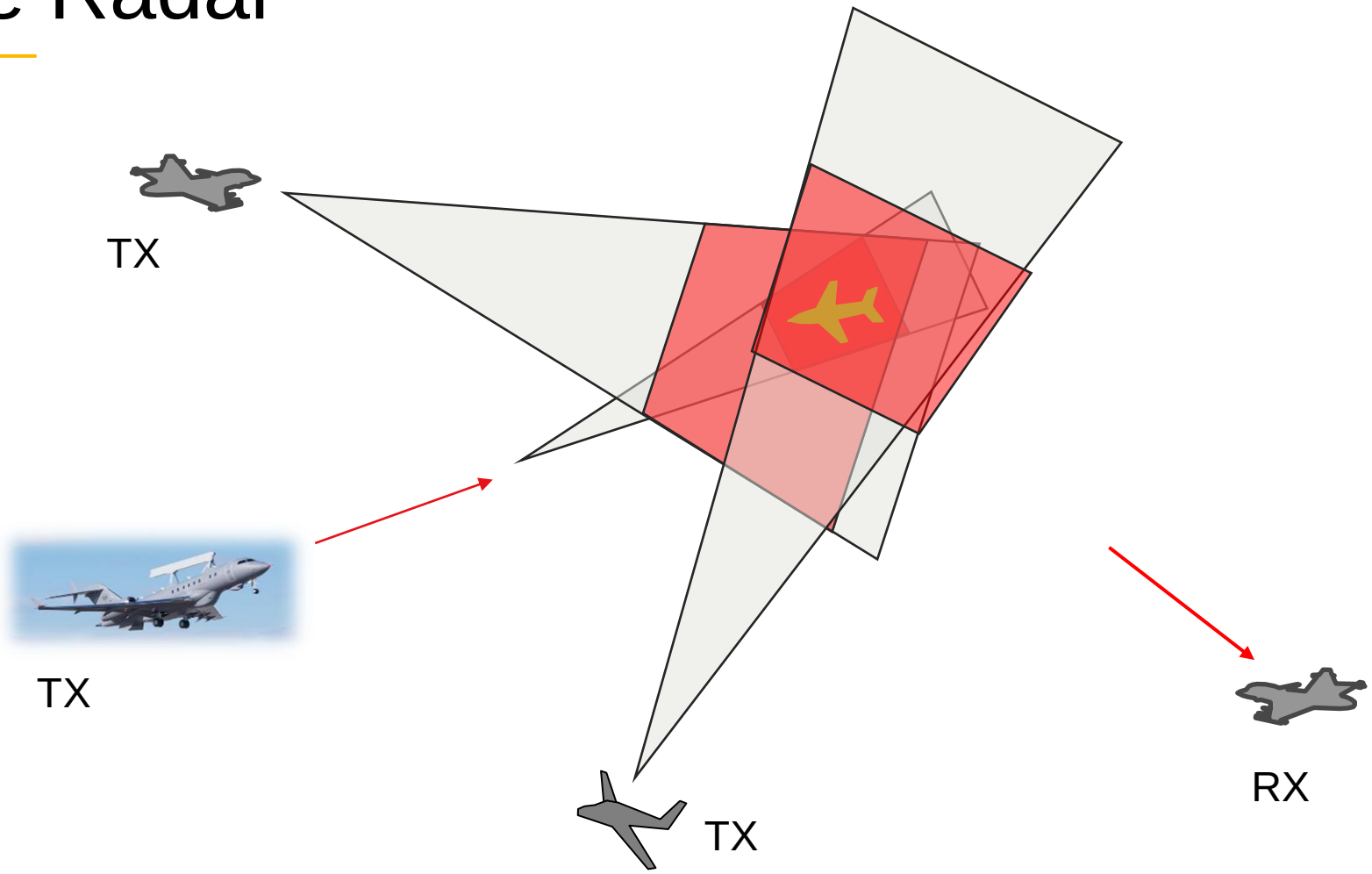


Beam Chasing

Pulse Chasing

Distributed Airborne Radar

+ Synchronization between multiple transmit platforms

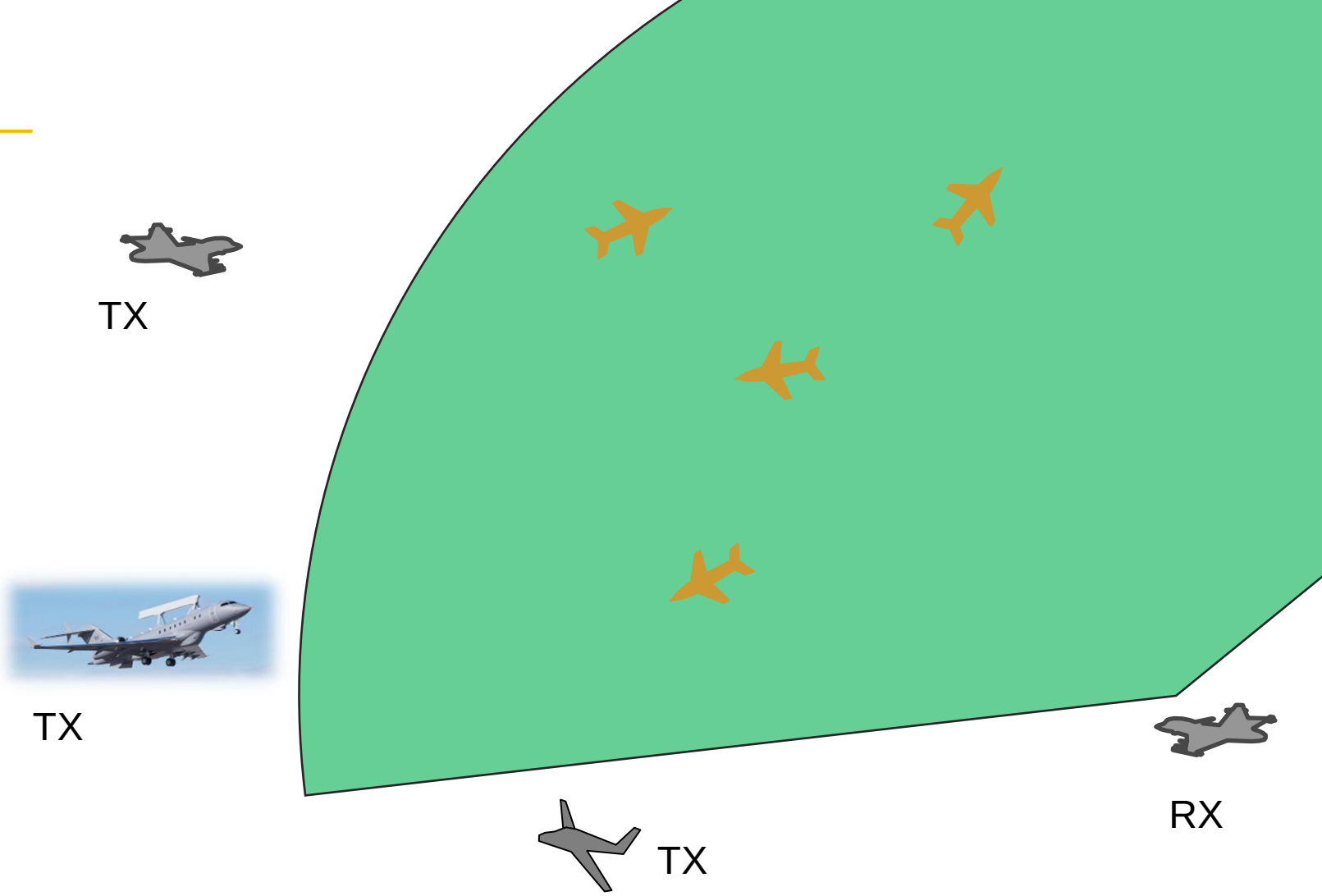


Beam Chasing
+
Pulse Chasing

Solution

Digital radar for receive platform:

- **Wide receive beam**
- **No pulse chasing**
- **No transmit synchronization**



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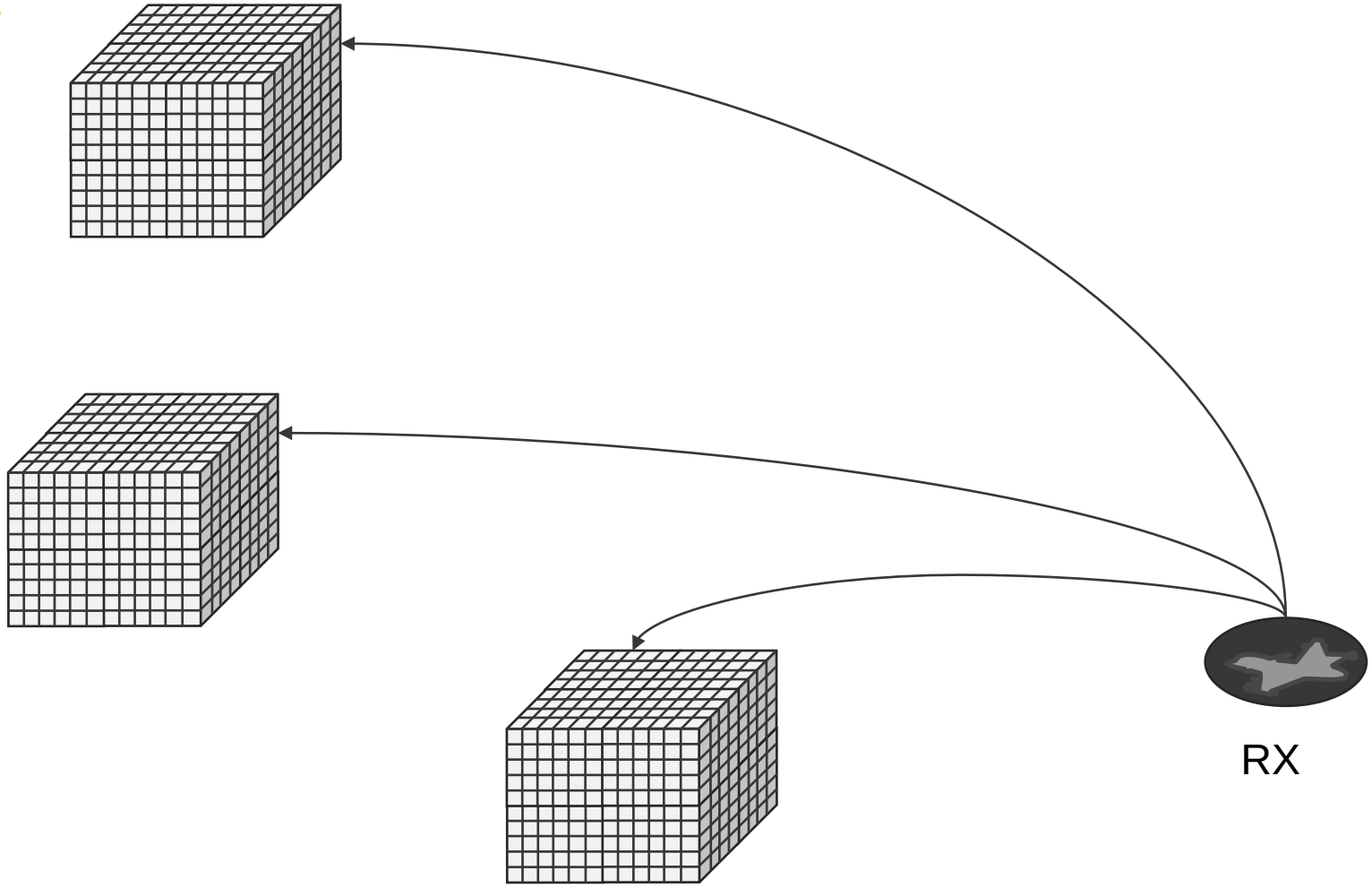
A Challenge and a Data Tsunami:

- **High data rates**
- **Large data sets**



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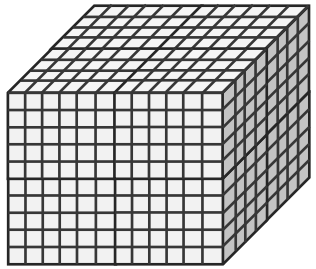
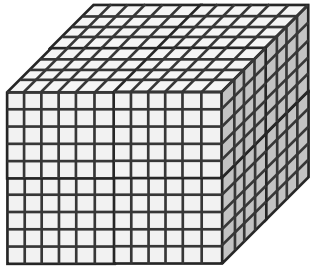
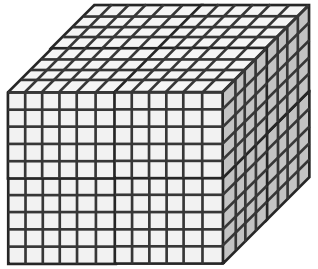
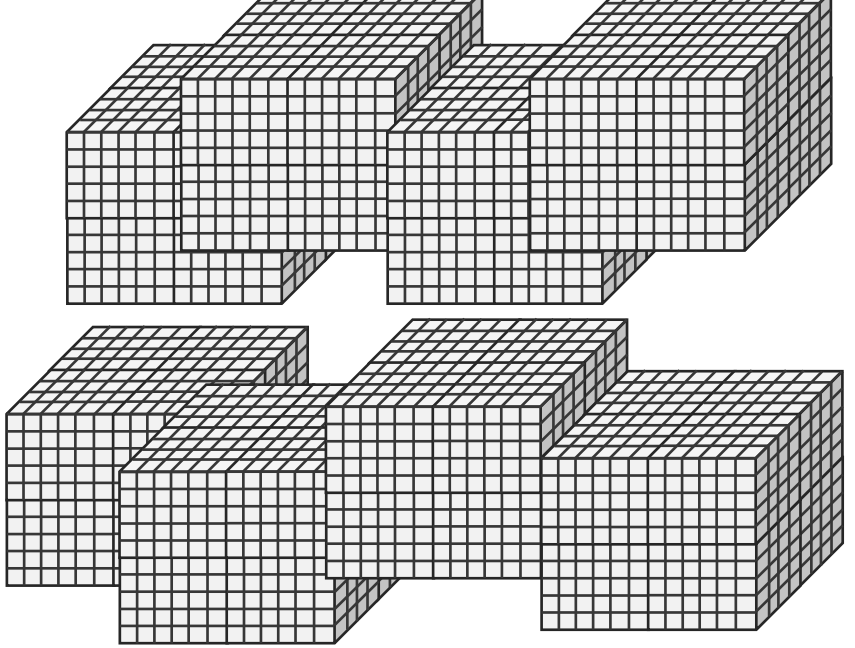








RX

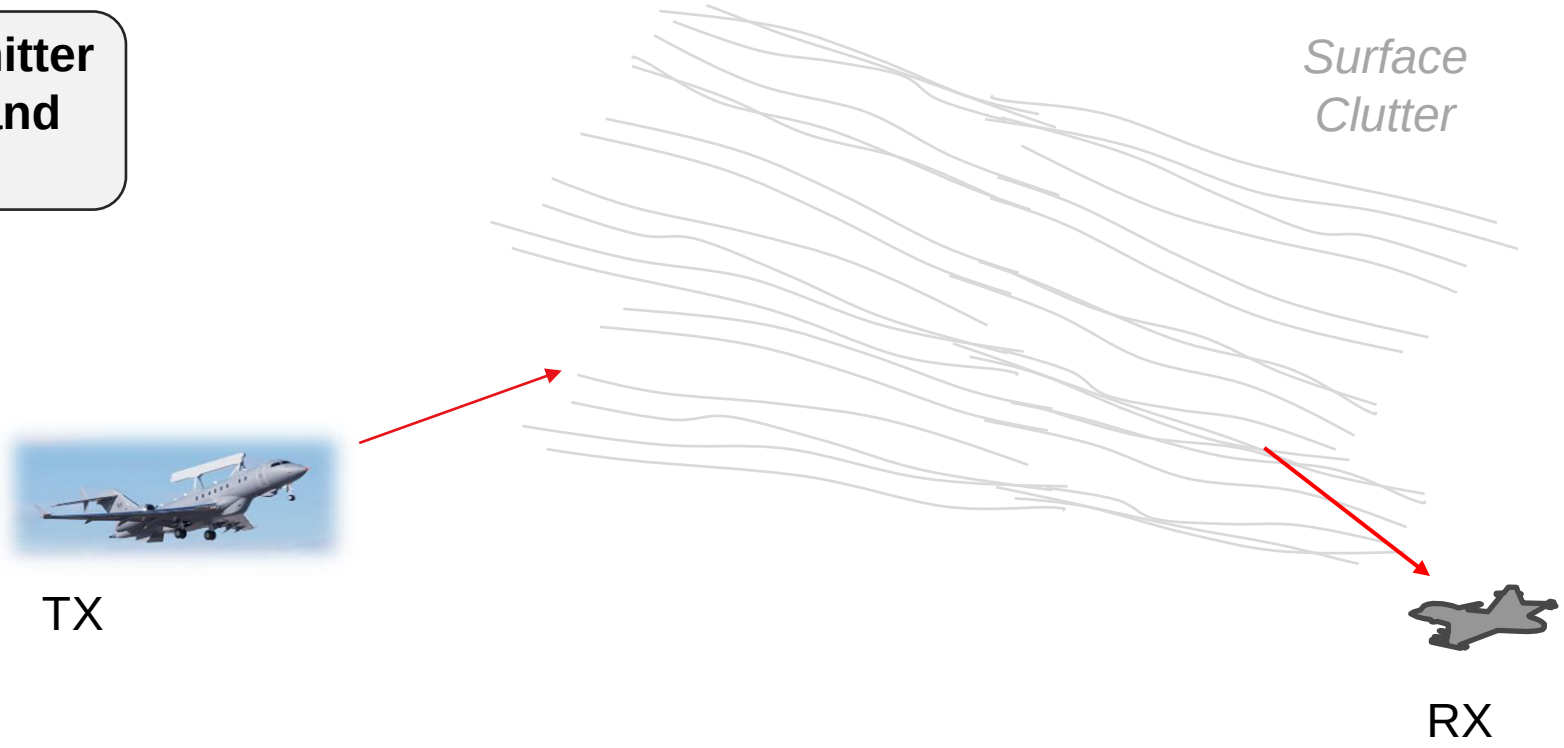
A Challenge and a Data Tsunami:

- **High data rates**
- **Large data sets**
- **<u>Many data sets</u>**
  *There can be many transmitter platforms and thus **many transmit-receive pairs***

Scenario prediction

Major innovation from NFFP7:

The position and velocity for a transmitter platform can be estimated, tracked and predicted in the receiver platform



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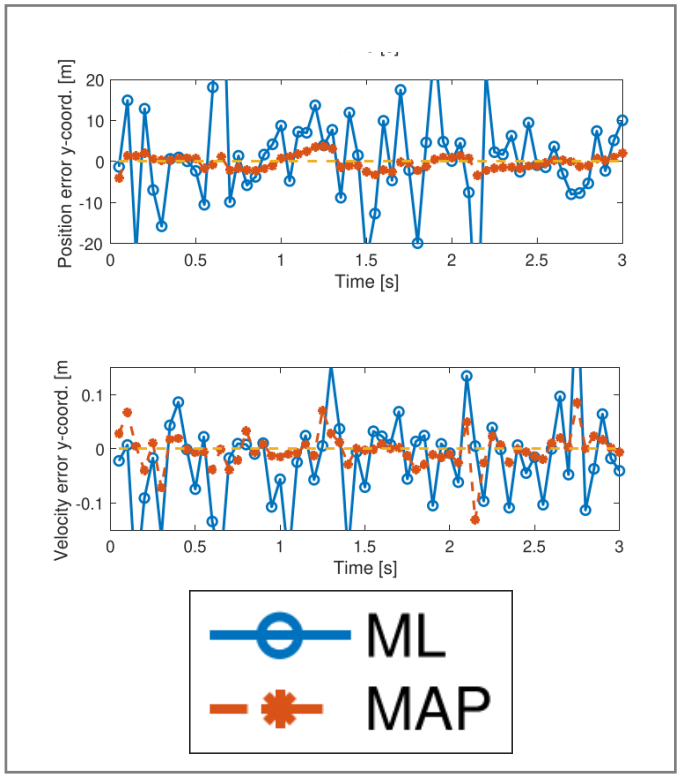
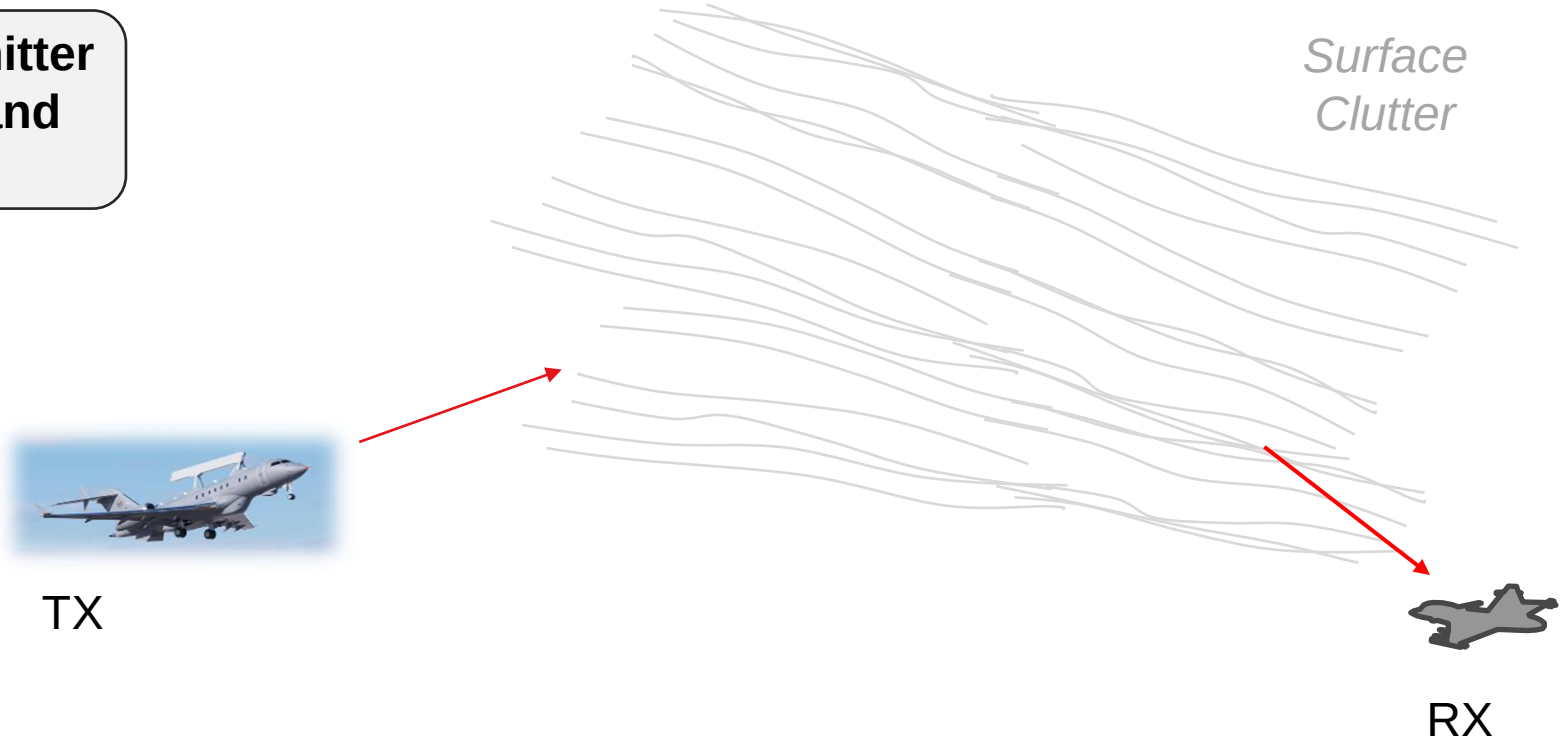




NFFP7:

[1] A parametric approach to space-time adaptive processing in bistatic radar systems, *IEEE Transactions on Aerospace and Electronic Systems*, 2021

[2] Scenario tracking for airborne bistatic radar systems, *IEEE Transactions on Aerospace and Electronic Systems*, 2024

Scenario prediction

NFFP8: Perform for all pairs!

TX

TX

Surface Clutter

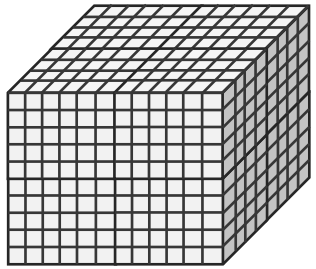
TX

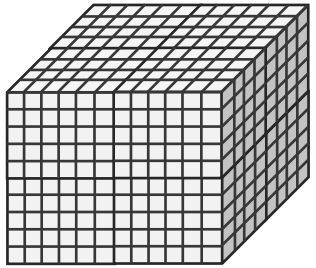
RX

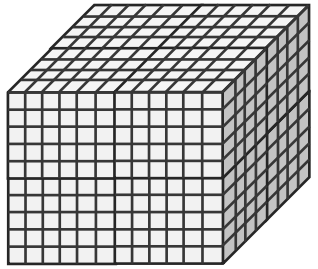
Scenario prediction

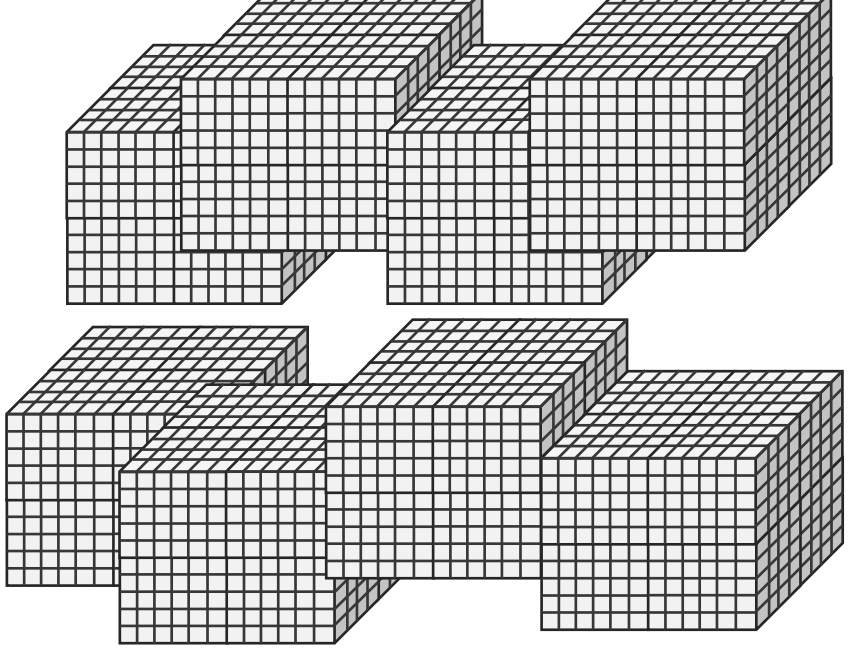
NFFP8: Perform for all pairs!

1. **Compute information gain for all pairs.**







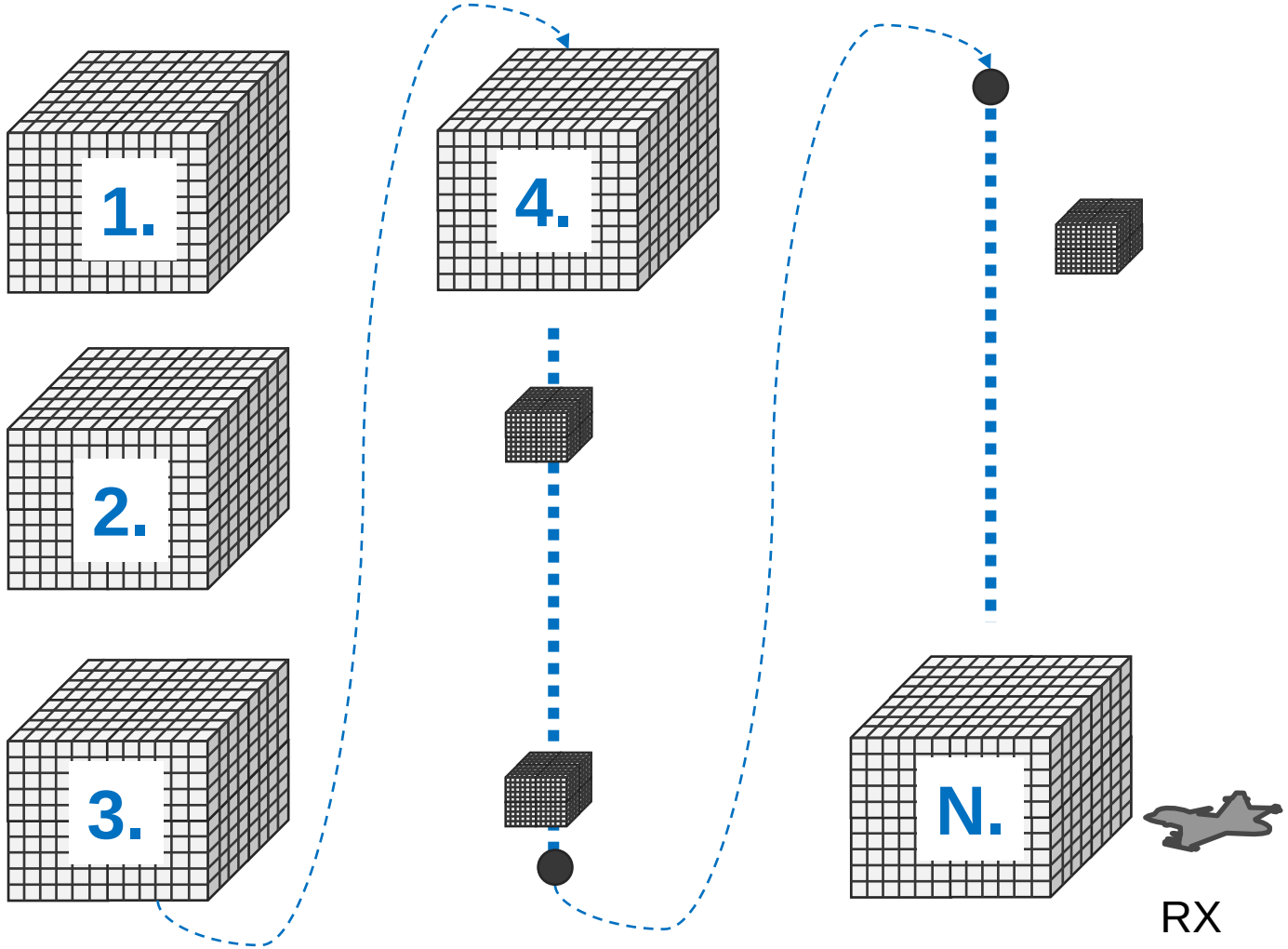


RX

Scenario prediction

NFFP8: Perform for all pairs!

1. **Compute information gain for all pairs.**
2. **Rank all pairs for processing**



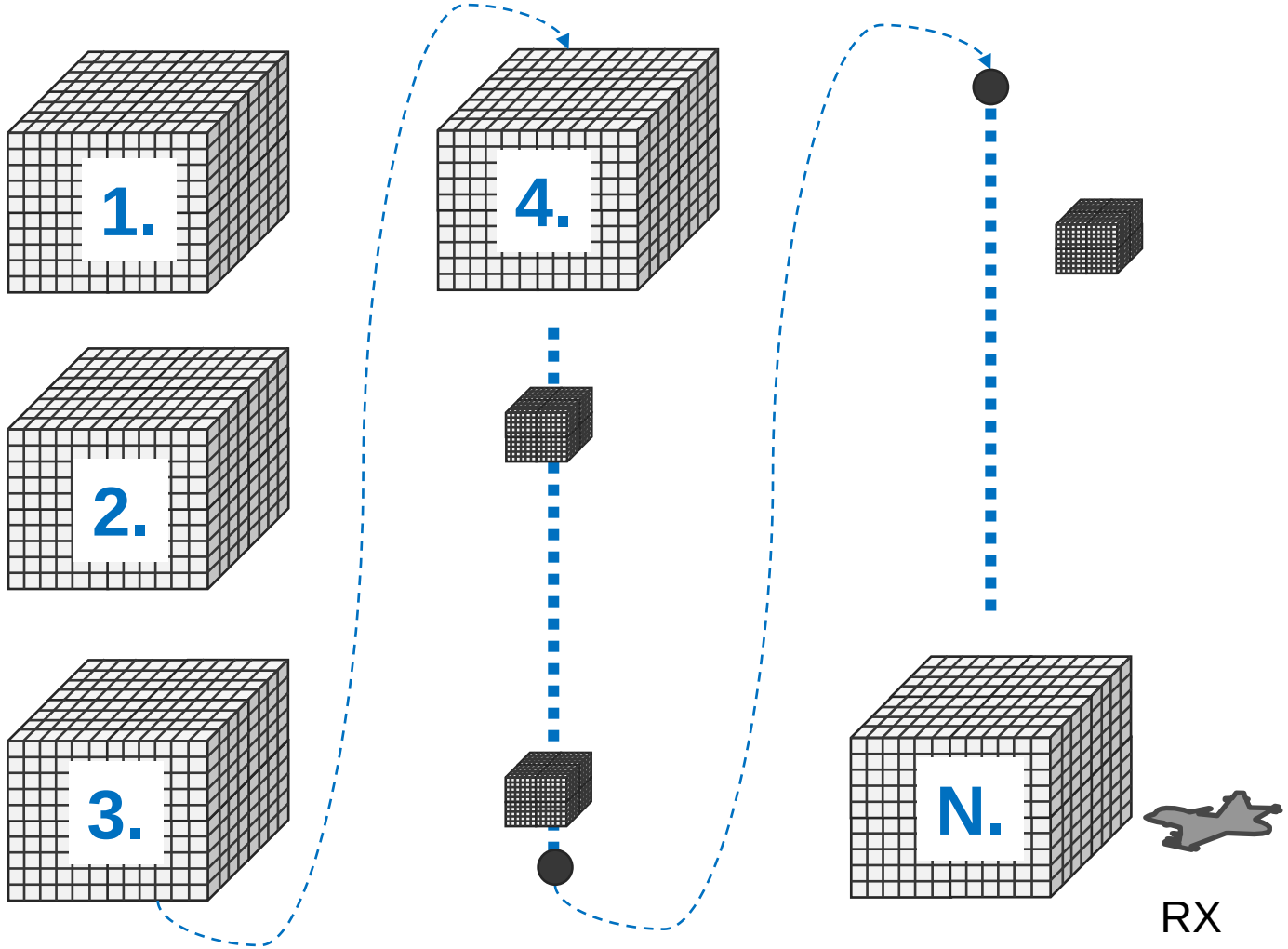
Scenario prediction

NFFP8: Perform for all pairs!

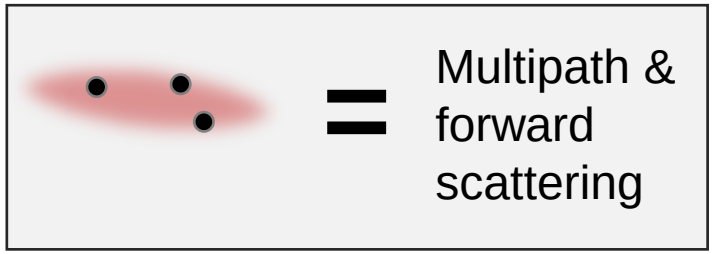
1. **Compute information gain for all pairs.**
2. **Rank all pairs for processing**

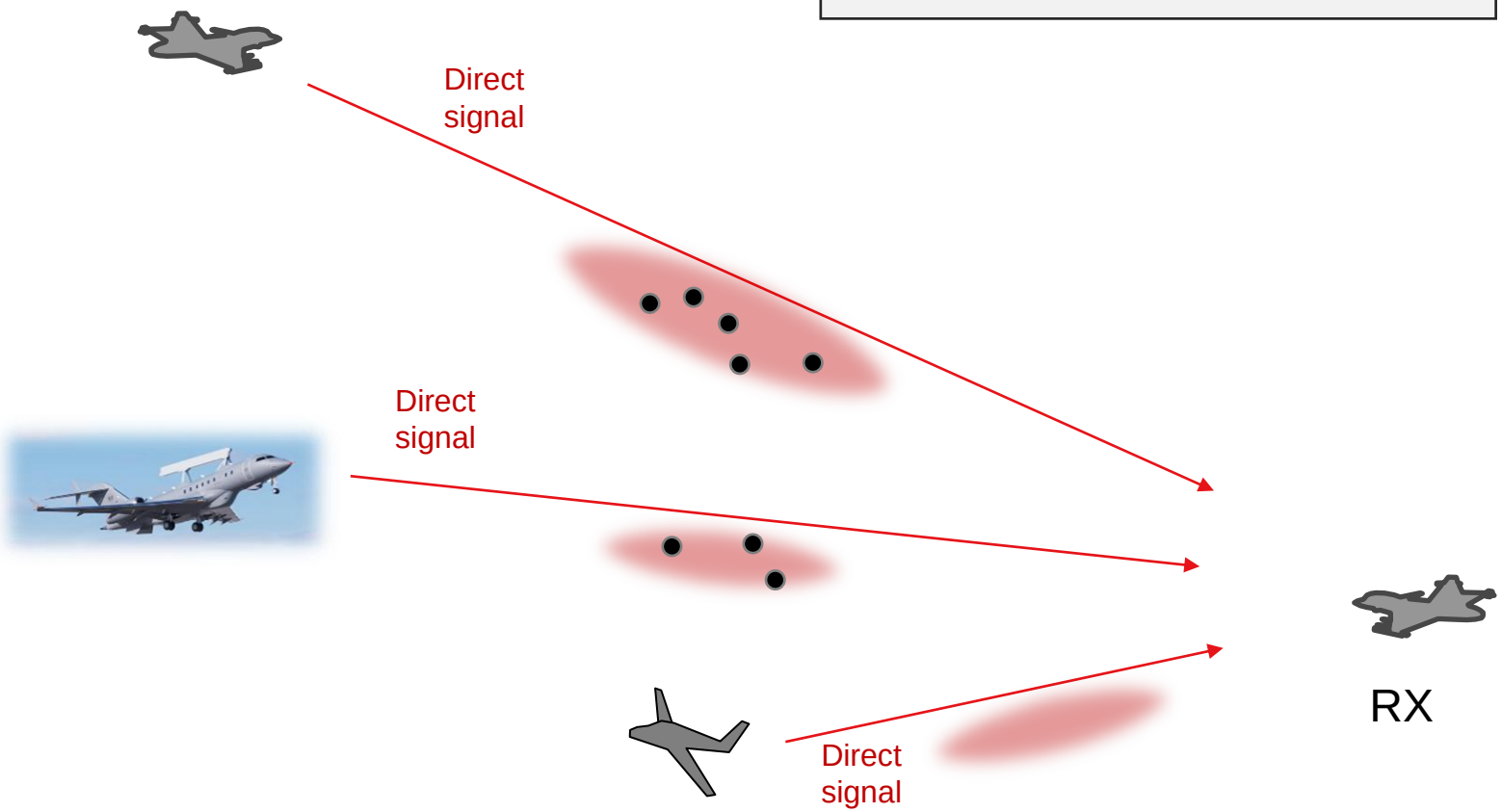
⇒ **A controlled processing load**

⇒ **Operational Restrictions & Planning are minimized.**



Exploitation of Direct Signals

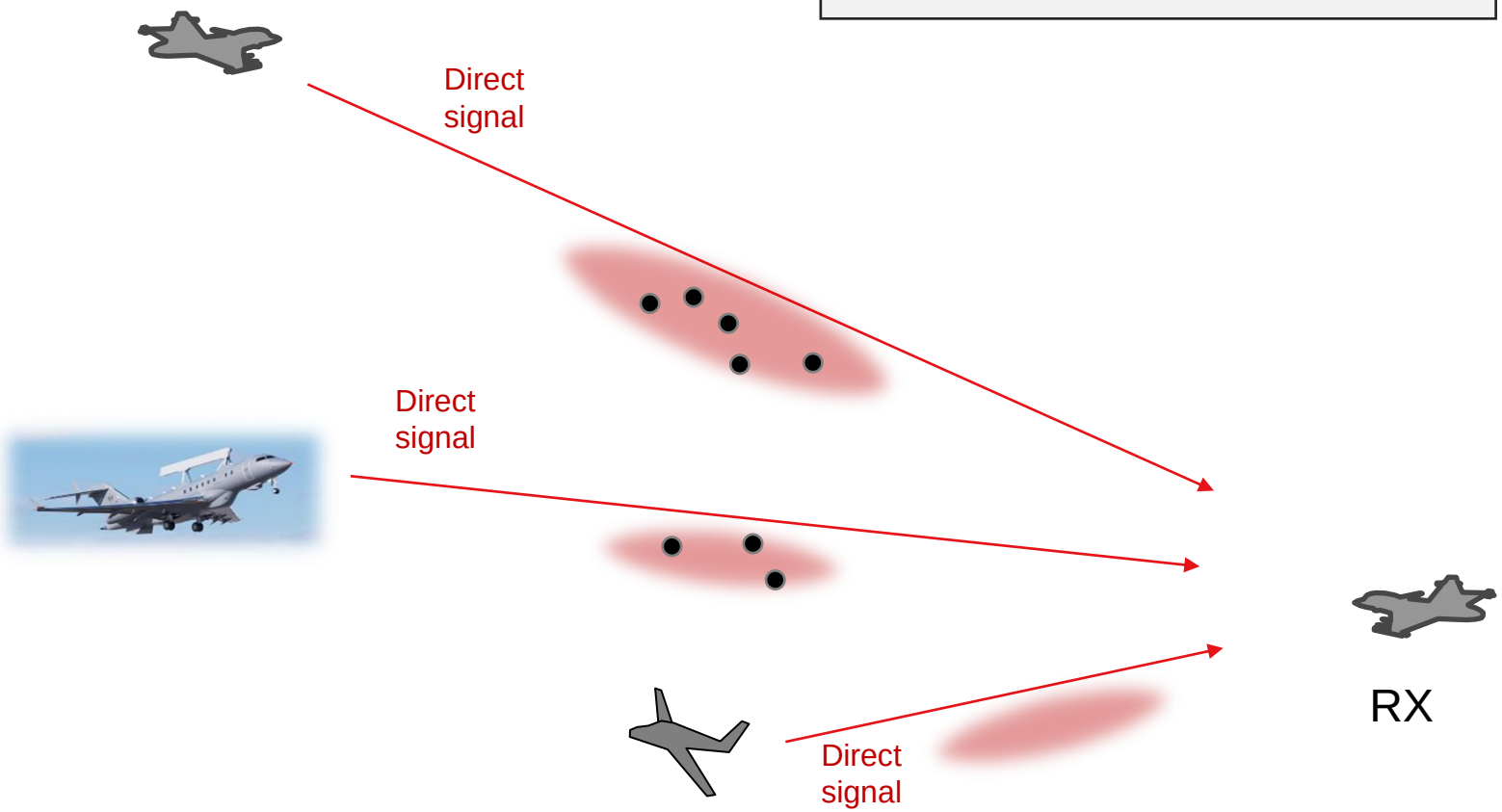




Exploitation of Direct Signals

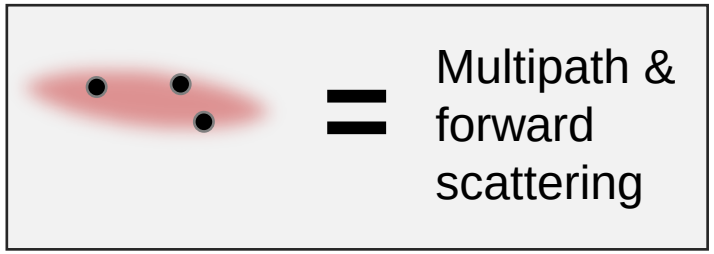
Initial tests in NFFP7

Estimation of needed waveform parameters and ensuring transmitter-receiver pair coherence.



Multipath & forward scattering

Exploitation of Direct Signals



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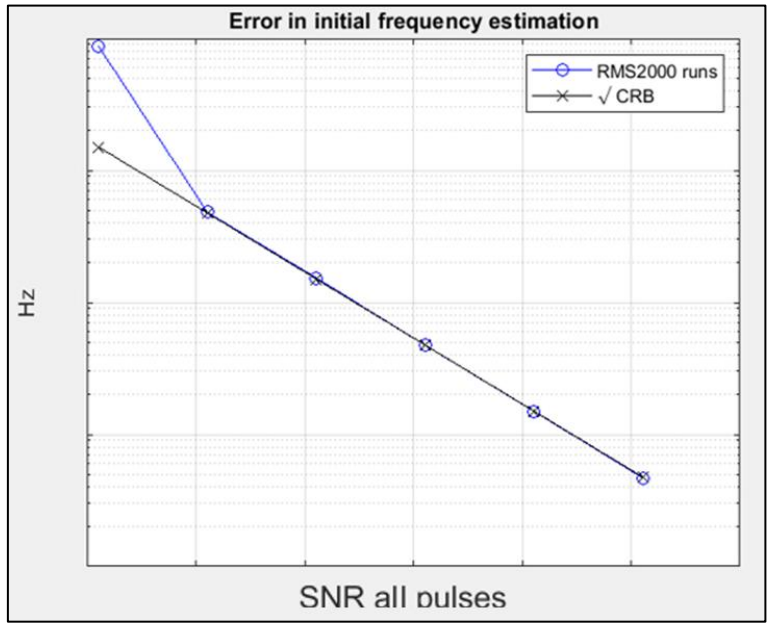

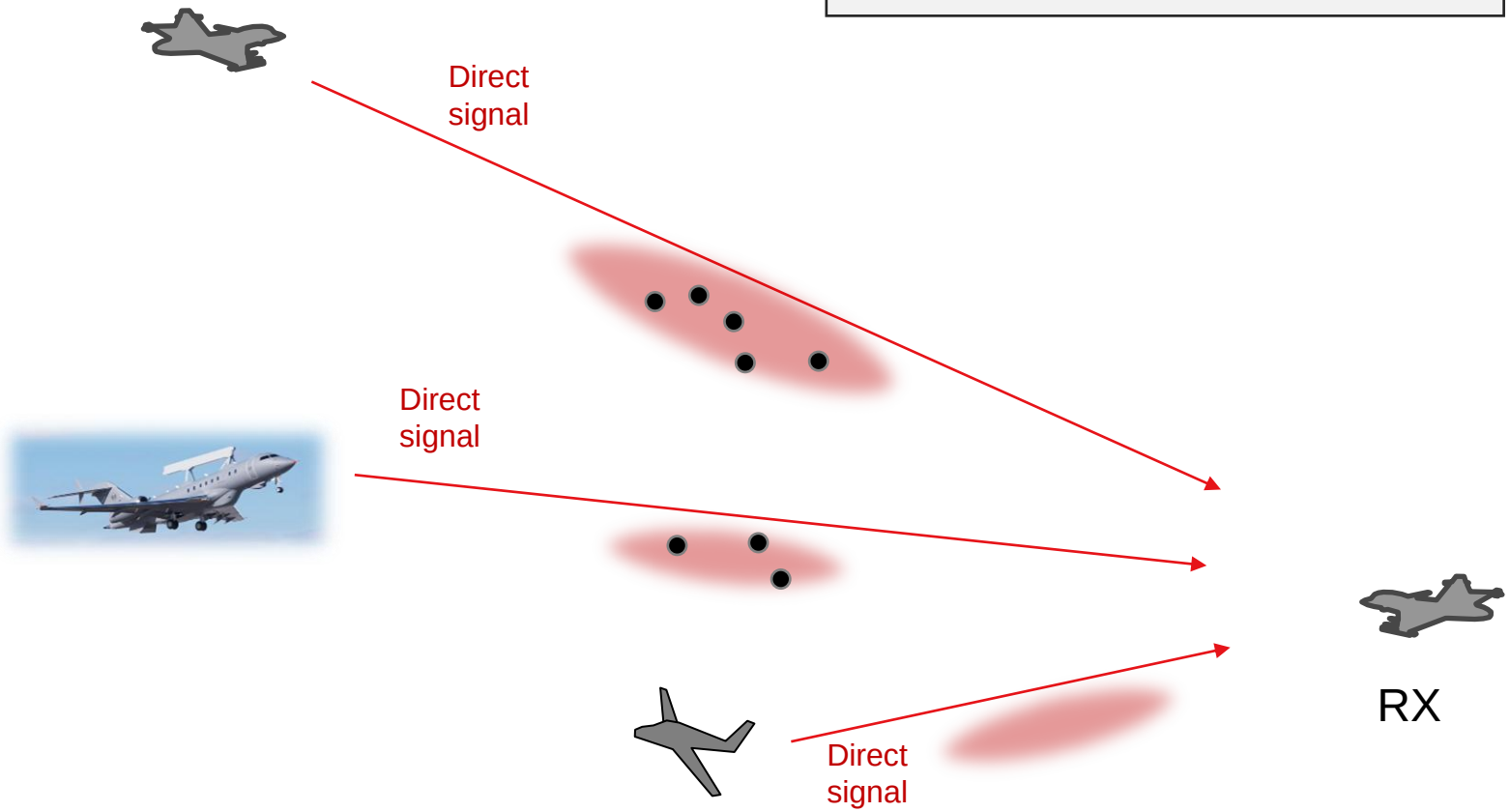

More results and methods
in-house @ Saab (not disclosed)

Airborne Distributed Radar – Conclusions (1)

- Background
  - Synchronization of many transmitters – is this even technically feasible?
  - Synchronization of many transmitters implies too restrictive operations
  - ⇒ Limited operational flexibility and limited adaptivity for changing geometries

- Solutions
  - **Digital Radar** removes need for pulse and beam chasing, i.e. less synchronization needs
    - ⇒ Creates a **tsunami of data to process**
  - **Multistatic Scenario Tracking** ranks predicted information gain for each Transmit-Receive pair
    - ⇒ Processing burden can be greatly reduced
  - A **Direct Signal** provides needed processing information
    - ⇒ Coherence
    - ⇒ Waveform types & modulations
    - A **Direct Signal** has in most cases high SNR ⟶ Accurate processing information
    - **Target echoes** ⟶ Additional source for processing information

Airborne Distributed Radar – Conclusions (2)

- Vision for our R&T activities for an Airborne Distributed radar

  ⇒ A set of methods that allows the following:

  - Less dependent on detailed planning phases & enabling a more flexible operation
  - Capability to adapt to changing operational circumstances in real-time
  - Larger operational envelope
  - Open up a wider range of ADR platforms, i.e. from small drones to large aircrafts.
  - Less dependent on dedicated hardware
  - Less dependent on GNSS

Thank you