Analysis of Naval Air Defence

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Agenda

- Anti-ship missiles vs. ship air defences
  - Conclusions for ASM
  - Conclusions for ship-air defence
- Comparison of rotating and fixed-plate radars

Introduction

- Based on recent Swedish studies:
  - New anti-ship missile (Navy & Air Force)
  - Assessment of fixed-plate and rotating radars (SAAB)
  - [New ground based air defence (Army)]
- Unclassified and general conclusions

Anti-ship missiles vs. ships in the littorals

- Challenges for the anti-ship missile
  - Finding the target among non-targets (islands, civilian ships…)
  - Overcoming electronic warfare
  - Overcoming air defence

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Finding targets – challenges for anti-ship strikes

- Finding and classifying targets at long range in a complex environment is a real challenge
- Combination of sensors is essential
  - Radar sensors (airborne for long range)
  - Signal/electronic intelligence for identification
  - Underwater sensors
  - Forward deployed sensors
- Missile seeker with high resolution

Ship air defence

- Combat ships have multi-layered air defence systems
  - Long/Medium range surface-to-air missiles
    - Standard, ASTER, ESSM, 9M96E
    - Vertical launch

  - Short range surface-to-air missiles
    - RAM, Sosna
  - Close-in weapon systems (CIWS)
    - Goalkeeper, Palma/Palash

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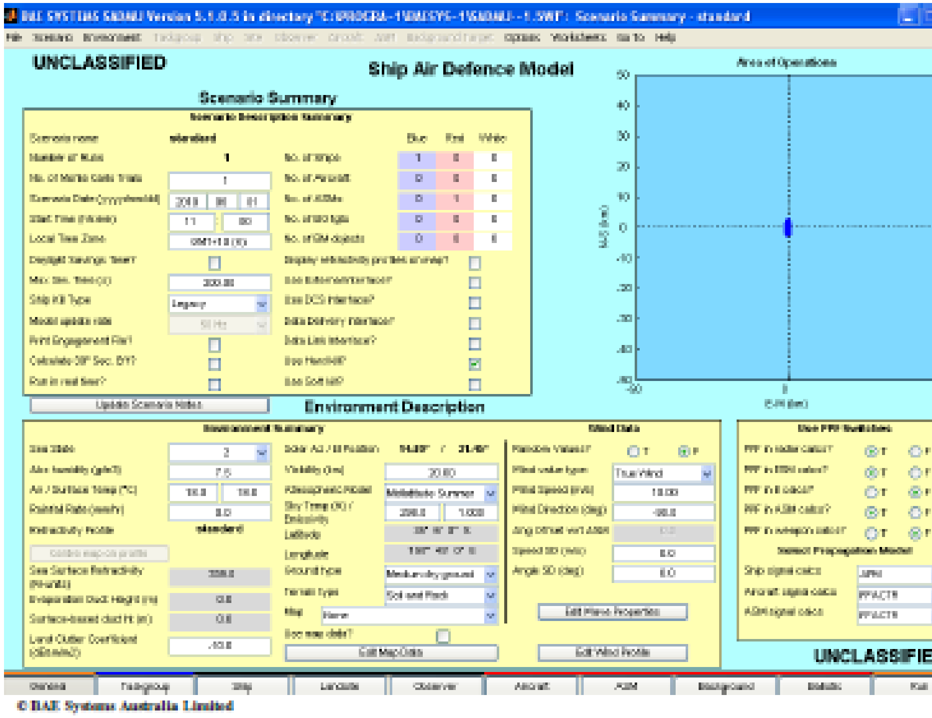
Method

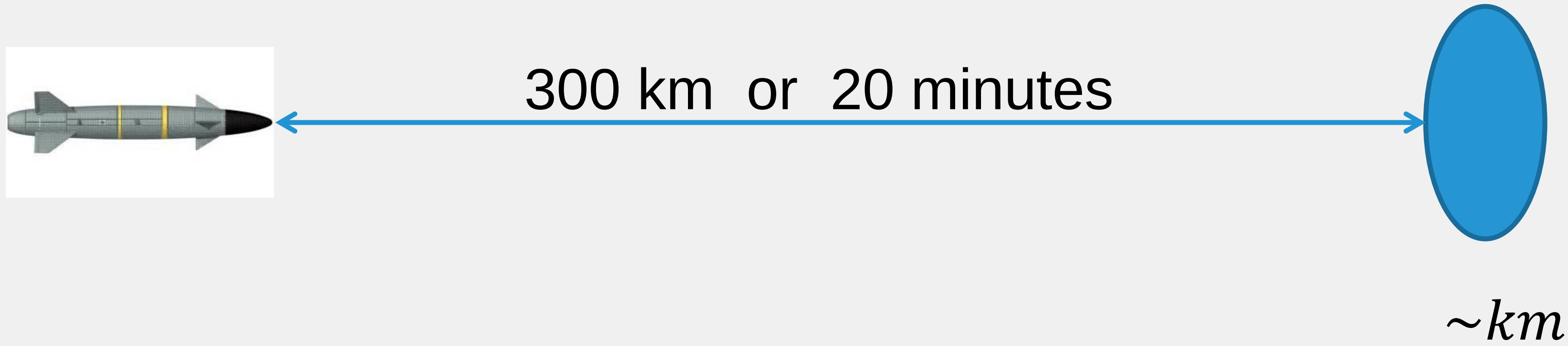
- Ship Air Defence Model (SADM) software for multiple dynamic simulation runs. The SADM simulation tool is a computer model developed by BAE Systems Australia and used by many nations around the world.
- Populate the SADM model with a scenario and with models of the involved systems i.e. threats, surveillance radars, fire control radars and air defence missiles.
- Measures Of Effectiveness (MOE) based on saturation of the air-defence system by multiple incoming threats.
- Two basic scenarios: one without jamming and one with background jamming from an aircraft against the surveillance radars.

SADM – Ship Air Defence Model

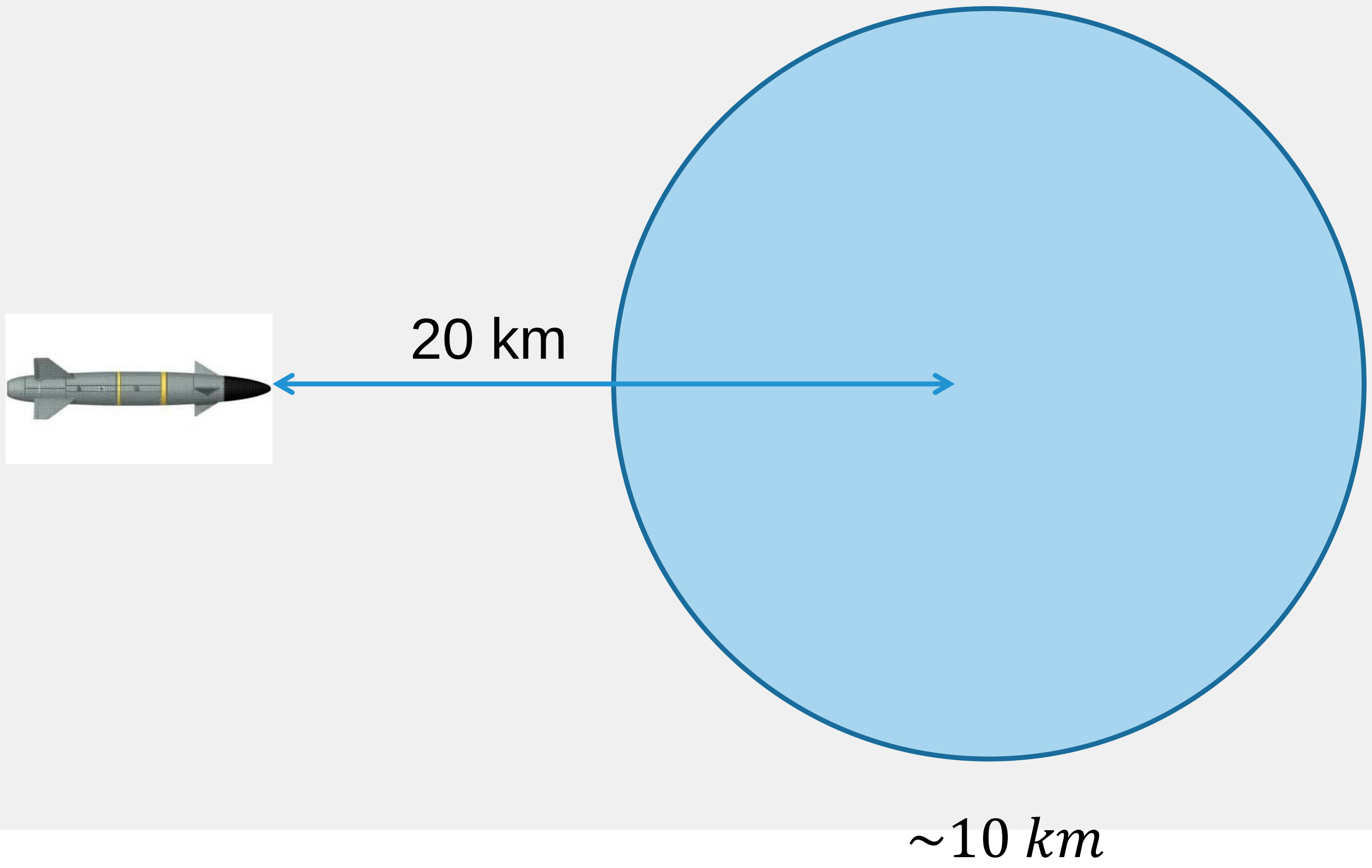
- Developed by BAE Systems
- SADM is a software simulation tool directed at the Maritime Self Defence problem (air and surface threats)
- Simulates the defence of a task group against other ships, aircraft, ASMs, and background targets
- Includes littoral effects
- Consists of detailed models of
  - Platforms (ships, aircraft, land-based weapon sites etc)
  - Sensors (many types of radars, IRST, ESM)
  - Trackers and track management systems
  - Command and control, weapons control systems
  - Weapons (hard kill and soft kill)
  - Anti-ship missiles (seekers, body and electronic environment)
  - Environment (atmosphere, terrain, propagation)
  - Interactions between subsystems



Finding the target - Uncertainty at launch



Uncertainty at target acquisition (no updates)



Finding targets at long range

a) Missiles flies at high altitude and scans with powerful radar

- Not a survivable option

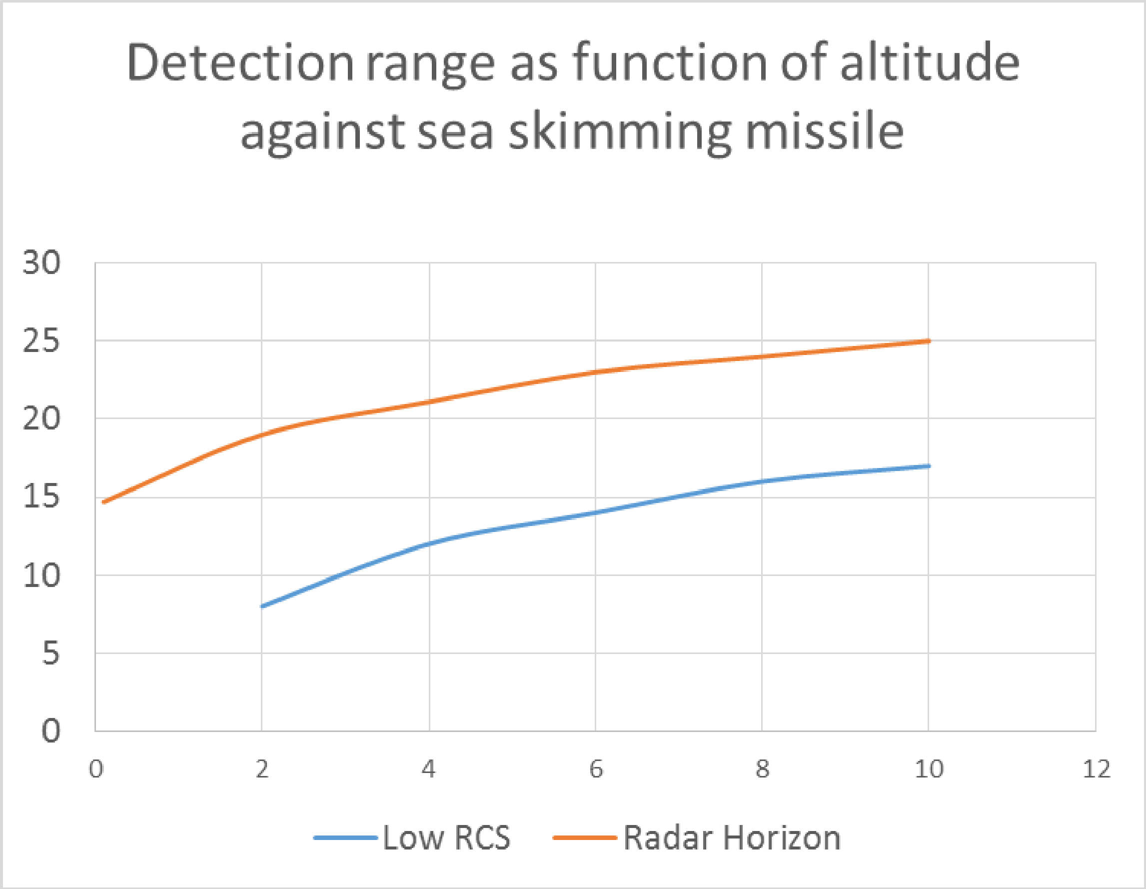
b) Missile receives target updates via data link

Overcoming air defence

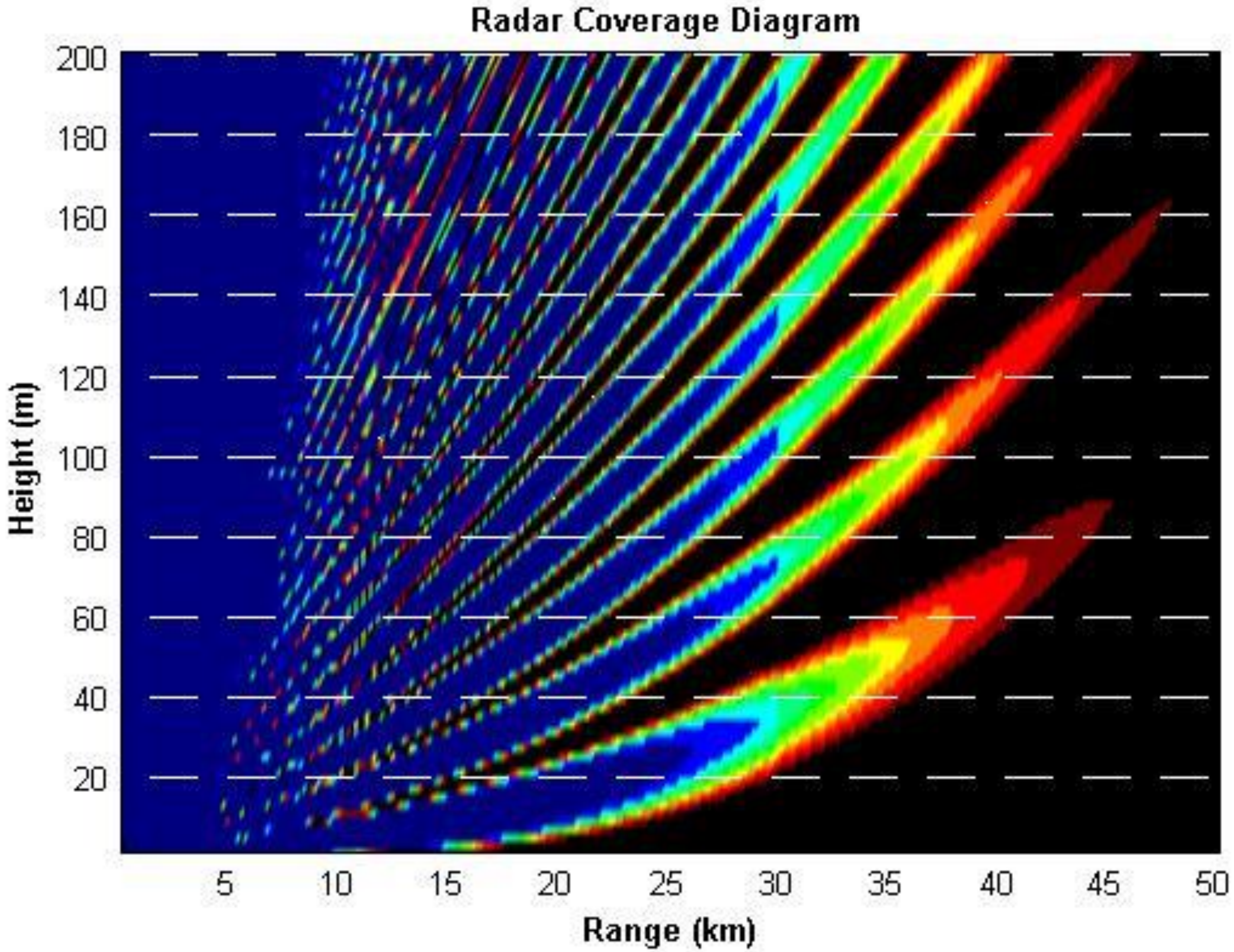
- Medium range surface-to-air missiles
  - High capacity against simultaneous targets
  - Decreased performance against targets at extremely low altitude
  - Reaction time and inner launch zone can limit performance against targets with low RCS, high speed, low altitude

How to overcome SAMs

- Very low signature
- Low altitude (sea skimming)



Radar Coverage Diagram



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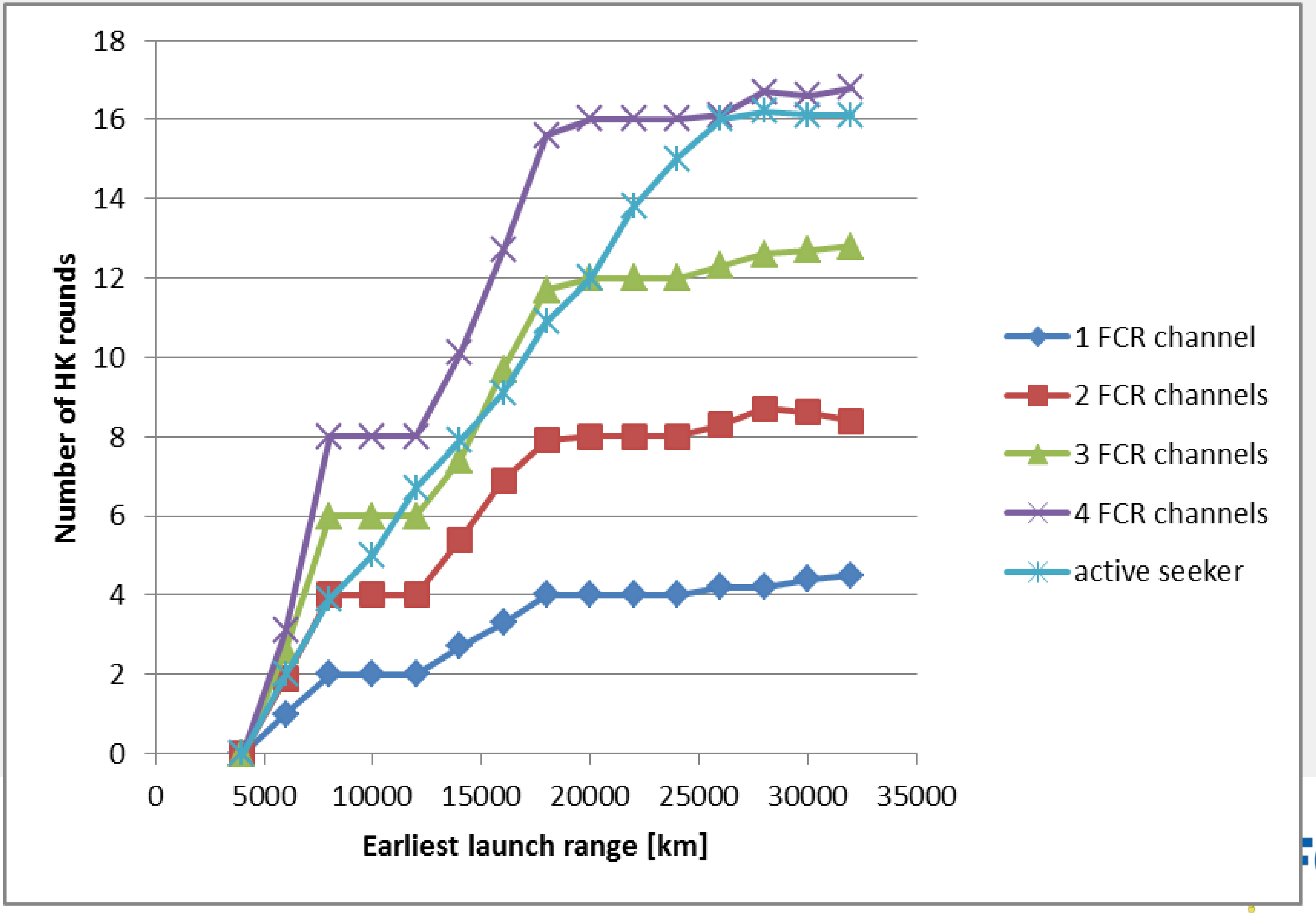
Air defence systems

Weapon systems

- active Mach 3 missile with up-link
- semi-active Mach 5 missile with either one, two three or four director channels

Number of possible air defence missiles for different air defence solutions and max launch range against 12 ASMs



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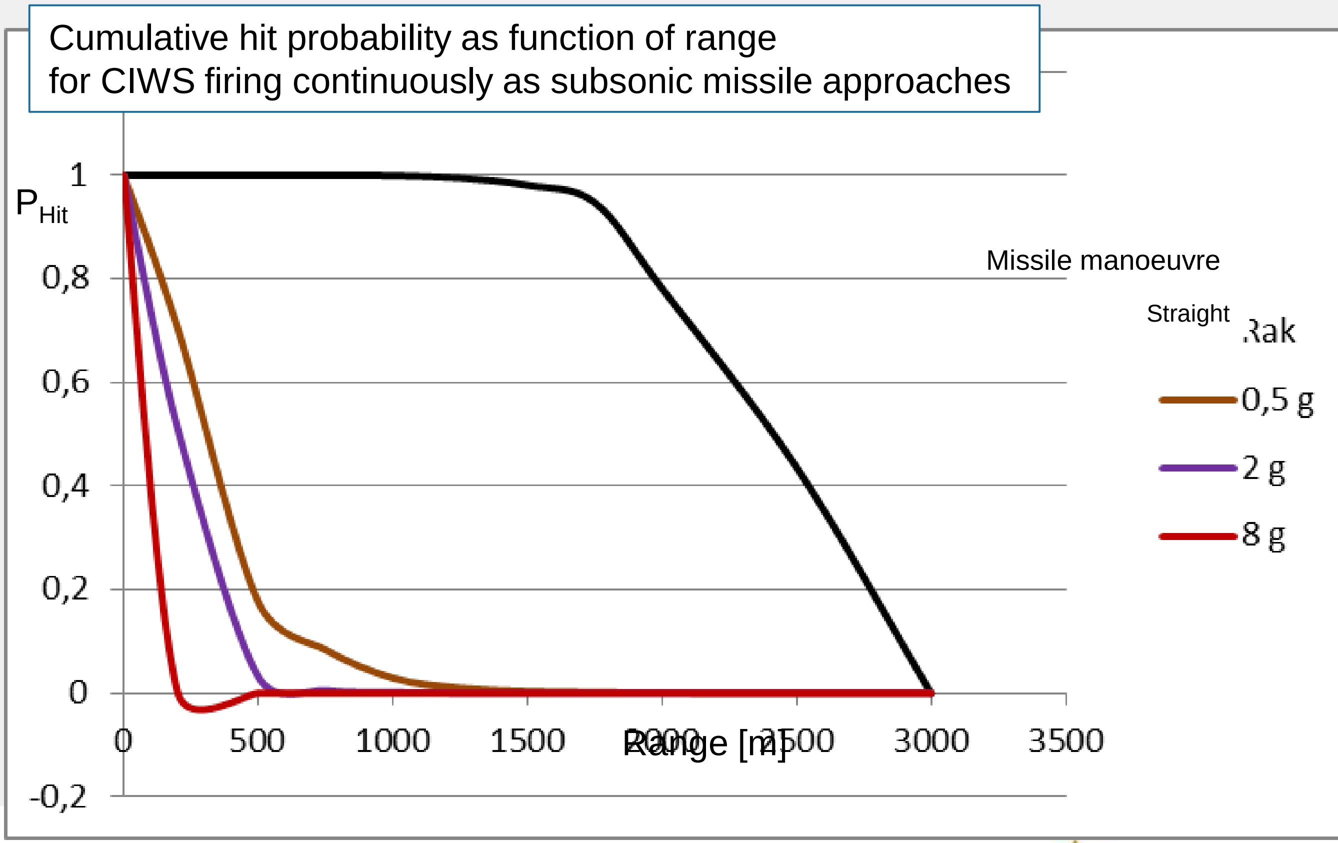
Saturation: low RCS, low altitude and high speed

- Very low altitude and very low RCS can give detection range less than 10 km
- This equals 30 seconds for subsonic ASM and 15 seconds for supersonic
- Saturation is then achieved with
  - One supersonic anti-ship missile
  - A handful of subsonic anti-ship missiles

Overcoming CIWS

- CIWS with close range guns are affected by evasive manoeuvres



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Anti-ship missile success factors

- Difficult to penetrate qualified air defence
- Critical success factors for the anti-ship missile
  - Low altitude
  - Low signature
  - No emissions
  - Simultaneous time on target

  } Data link + external sensor

  - Separate targets and decoys — IR seeker
  - Terminal evasive manoeuvres
  - All weather capability — Radar seeker

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Cooperation

- Cooperative engagement useful to overcome air defence
  - Anti-ship missile flying low and silent requires target update from external sensor
  - Very close coordination of time-on-target against mobile ships requires target updates
- Possibly cooperation within a swarm of anti-ship missiles

Conclusions on anti-ship missiles

- In order to be effective, anti-ship missiles need:
  - Find right target
    - External sensors giving target location
    - Target update via data link
    - Have seeker with high resolution
    - Discriminate electronic countermeasures
  - Fly very low
  - Have very low RCS and be silent
  - Be fast
  - Perform evasive terminal manoeuvres
  - All aspects need to be combined in a balanced concept

Conclusions on ship air defences

- Elevated sensor to give early warning
- Short reaction times
- Good performance against
  - extremely low-altitude targets
  - low signature targets
  - high-speed targets
- Handle saturation
- Many available surface-to-air missiles (affordable)
  - Tiers of short and medium/long range

Shipborne radars for air defence

- Shipborne radars are usually in the S-X band range, i.e. wave-lengths 3-10 cm
- Antennas are either:

1. Rotating
   - Reflector
   - Electronically scanned (AESA)
2. Fixed plate
   - Electronically scanned (AESA)

Characteristics

- Rotating antenna
  - Lighter than multiple fixed antennas
  - Measures with the main beam
  - Has limited update rate
  - Has moving parts

Air defence systems

Weapon systems

- active Mach 3 missile with up-link
- semi-active Mach 5 missile with either one, two three or four director channels

Surveillance systems

- Three rotating radars at different frequency bands
- One fixed-plate radar with four plates

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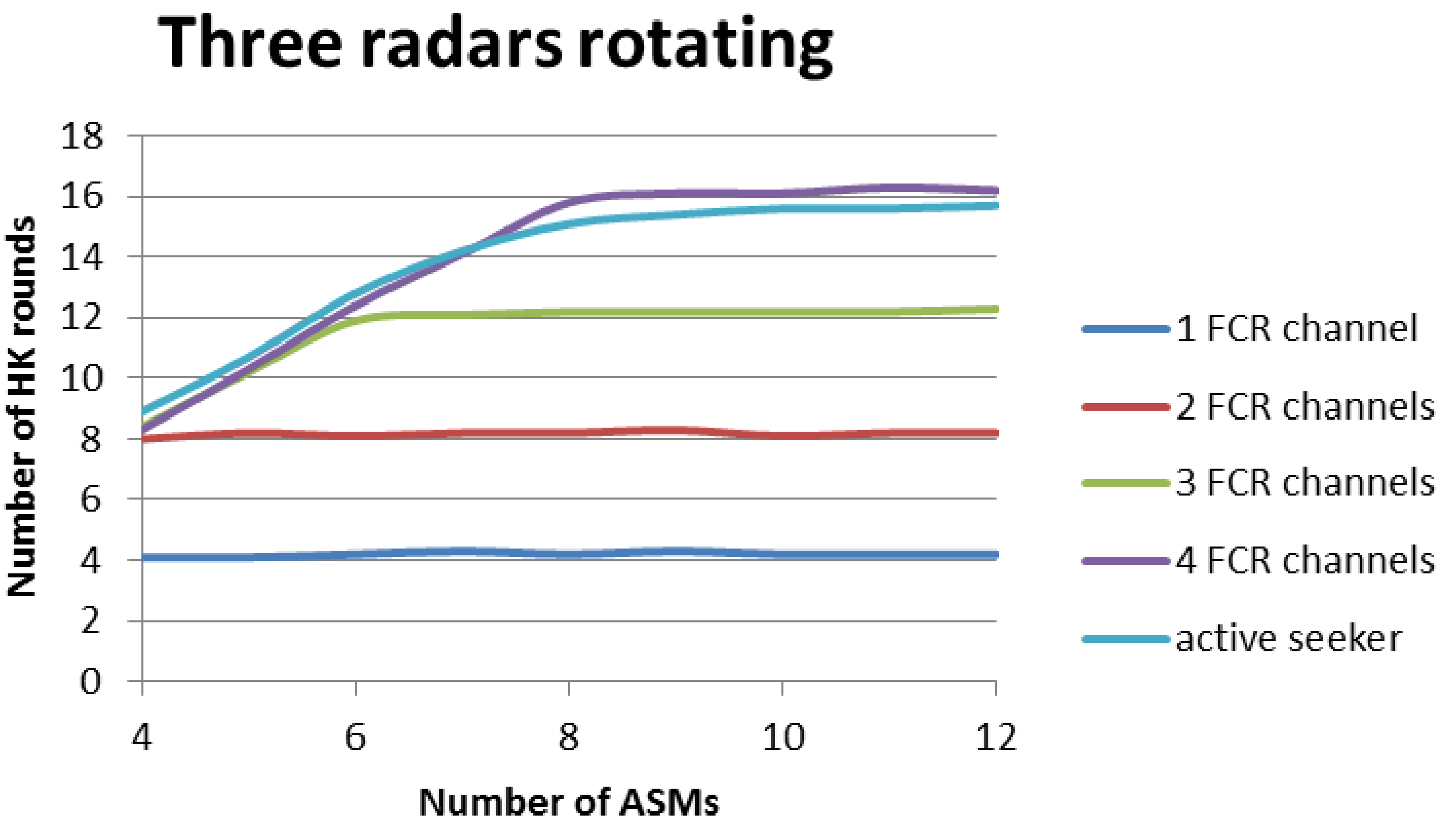
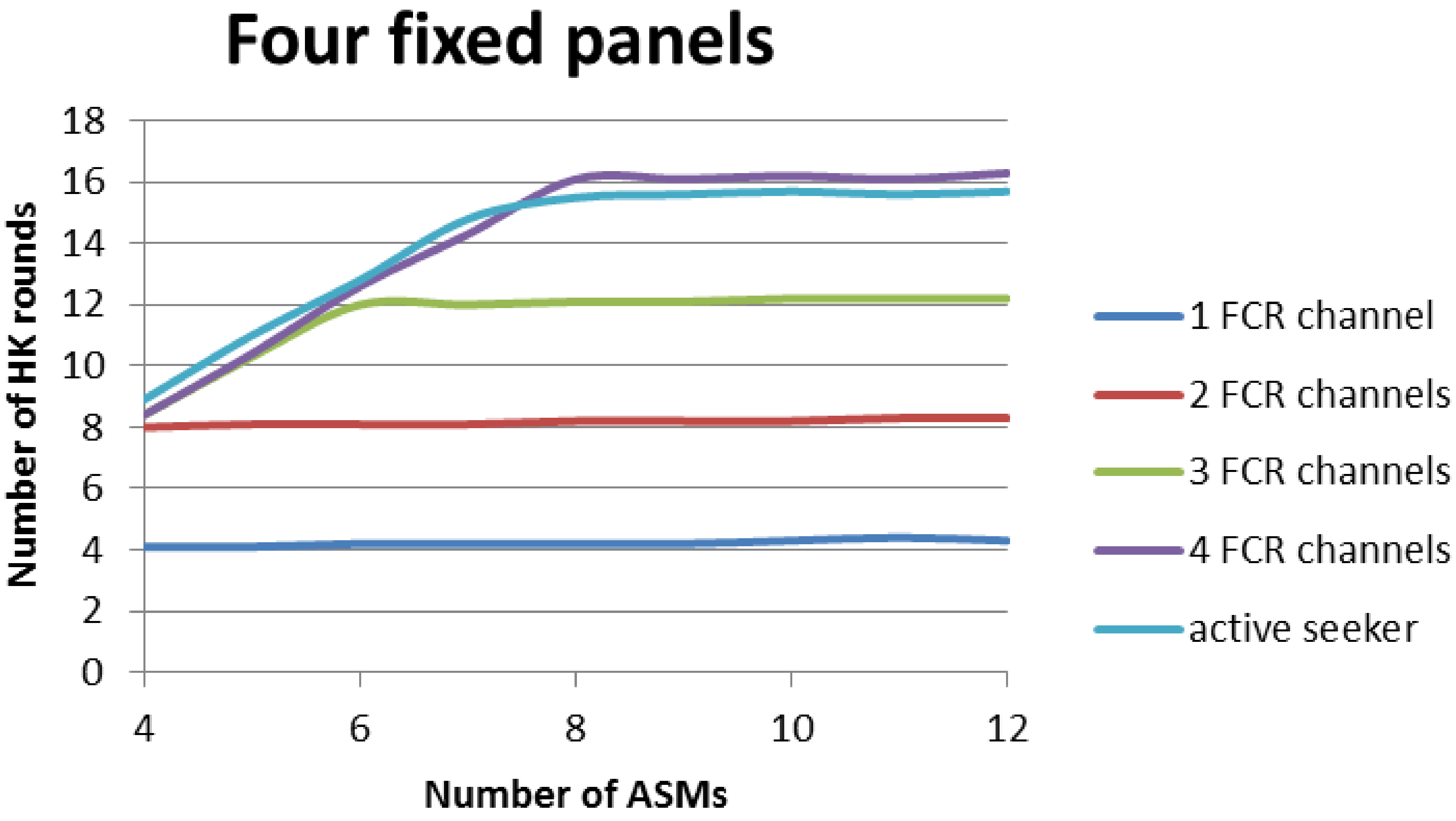
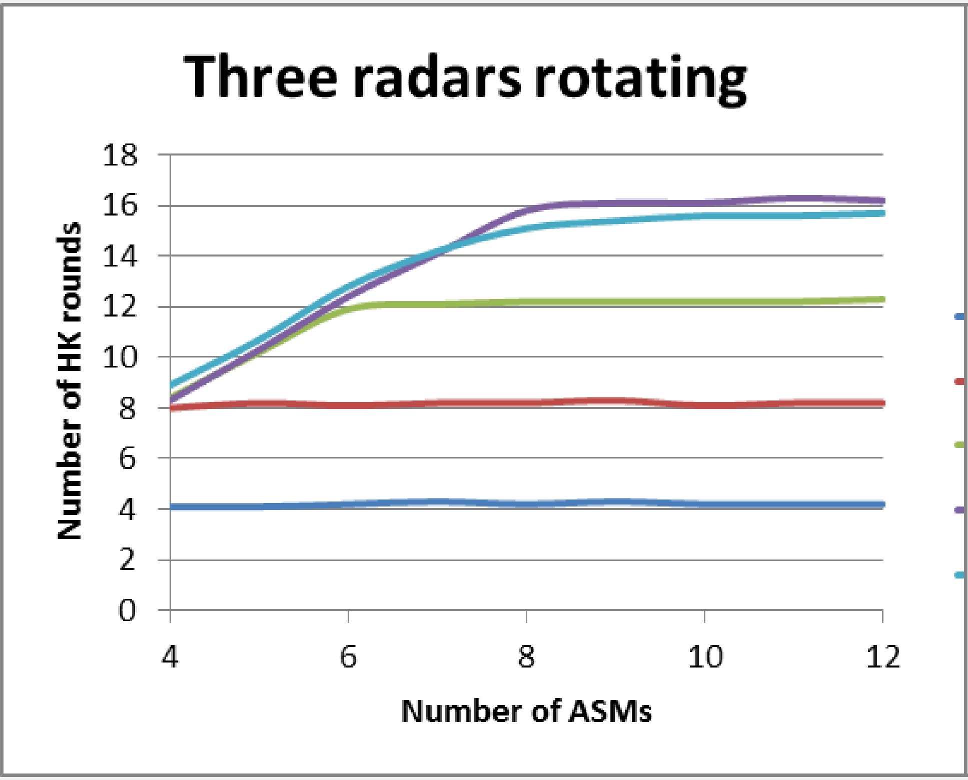
Number of launched air defence missiles

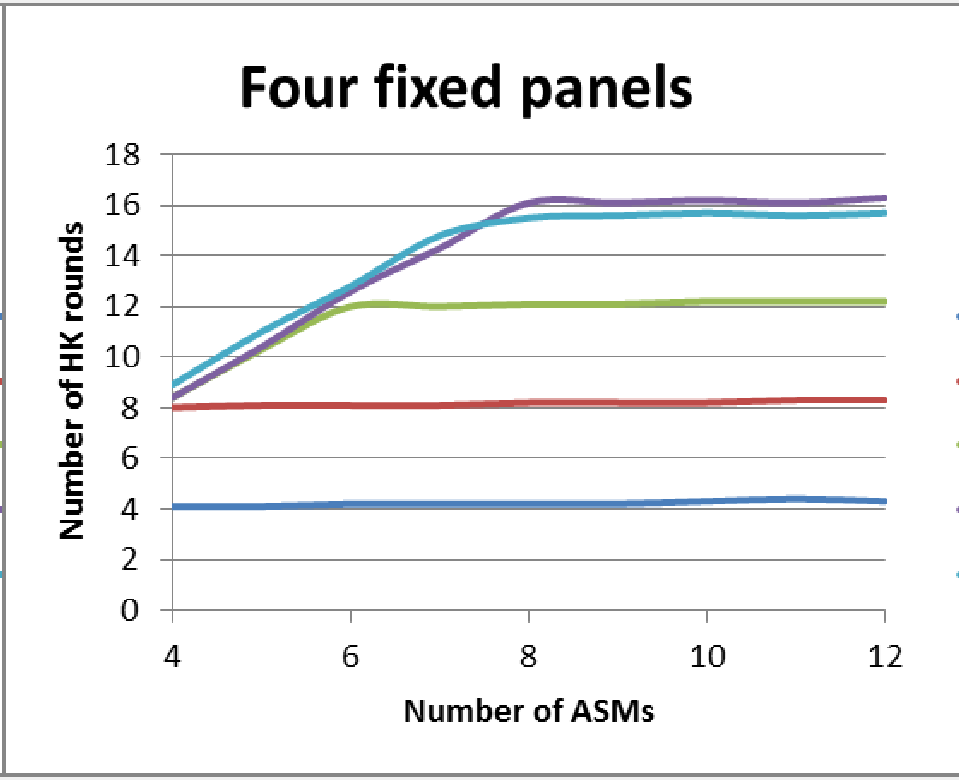


Number of launched air defence missiles



Comparison


Three radars rotating
Number of HK rounds
18
16
14
12
10
8
6
4
2
0
4
6
8
10
12
Number of ASMs


Four fixed panels
Number of HK rounds
18
16
14
12
10
8
6
4
2
0
4
6
8
10
12
Number of ASMs

Conclusions on rotating vs. fixed radars

- No difference between three rotating radars and a radar with four fixed plates
- In jamming, the detection range is reduced more for the rotating radars, but with no difference on number of launched missiles
  - However, diversity in frequencies makes the radar solution with multiple frequency bands more robust and resilient against jamming

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