The Sensors and Electronics Technology – SET-284

TOPIC:

MANEUVERABILITY OF THE PASSIVE & ACTIVE RADARS AS THE KEY ABILITY TO SURVIVE TO OPERATE ON THE MODERN-DAY BATTLE FILED

LtCol Stanisław CZESZEJKO

PhD. Eng.

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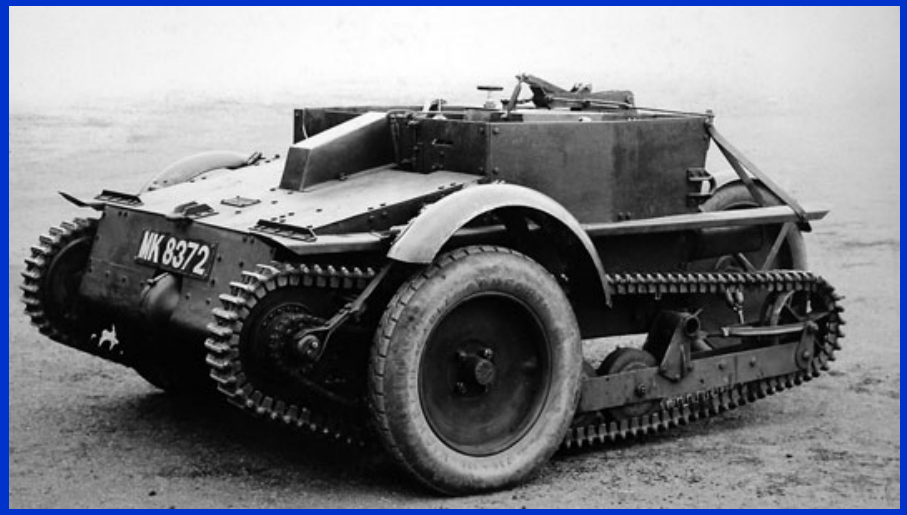
0. Order of speech

1. *Maneuverability*
2. *Main threat – anti-radiation missile (ARM)*
3. *Experiences*
4. *Time of operating on radar picket*
5. *Maneuverability in depending of radar parameters*
6. *Active radars*
7. *Passive radars*
8. *“Continuity of tracking” and “the information continuity”*
9. *Maneuverability of radars*
10. *Conclusions*
11. *System requirements*
12. *Summing-up*

Maneuverability (sample definitions)[1]:

1. capacity of a vehicle or a ship, to perform a movement in terrain in military or naval tactics;



or

2. ability of the troops to perform fast redeployment.

[1] Słownik języka polskiego PWN, dostęp w dn. 21.12.2019 r. (https://sjp.pwn.pl/sjp/).

1. Maneuverability

In case of operating the radars, maneuverability should be understood as the ability to:

1. *efficient folding of the radar and to leave the combat position quickly, moving to a secure distance;*

or

2. *efficient radar troops redeployment aiming at effective air target detection by keeping the ability to survive to operate.*

2. Main threat – anti-radiation missile (ARM)

No.	Missile type	Country	Years of implementation	Flight speed [m/s]	Min. range [km]	Min. flight time [s]	Max. range [km]	Max. flight time [s]
1.	Ch-25MPU	USSR	1981	400-500 max. 850-920	3	8-6 min. 3	40	100-80 min. 43
2.	Ch-31P	USSR	1984	600 max. 1000	15	25 min. 15	110-200	183-333 min. 110
3.	Ch-15P	USSR	1988	1000-1100 max. 1700	40	40-36 min. 23	150	150-136 min. 88
4.	Alarm	Great Britain	1991	320 max. 695	8	25 min. 11	45-93	140-290 min. 64
5.	Ch-32P [Ch-22MP]	USSR	1995	1190	n.d.a.	-	700	588
6.	Ch-31PD / Ch-31PM	Russia	2002 / 2005	600-700 max. 1000 / max. 1170	15 / -	25-21 / - min. 15 / -	180-250 / -	257-416 min. 180 / -
7.	Ch-58USzE / Ch-58USzKE	Russia	- / 2007	450-600 max. 1166	10-12	26-16 min. 8	245	544-408 min. 210
8.	AGM-88 D Harm Block 6 / AGM-88 E AARGM	USA	2003 / 2009	680 max. 2040	n.d.a.	-	180 / 110	264 / 161 min. 88/53
9.	Armiger	Germany	2008	- max. 1020	n.d.a.	-	200	- min. 196
10.	Star-1	Israel	n.d.a.	270	n.d.a.	-	100	370

n.d.a. - no data available

2. Main threat – anti-radiation missile (ARM)

ARMIGER

Armiger & Alarm
- <u>precision of hit ≤ 1 meter</u>

ALARM

2. Main threat – anti-radiation missile (ARM)

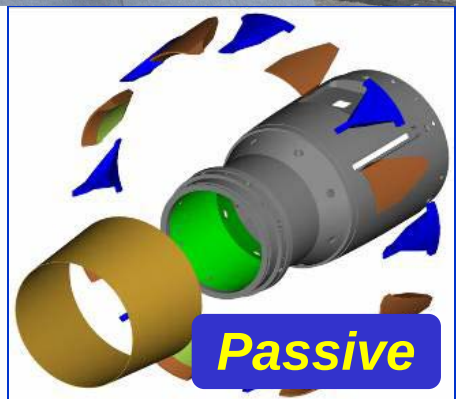
AGM-88E AARGM

2. Main threat – anti-radiation missile (ARM)

AGM-88 Harm

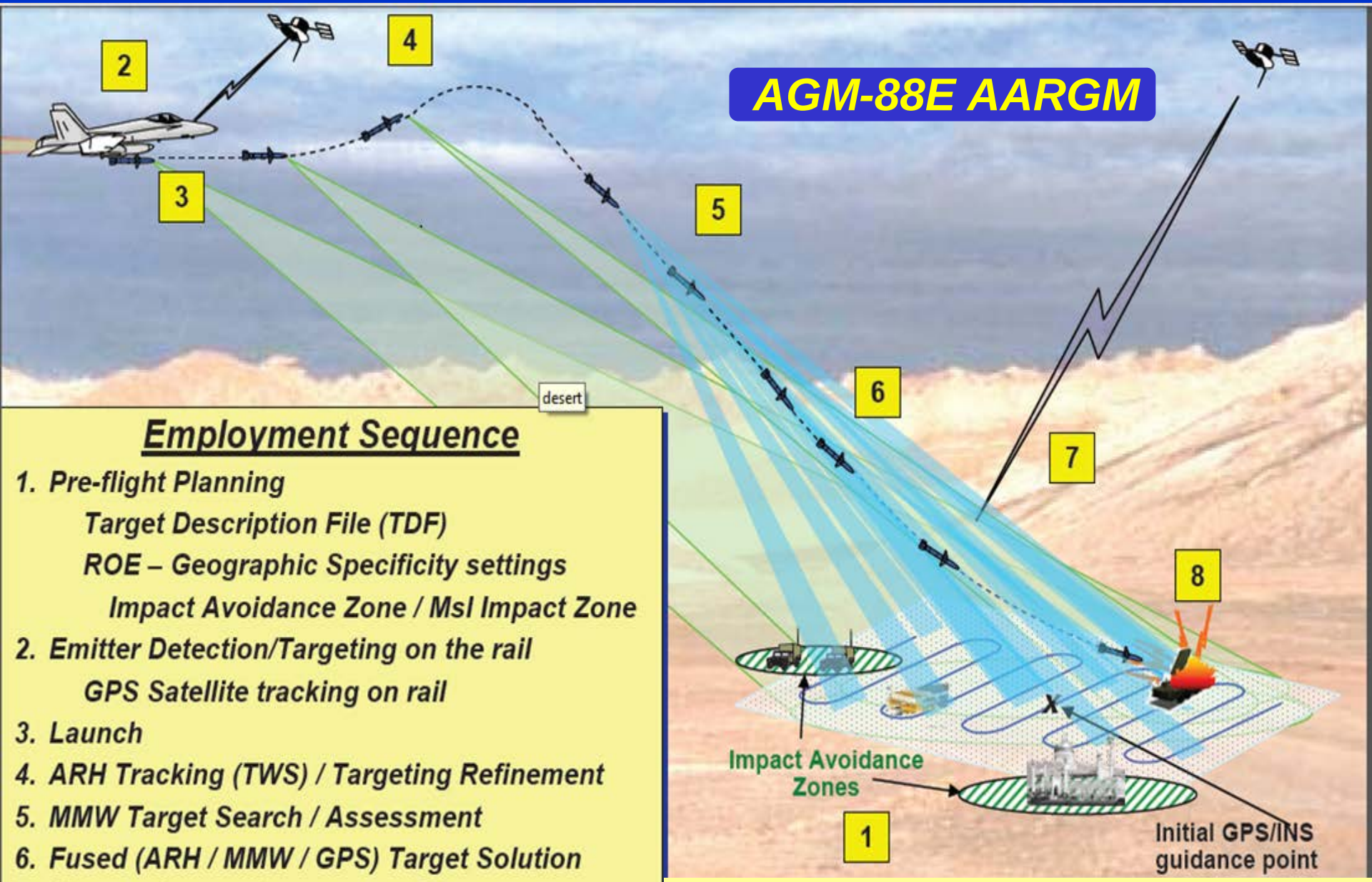
AGM-88E AARGM

Active



Passive

2. Main threat – anti-radiation missile (ARM)



Employment Sequence

1. Pre-flight Planning
   - Target Description File (TDF)
   - ROE – Geographic Specificity settings
     - Impact Avoidance Zone / Msl Impact Zone
2. Emitter Detection/Targeting on the rail
   - GPS Satellite tracking on rail
3. Launch
4. ARH Tracking (TWS) / Targeting Refinement
5. MMW Target Search / Assessment
6. Fused (ARH / MMW / GPS) Target Solution
7. Weapon Impact Assessment Message
8. Fuzing

ARH – Anti-Radar Homing; MMW – Millimeter Wave;

GPS – Global Positioning System.

DESTROYED RADAR FACILITY IN PRISTINA, KOSOVO

3. Experiences

Balkan war

Falklands war

Georgia

3. Experiences

During the 1995 Balkan conflict campaign,

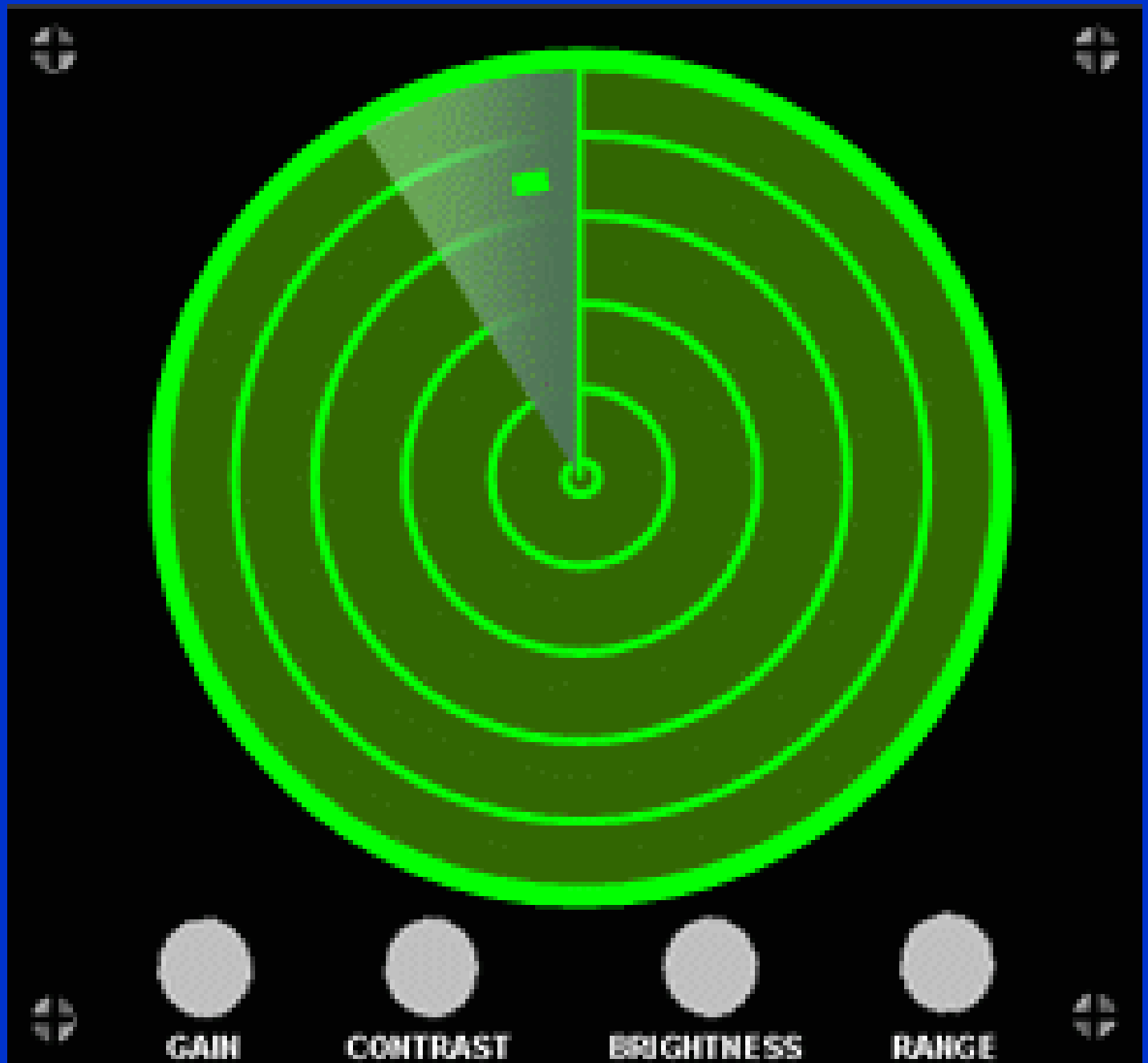
the major role - the precision guided weapon - ARMs, too.

The high efficiency of the Yugoslavian forces' operations, i.e.:

- *the high discipline level concerning the limited time of radars' radiation (up to 10 seconds);*
- *the high mobility of the forces (constantly changing the positions of the anti-aircraft weapons).*

The NATO official reports:
the efficiency of the HARM missiles was 3% - 6.6%.

4. Time of operating on radar picket



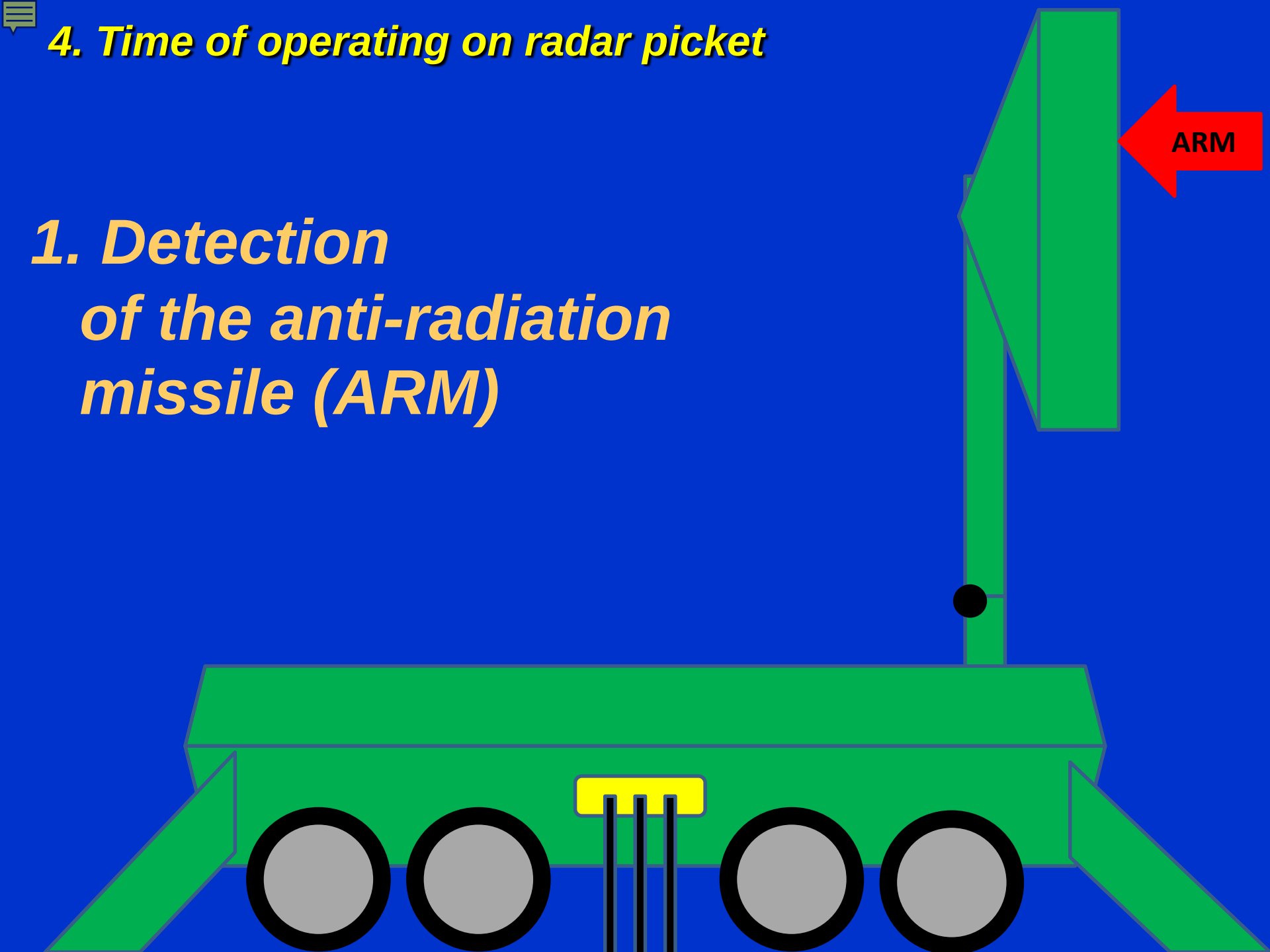
4. Time of operating on radar picket

No.	Radar make	Rotate per minute of antenna [rpm]	Time of one antenna rotation [s]	Max. range of detection* (instrumental) [km]	Time of folding [min.]
1.	AVIA-W	10	6	100 (118)	FADR
		15	4		
2.	NUR-31 (RO-82), NUR-31M (RO-82M),	6	10	160 (200)	MADR
3.	NUR-31MK (RO-94)	6	10	180 (200)	FADR
4.	NUR-41 (RST-11)	-	-	240 (-)	MADR
5.	NUR-12 (RST-12), NUR-12ME (RST-12ME)	6	10	250 ** (350)	DADR
6.	NUR-12M (RST-12M)	6	10	320 (470 / 350)	FADR
		12	5		
7.	NUR-15 (RST-15), NUR-15M (RST-15M)	6	10	200 (240)	MADR
		12	5	- (120)	
8.	RAT-31DL	5	12	180 / 320 (470)	FADR
9.	NUR-21	6	10	100 (120)	5
		12	5	b.d.	
10.	NUR-22	6	10	100 (120)	5
		12	5	b.d.	
11.	NUR-22-N-3D (NUR-26B), - (NUR-26C)	12	5	120 (120)	MADR
		24	2,5	60 (60)	

* – for SPO = 1 m2, PD = 0,8; PFA = 1*10-6
** – for SPO = 2 m2, PD = 0,8; PFA = 1*10-6

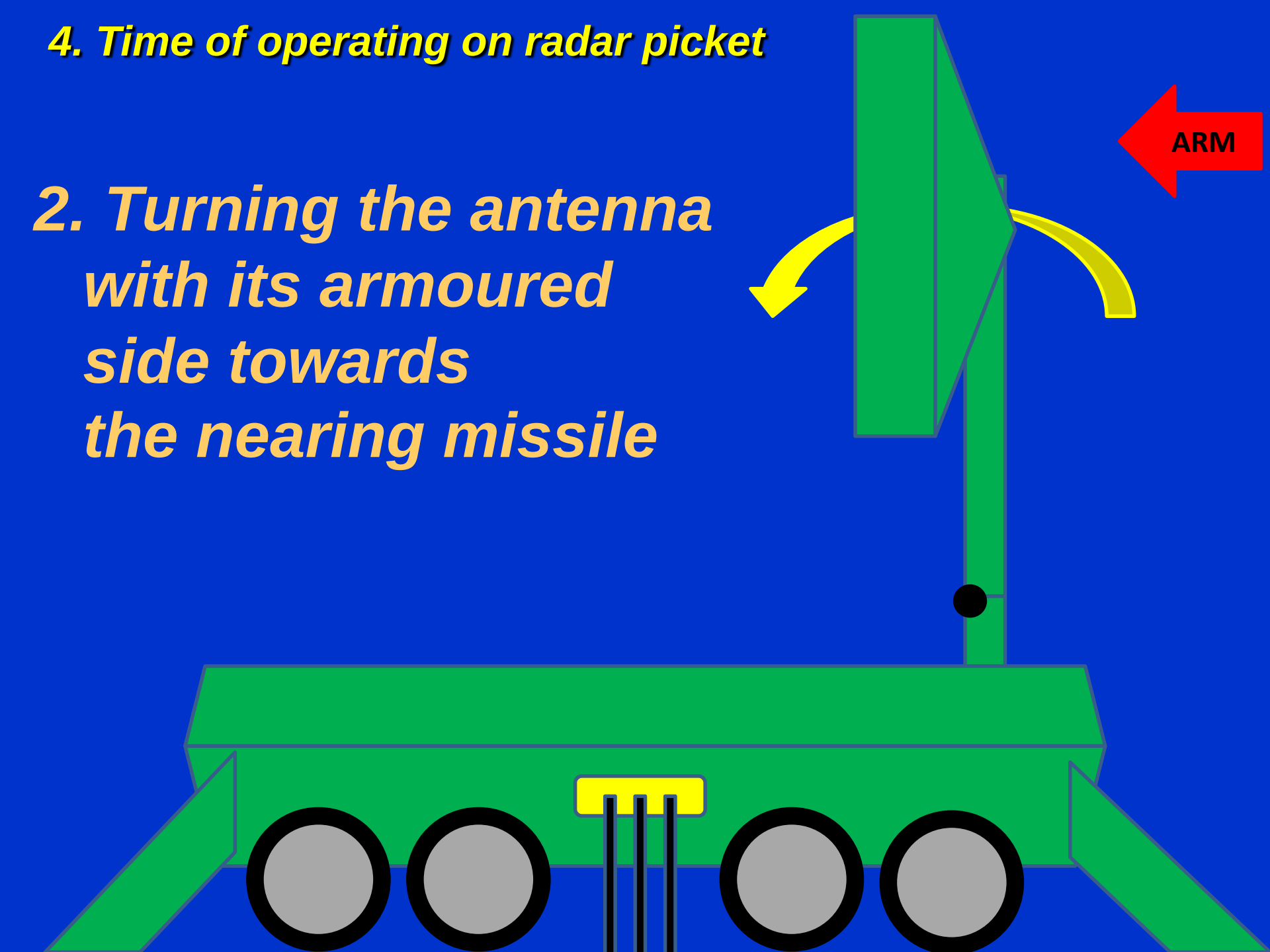
4. Time of operating on radar picket

1. Detection
   of the anti-radiation
   missile (ARM)



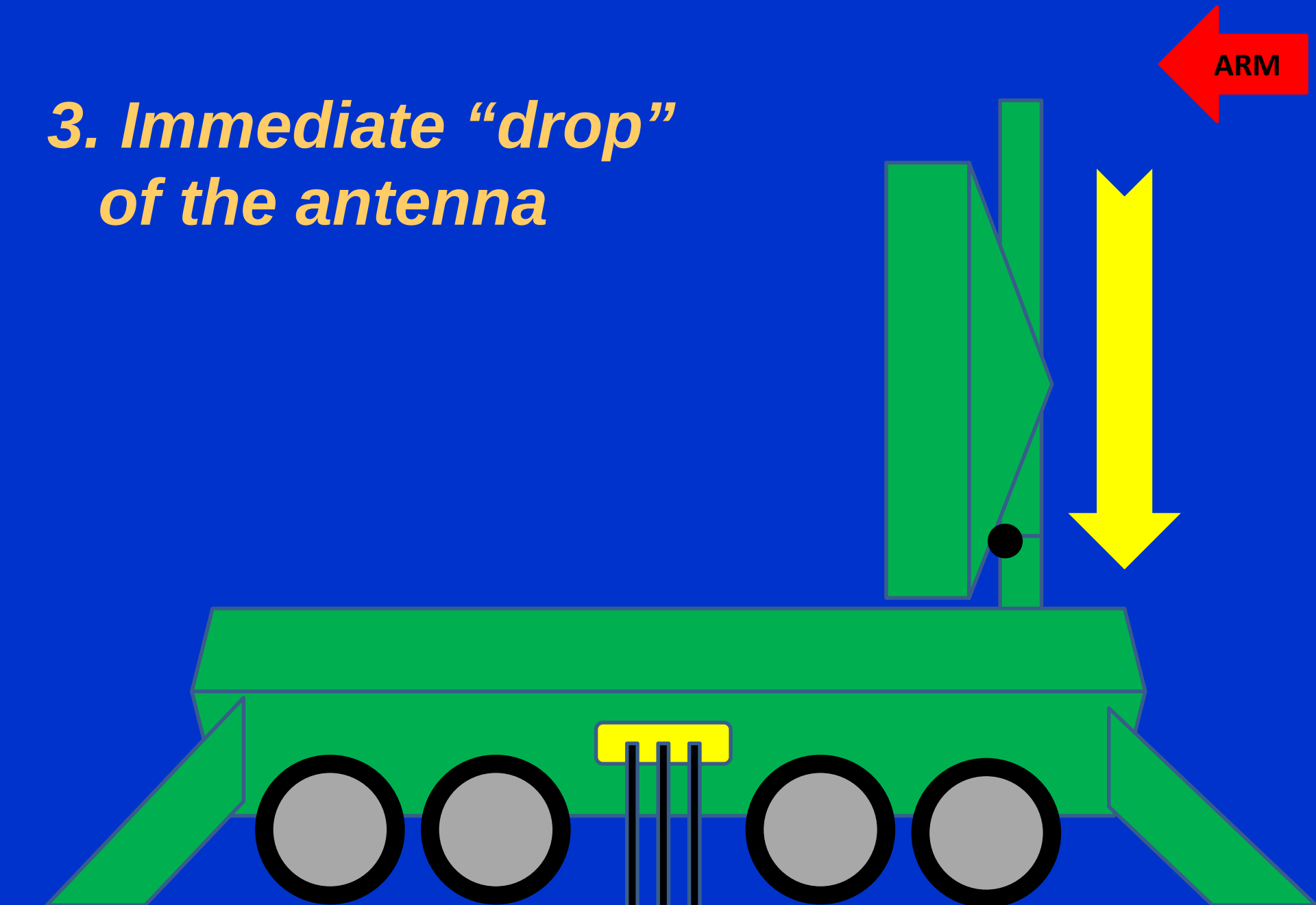
4. Time of operating on radar picket

2. Turning the antenna with its armoured side towards the nearing missile



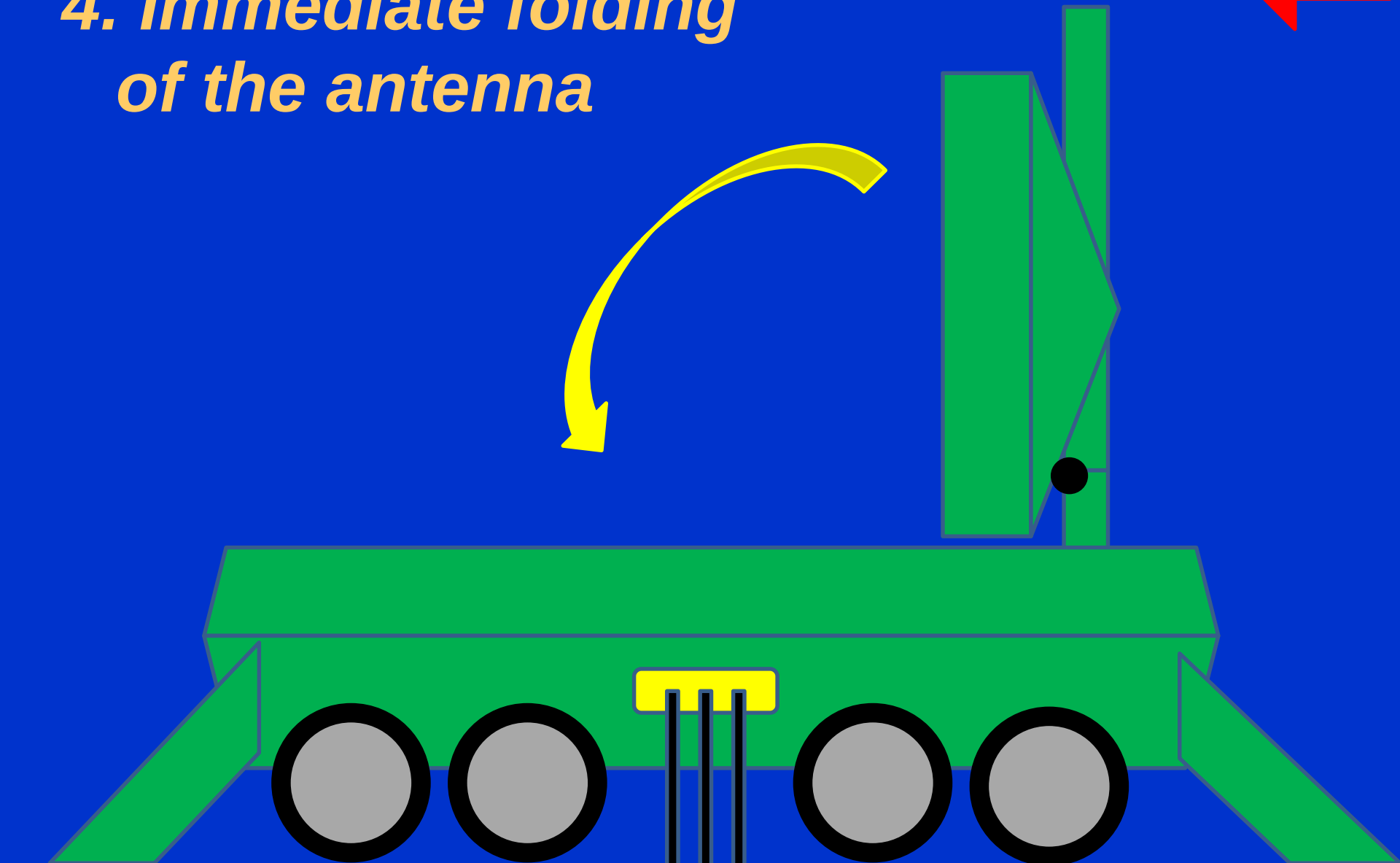
4. Time of operating on radar picket

3. Immediate “drop” of the antenna



ARM

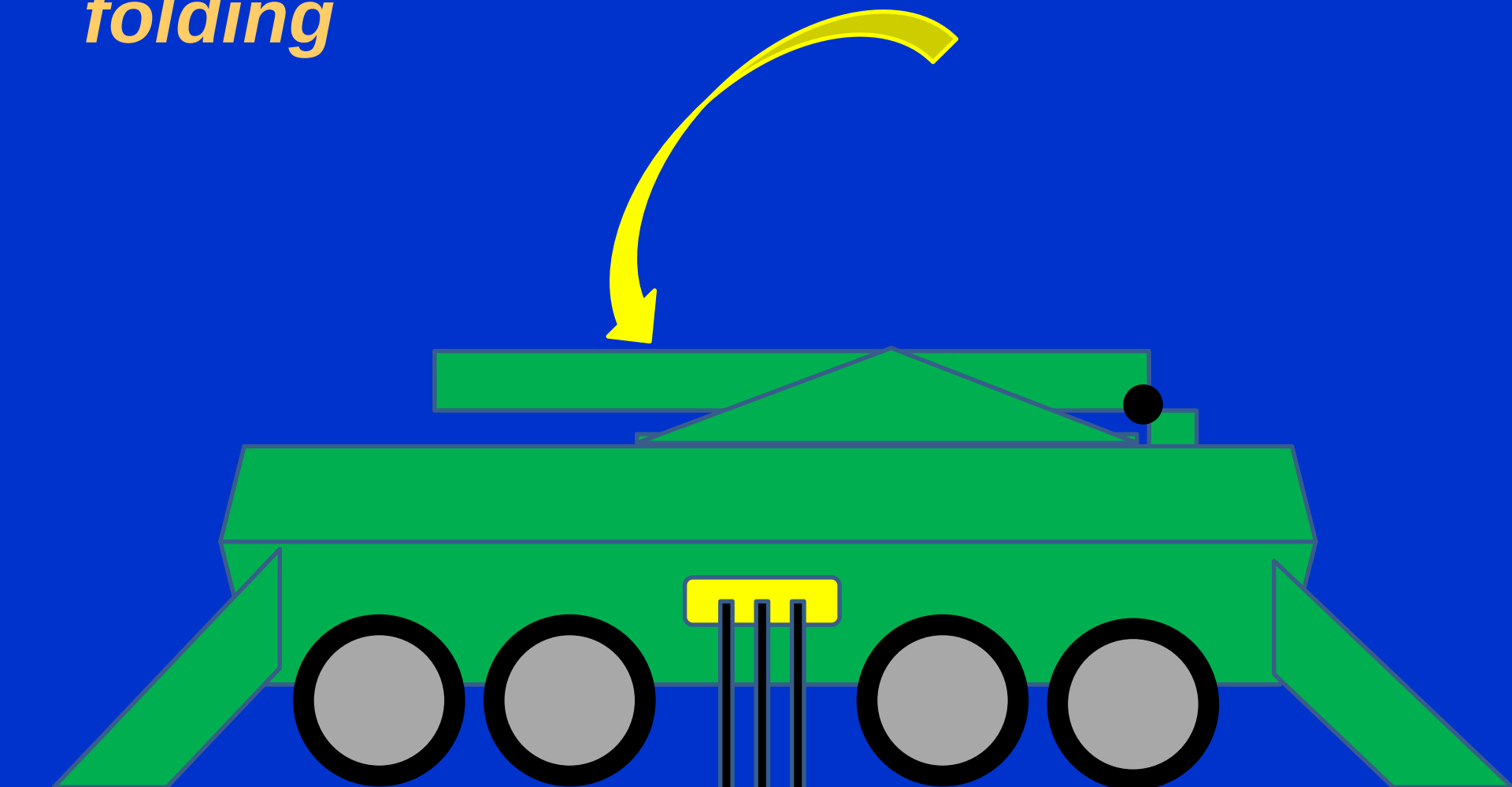
4. Immediate folding of the antenna



4. Time of operating on radar picket

ARM

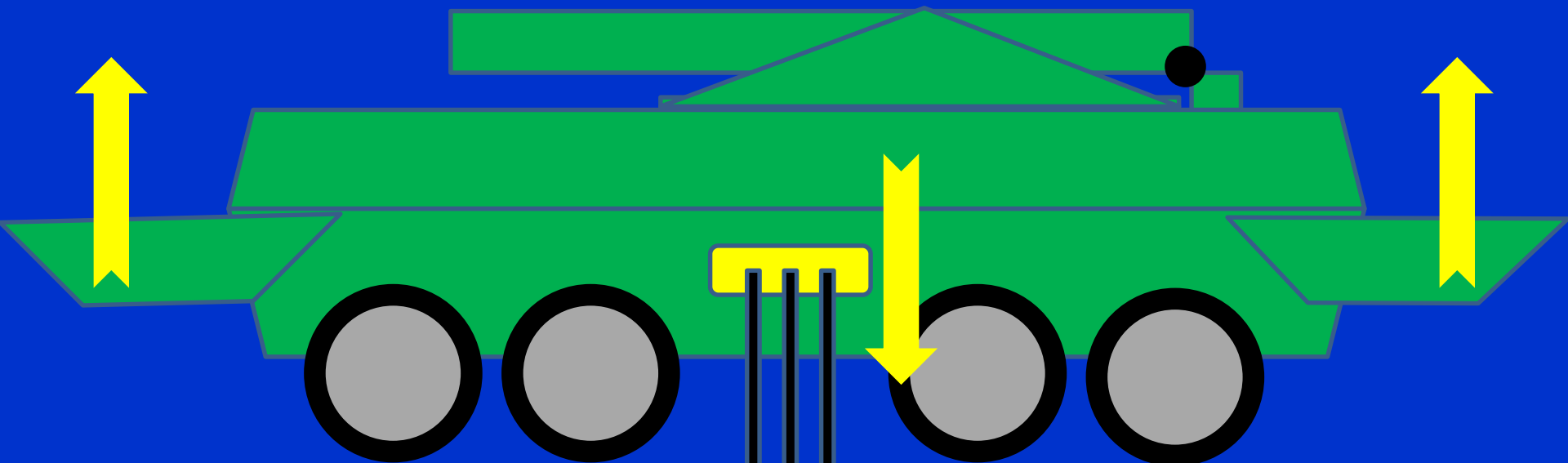
5. Hiding the antenna under the armouring after its immediate folding



4. Time of operating on radar picket

ARM

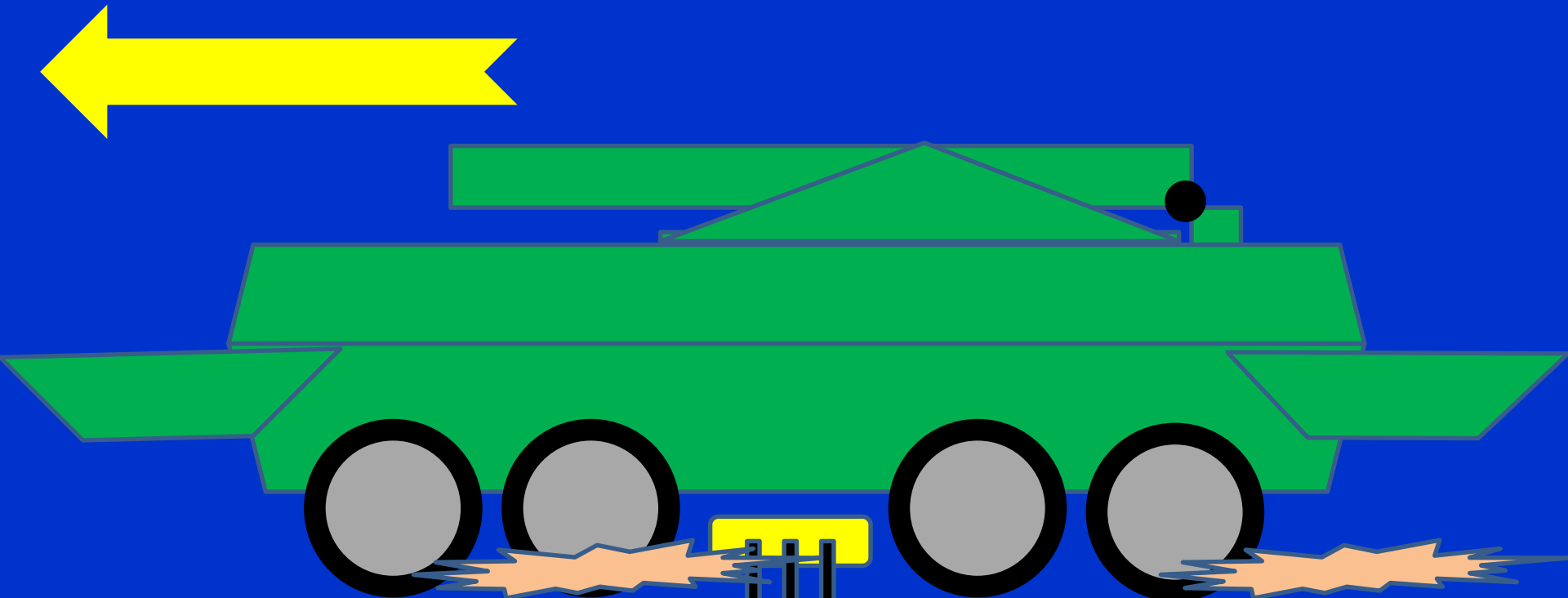
6. Immediate lifting of the supports and disconnecting the cable junctions



4. Time of operating on radar picket

ARM

7. Immediate driving the radar away from the radar picket



4. Time of operating on radar picket

8. Explosion of the anti-radiation missile (ARM)

4. Time of operating on radar picket

The operating time of a radar on radar a picket

- limited to a minimum,

- like in case of the Yugoslavian conflict,

- the electromagnetic radiation limited up to 10 seconds.

It is possible to reduce the time of the radar remaining on picket even to less than 60 seconds (one minute):

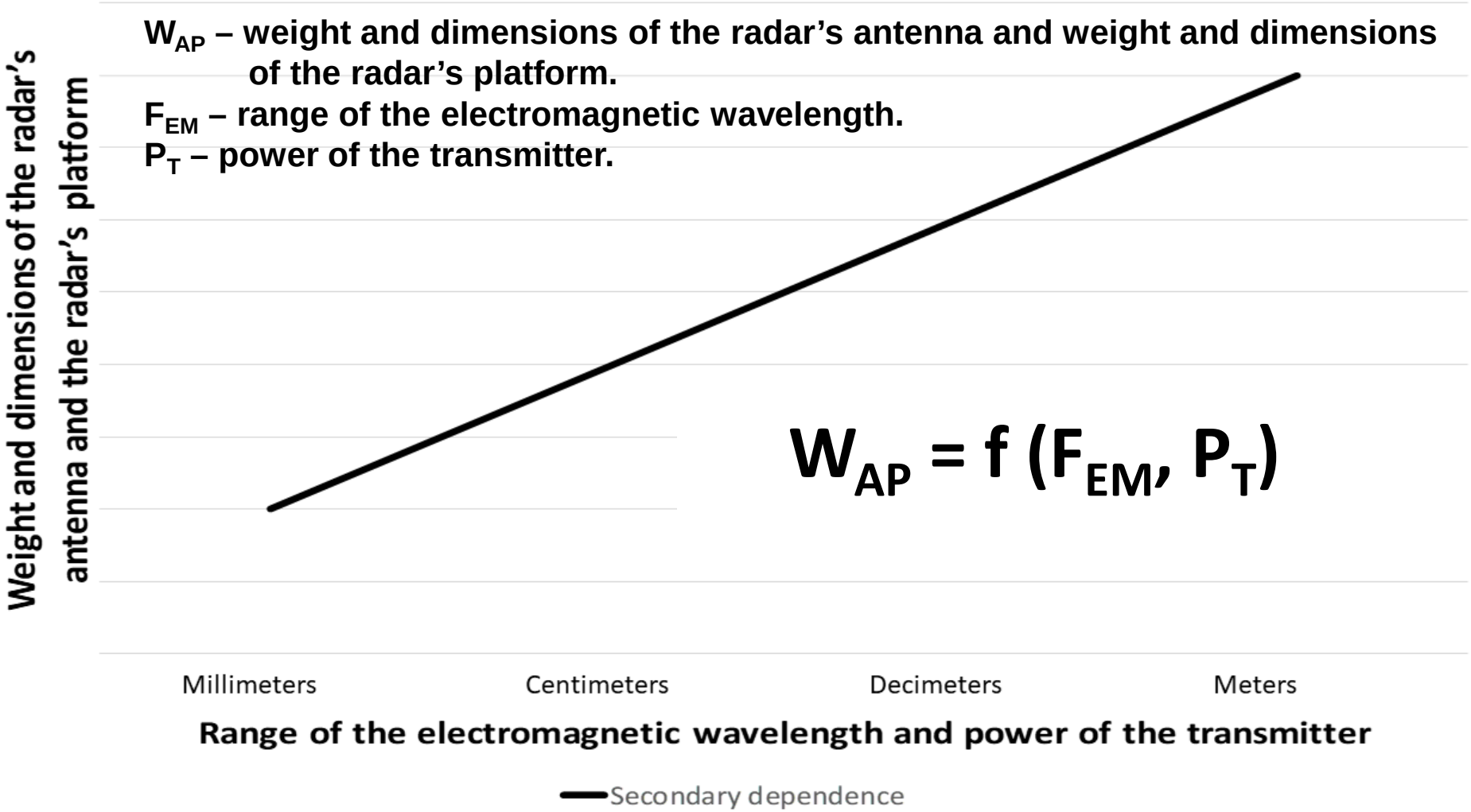
- **about 10 s of electromagnetic radiation,**
- **about 20 s for radar folding,**
- **about 30 s for a drive of more or less 40 m (with the speed of about 5 km/h, i.e. about 1.4 m/s).**

5. Maneuverability in depending of radar parameters

W_{AP} – weight and dimensions of the radar's antenna and weight and dimensions of the radar's platform.

F_{EM} – range of the electromagnetic wavelength.

P_T – power of the transmitter.



5. Maneuverability in depending of radar parameters

Destroying the object basically consists of two phases:

- **detecting;**
- **attack.**

Functioning of every object on the modern-day battlefield is basically divided into three phases:

- **work;**
- **folding;**
- **movement.**

5. Maneuverability in depending of radar parameters

MANEUVERABILITY COEFFICIENT :

$$M = \frac{(T_D + T_A)}{(T_W + T_F + T_M)}$$

M – maneuverability coefficient.
T_D – the detection time of the object by the enemy [s].
T_A – the attack time on the object, conducted by the enemy [s].
T_W – the work time of the object, attacked by the enemy on a picket [s].
T_F – the folding time of the object [s].
T_M – the movement time of the object [s].

Magnitude of maneuverability coefficient should be always equal or larger than magnitude one ($M \geq 1$), otherwise the attacked object is in danger of being destroyed.

5. Maneuverability in depending of radar parameters

$$M_{RR} = \frac{(T_{DR} + T_{AR})}{(T_{WR} + T_{FR} + T_{MR})}$$

M_{RR} – reference maneuverability coefficient of the radar.
T_{DR} – detection time of the radar by the enemy [s].
T_{AR} – time attack on the radar conducted by the enemy [s].
T_{WR} – acknowledged theoretical reference time of the radar's work (radiation – electromagnetic emission), radar attacked by enemy on a radar picket [s].
T_{FR} – acknowledged theoretical reference time of the radar's folding [s].
T_{MR} – acknowledged theoretical reference time of the radar's platform movement [s].

Desired magnitude of reference maneuverability coefficient of the radar (M_{RR}) will be equal or larger than the magnitude one ($M_{RR} \geq 1$), and its scale is comparable with the universal maneuverability coefficient of the any object (M). In case when $M_{RR} < 1$, the attacked radar will be in danger of being destroyed.

5. Maneuverability in depending of radar parameters

$$M_R = \frac{(T_{WR} + T_{FR} + T_{MR}) \cdot 10^2}{(T_W + T_F + T_M)}$$

M_R – current maneuverability coefficient of the radar.

10^2 – multiplier (weighting factor), depend of the technology advancement and difference between: acknowledged theoretical reference times (point of reference / frame of reference; benchmark) of the radar's and the real times: work, folding and movement of the radar's (assumed for now 100).

T_W – real time of the radar's work (radiation – electromagnetic emission) attacked radar on a radar picket) [s].

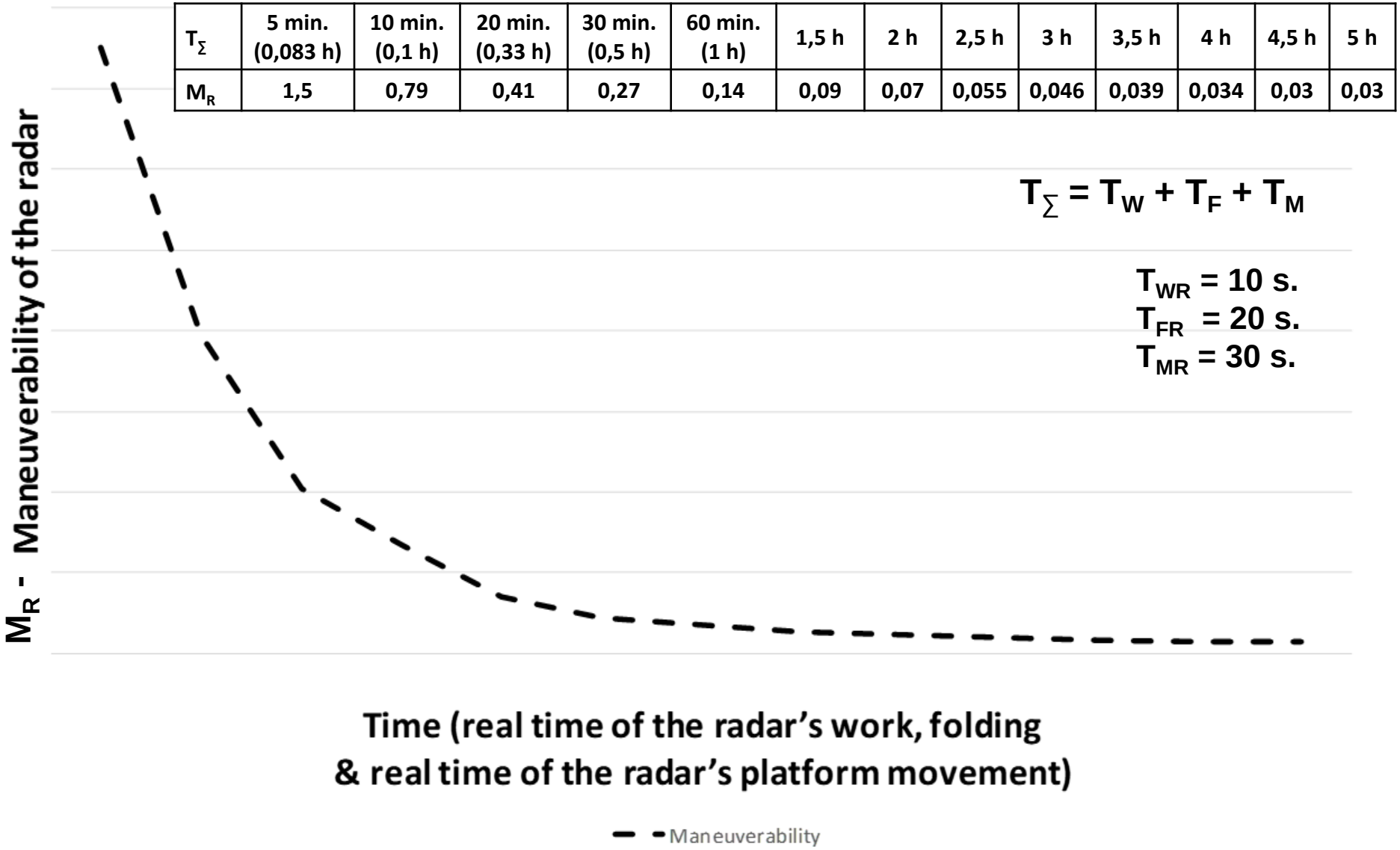
T_F – real time of the radar's folding of attacked radar [s].

T_M – real time of the attacked radar's platform movement on a safety distance [s].

Acknowledged coefficient allowing for producing the result the radar's current maneuverability coefficient (M_R), calculated as a number approximated to one.

5. Maneuverability in depending of radar parameters

T_Σ	5 min. (0,083 h)	10 min. (0,1 h)	20 min. (0,33 h)	30 min. (0,5 h)	60 min. (1 h)	1,5 h	2 h	2,5 h	3 h	3,5 h	4 h	4,5 h	5 h
M_R	1,5	0,79	0,41	0,27	0,14	0,09	0,07	0,055	0,046	0,039	0,034	0,03	0,03



6. Active radars

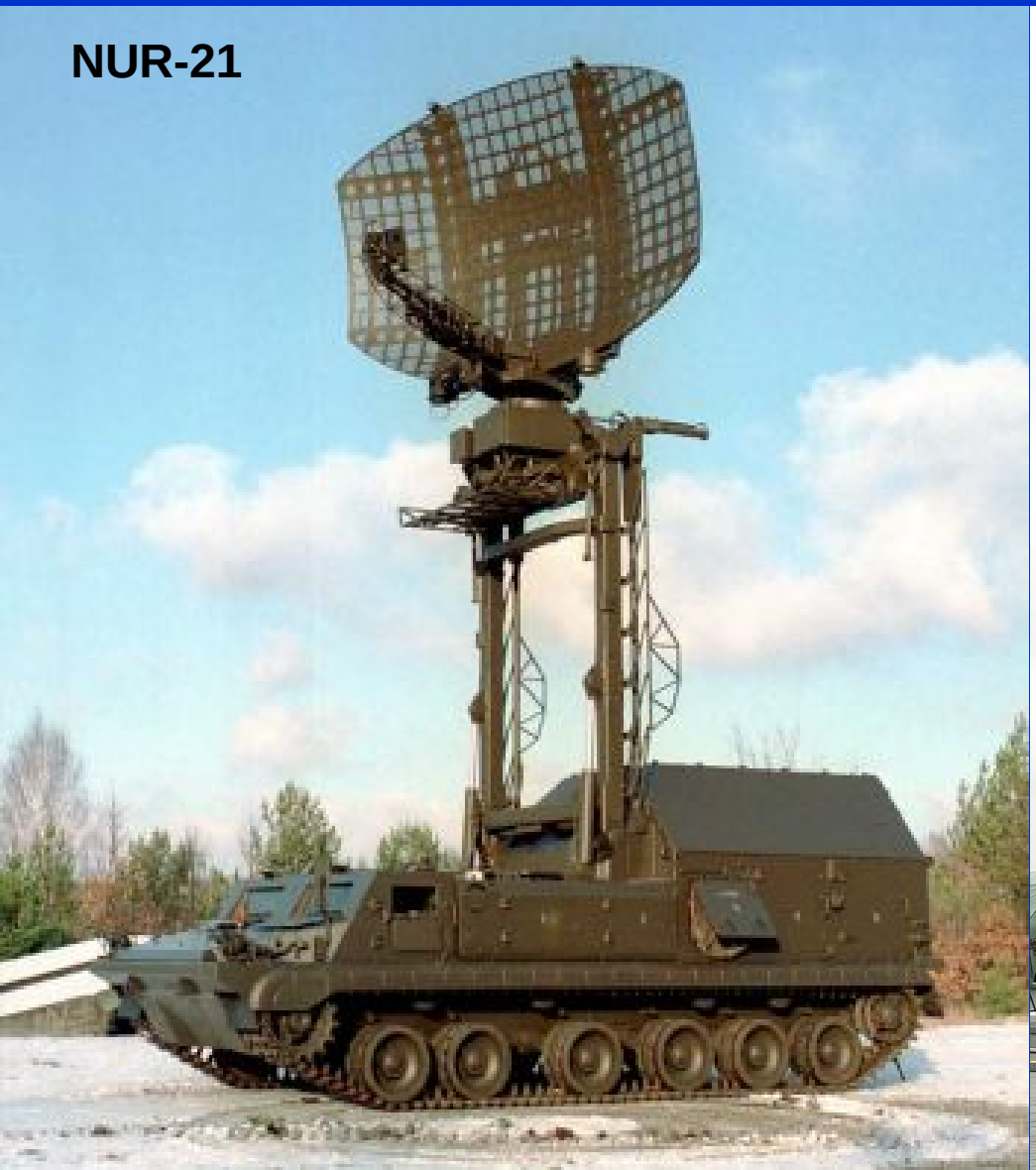
Giraffe - Sweden

On armored personnel carrier (APC) structure

Immunity against attack

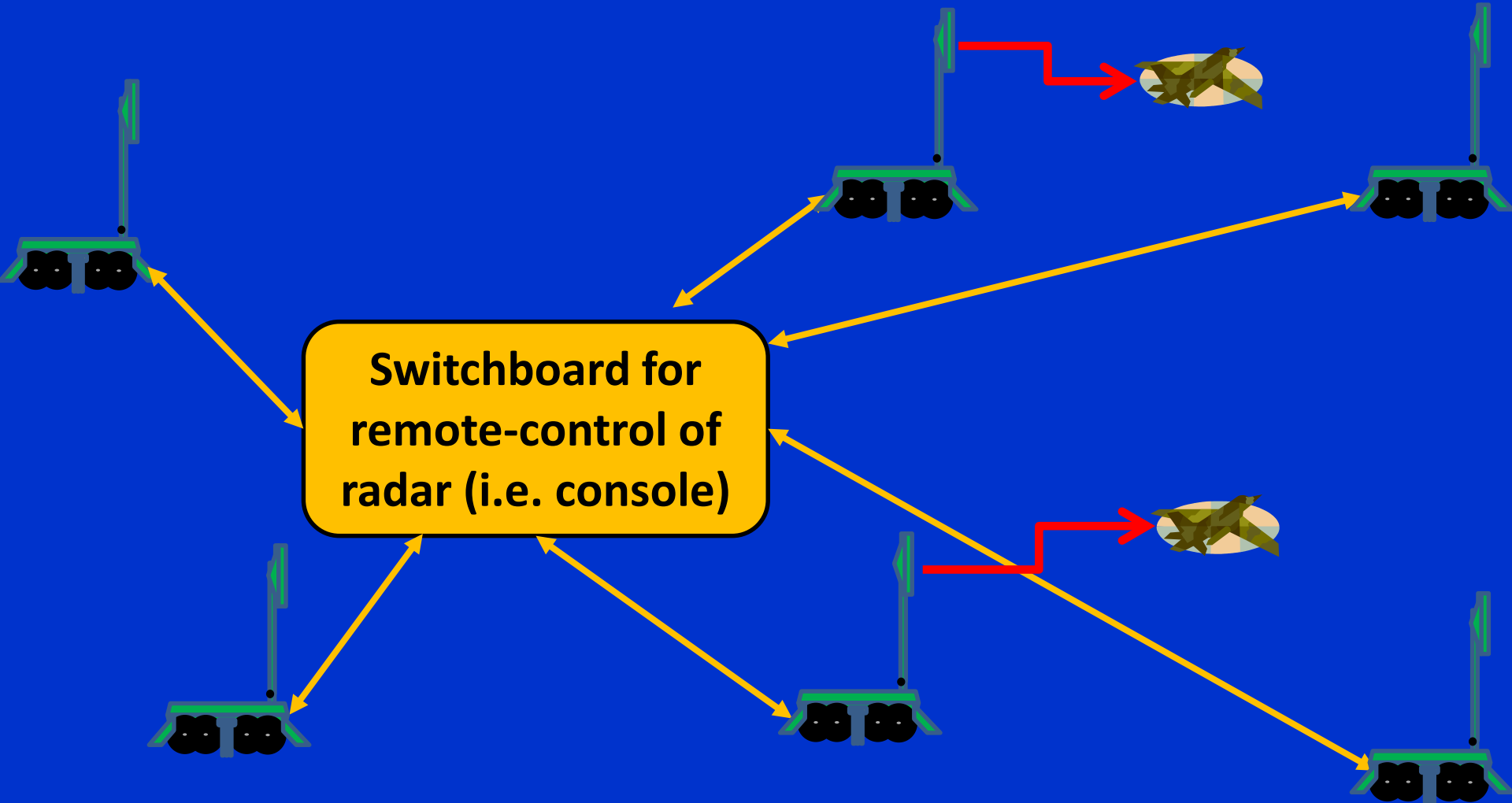
Immunity against attack

NUR-21



NUR-22

6. Active radars



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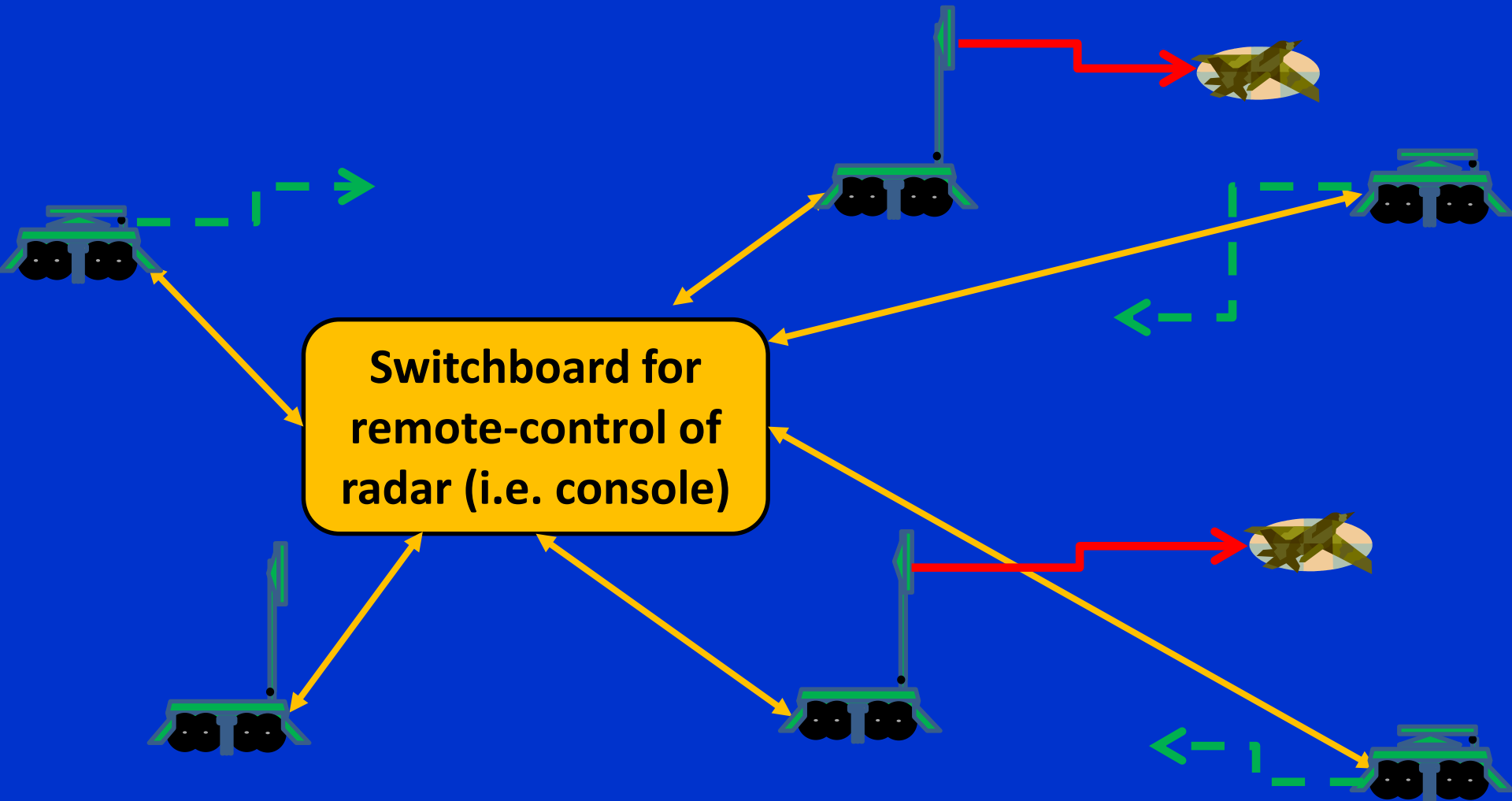
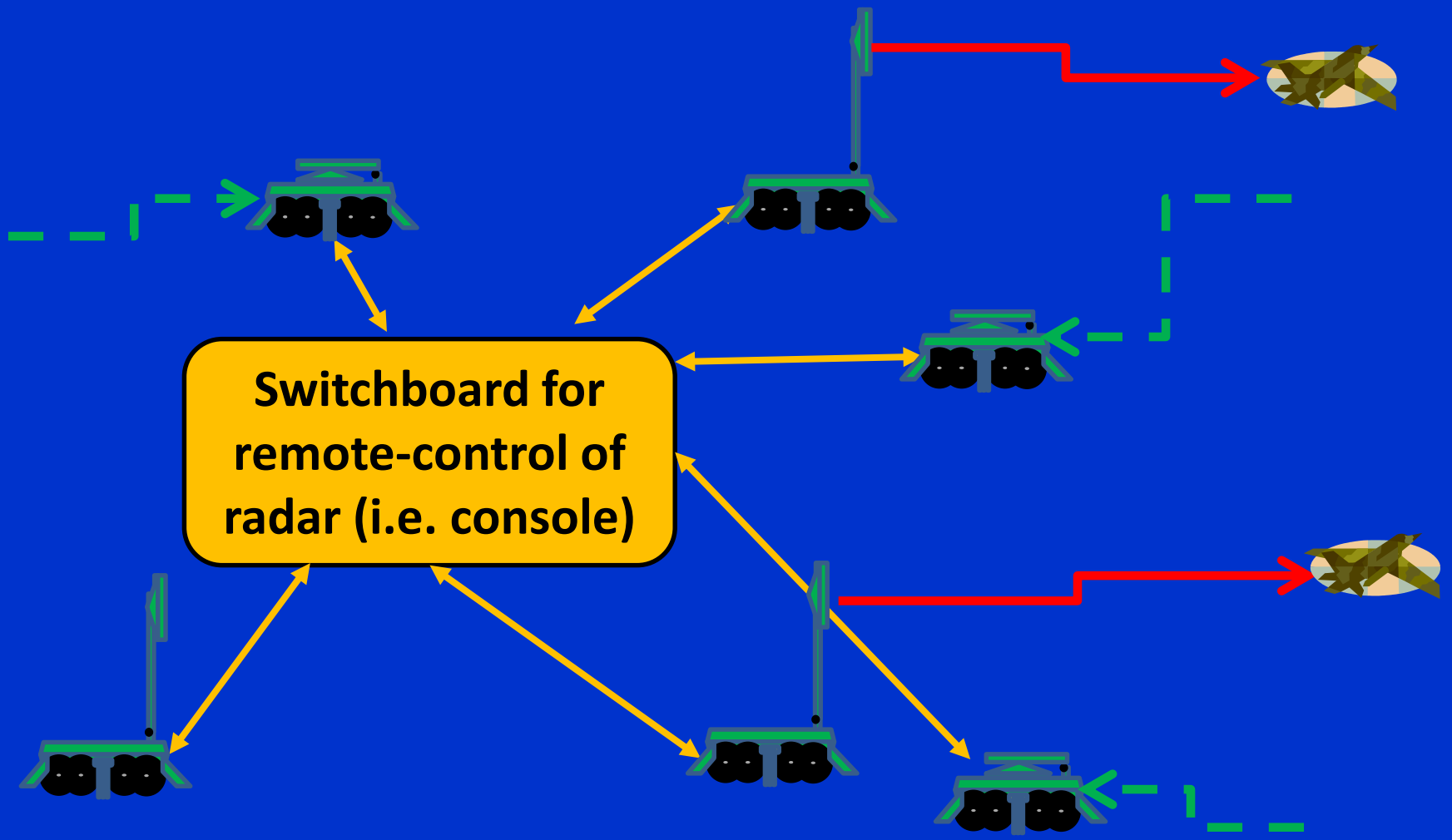


6. Active radars

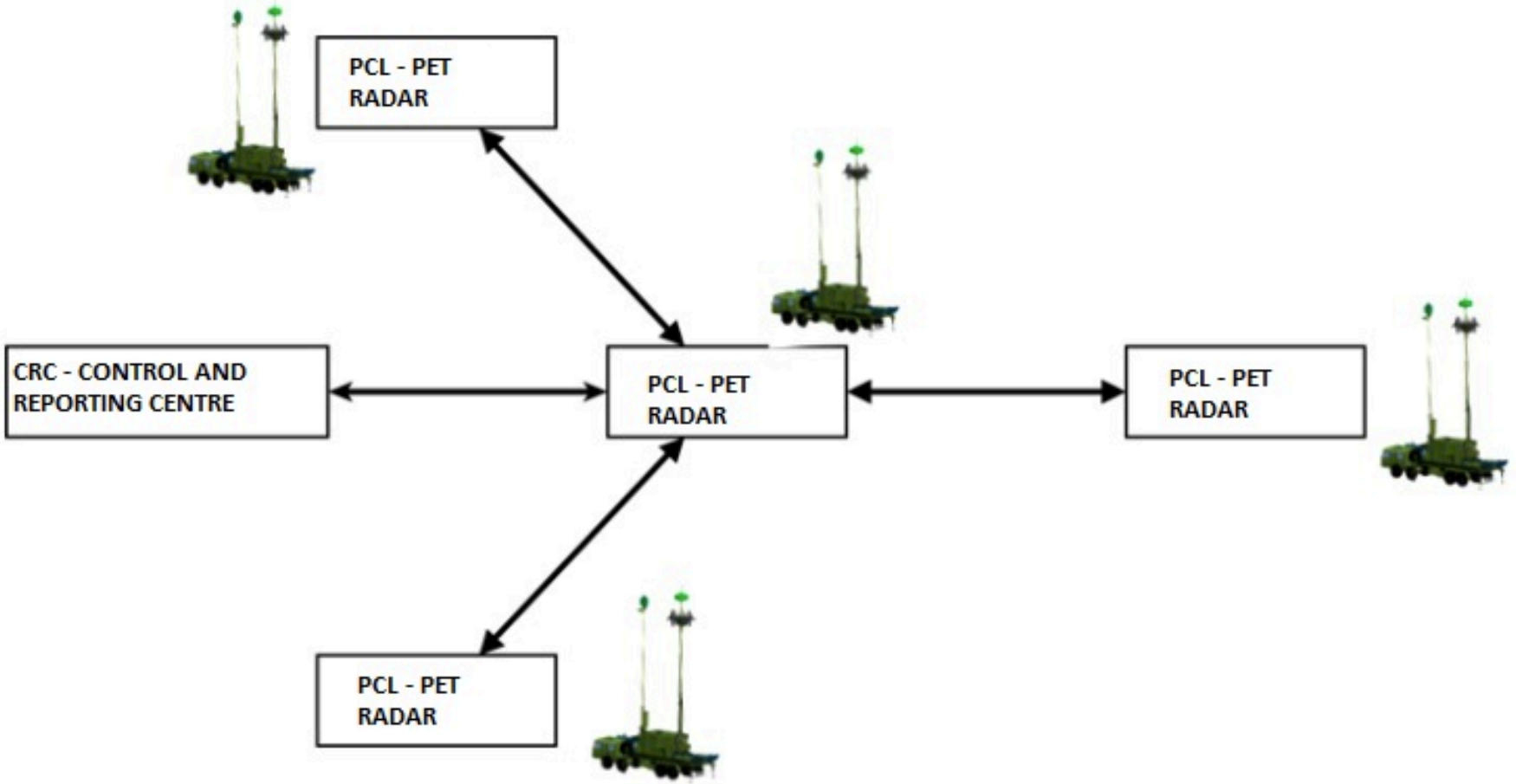


First passive radar (prototype) for Polish AD System of Warsaw University of Technology

First mobile PCL - PET radar (prototype) for Polish AD System of PIT-RADWAR C.O.

7. Passive radars

Architecture of mobile PCL - PET radars system for Polish AD System of AF – idea made by PIT-RADWAR C.O.



7. Passive radars

Fix
the passive radar's
transmitter
on light car
(for example
on military QUAD).

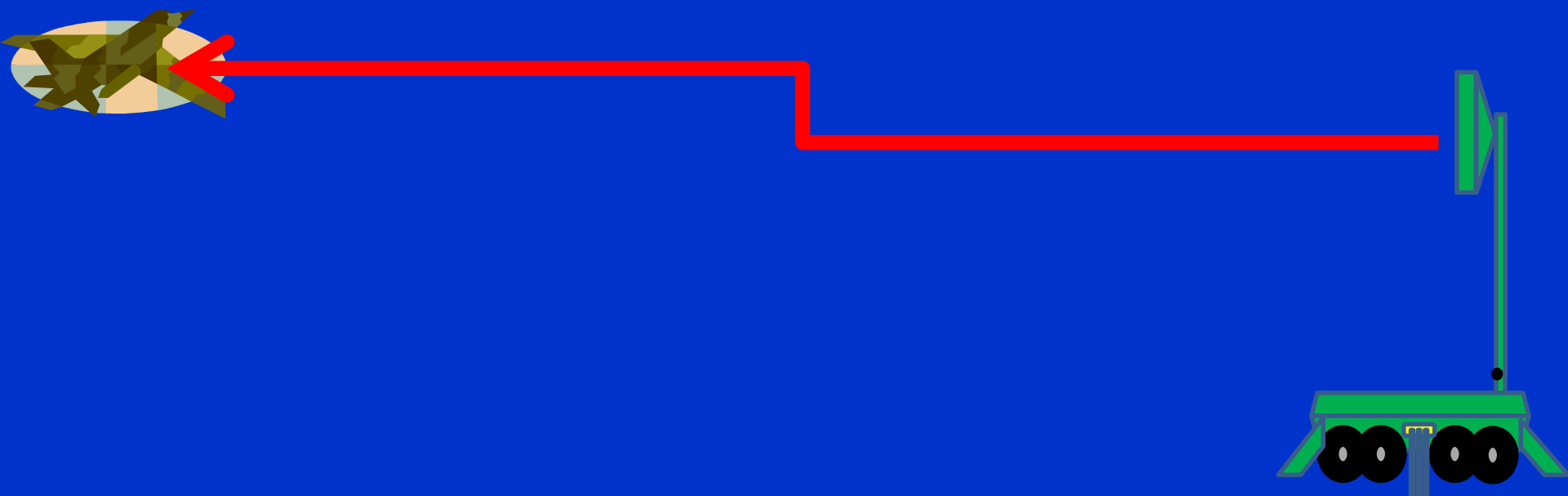
8. “Continuity of tracking” and “the information continuity”

On modern battlefield, “*continuity of tracking*” the air objects by the active elements of the radar surveillance system is not possible within the meaning of the current interpretation of this concept.

Therefore, during the phase of detection, observation and evaluation of the tactical operations of the adversary, it is enough to provide “*the information continuity*” concerning the opponent’s air objects.

8. “Continuity of tracking” and “the information continuity”

„continuity of tracking”



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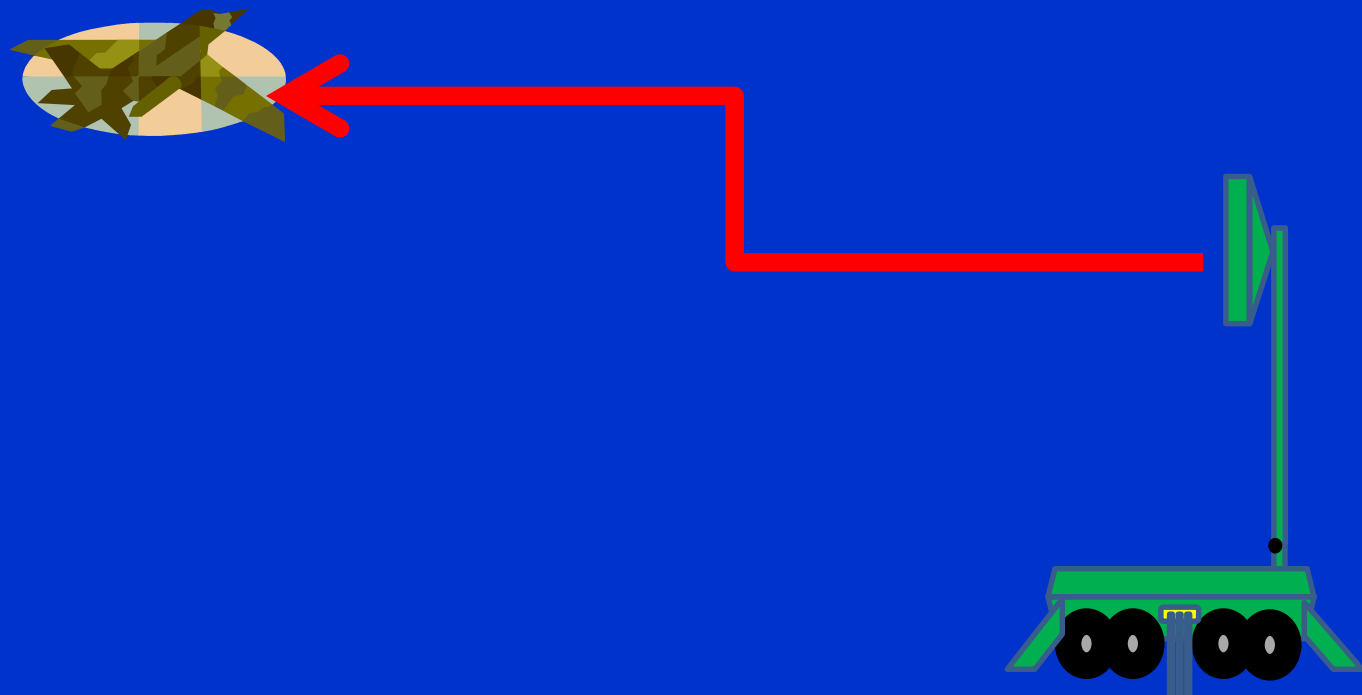

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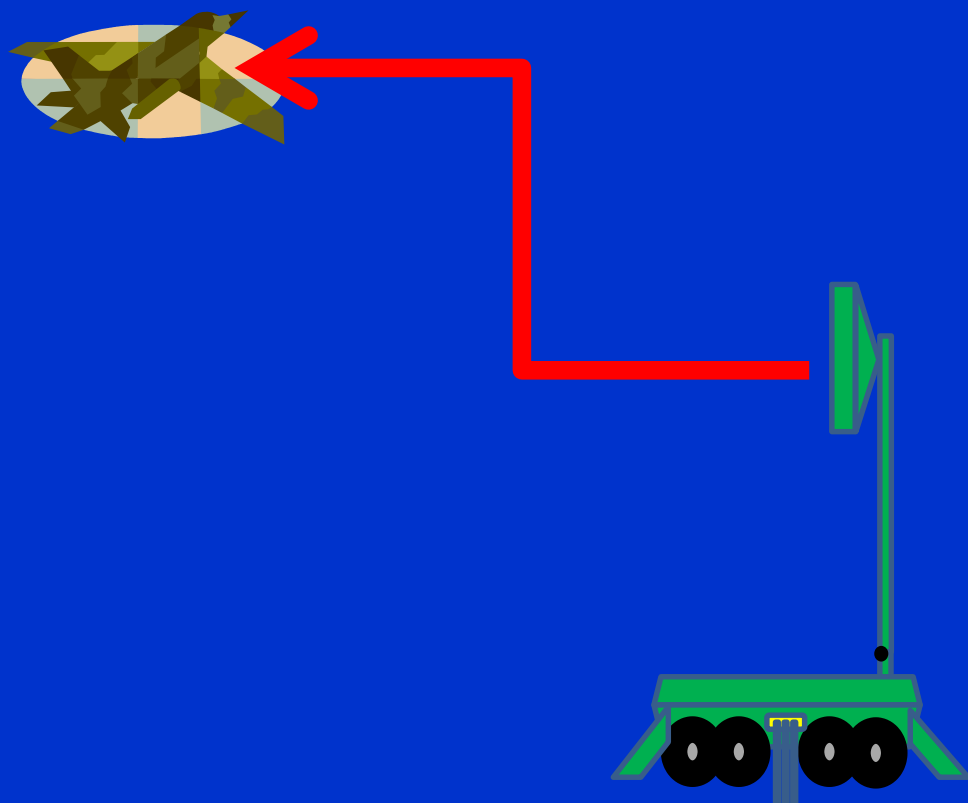
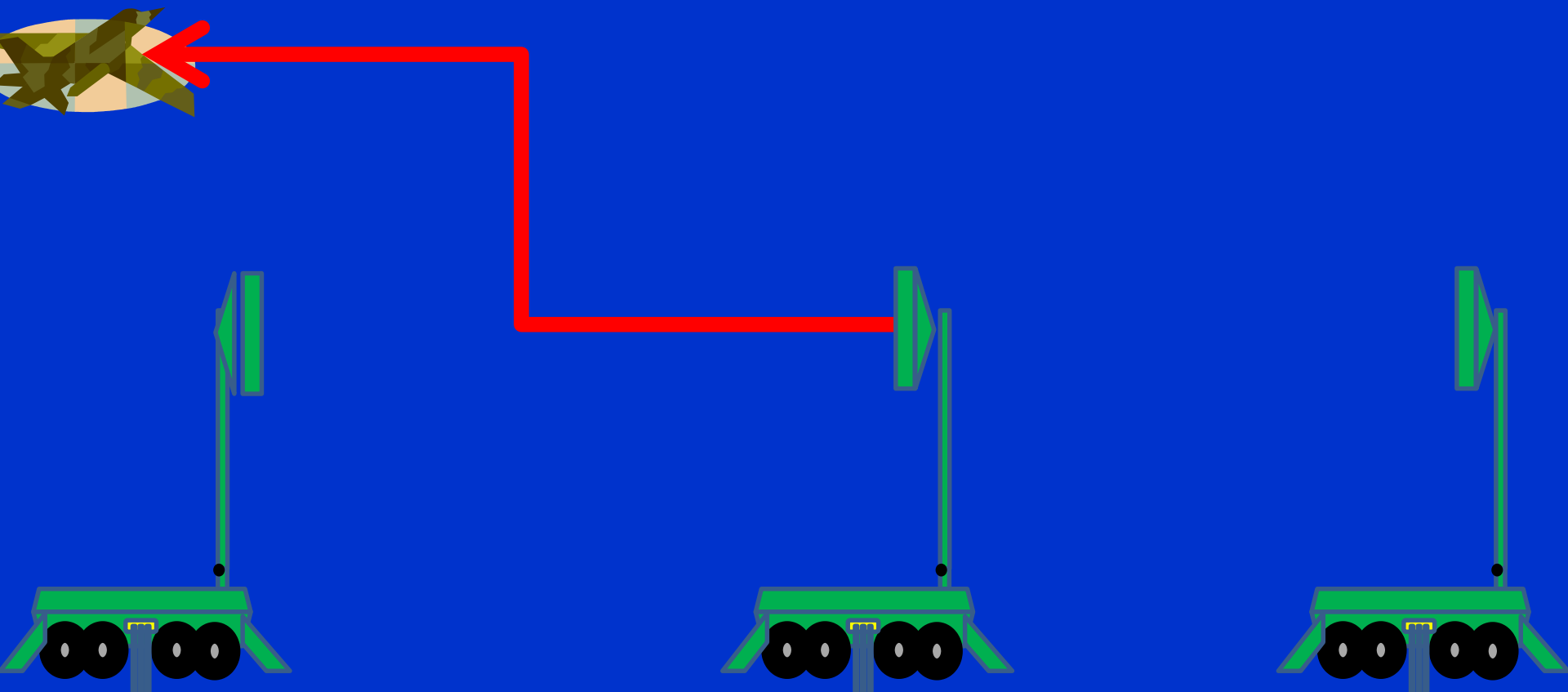


8. “Continuity of tracking” and “the information continuity”

„*the information continuity*”

- the so-called „flash”



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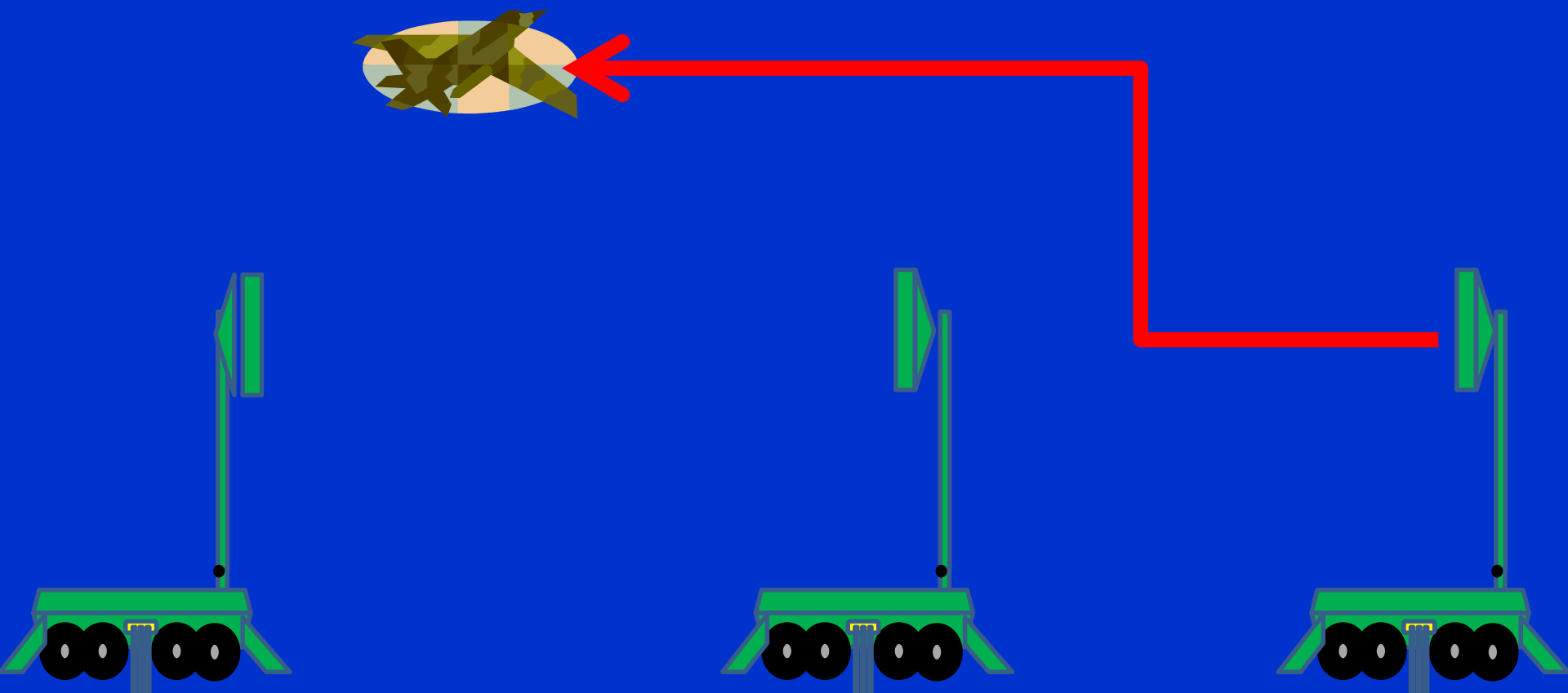

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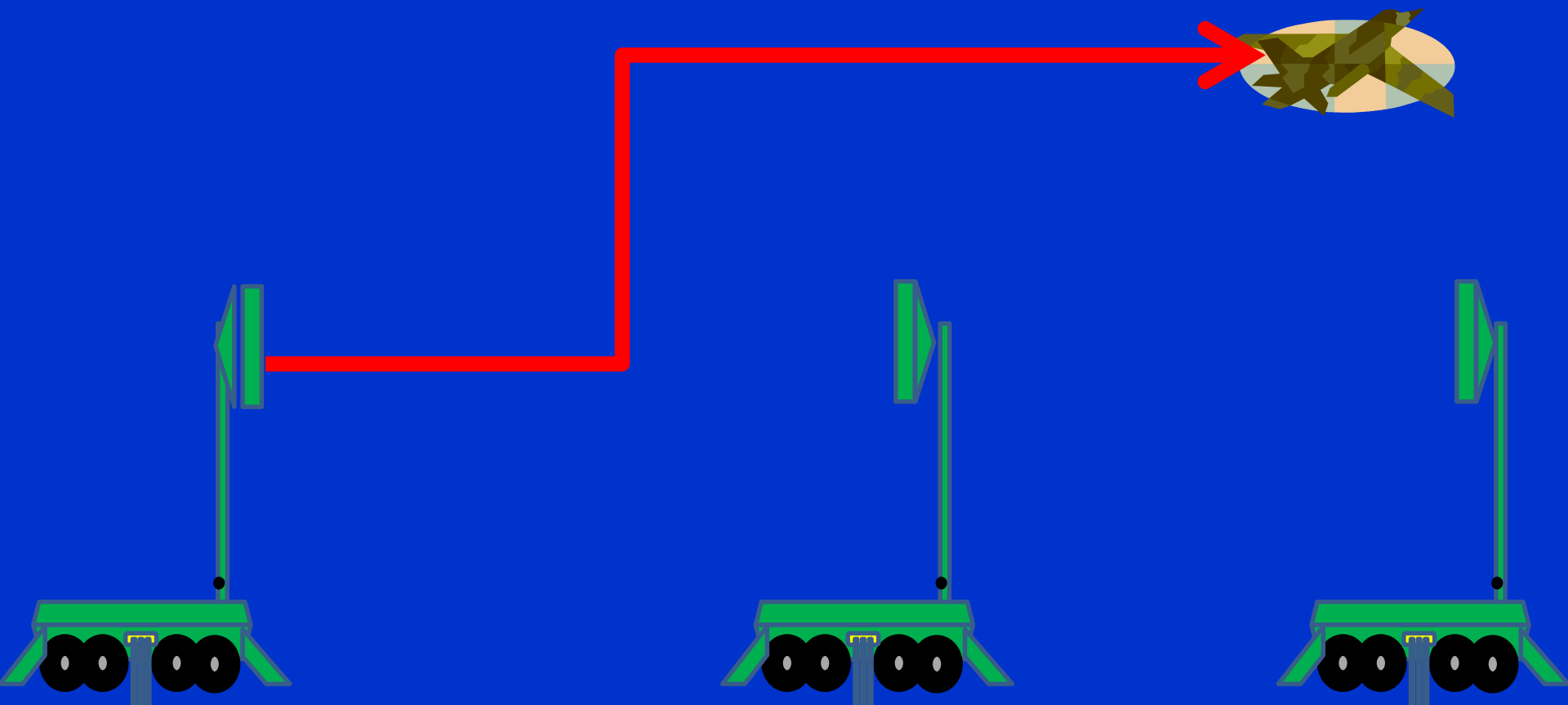

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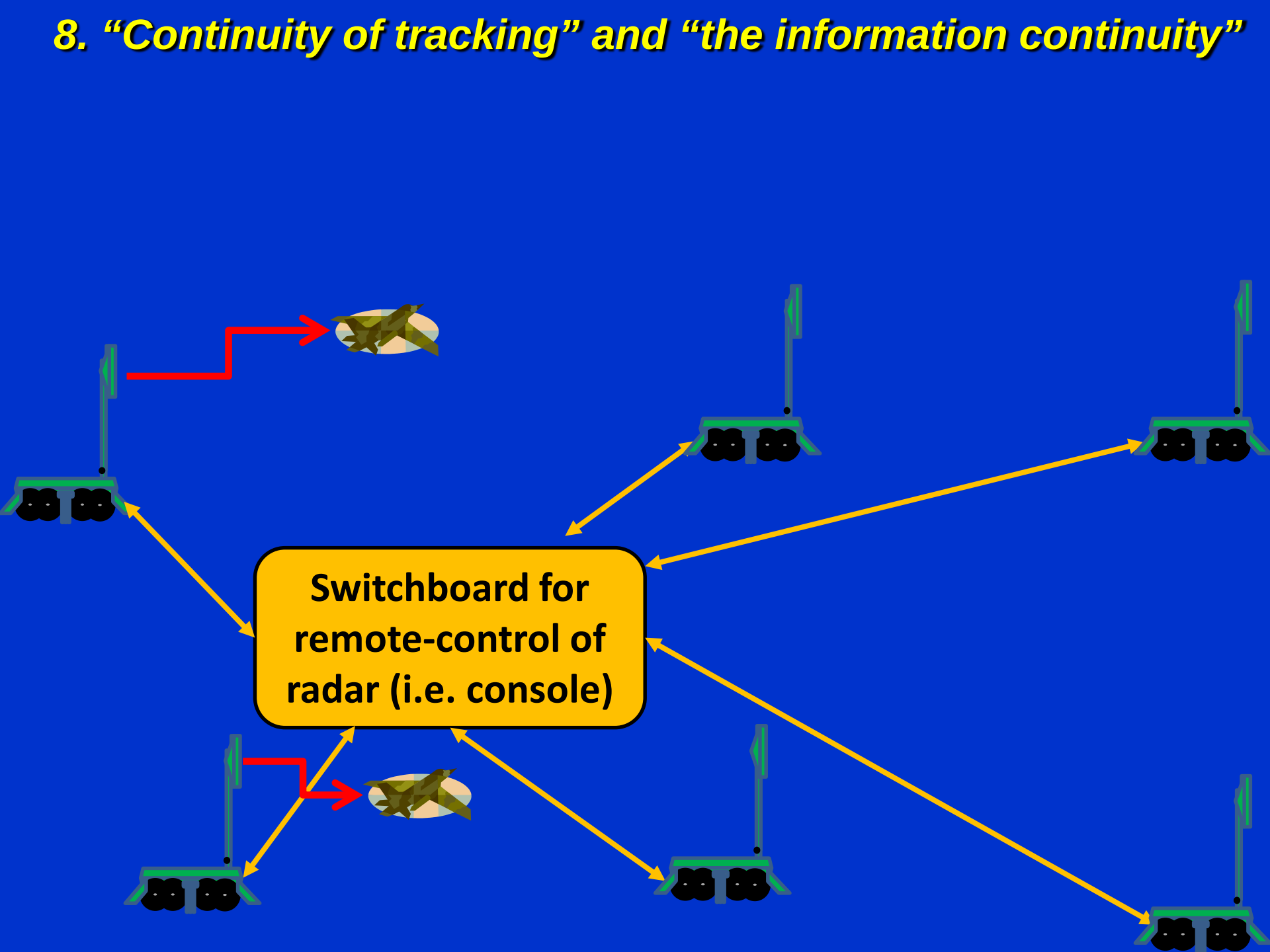

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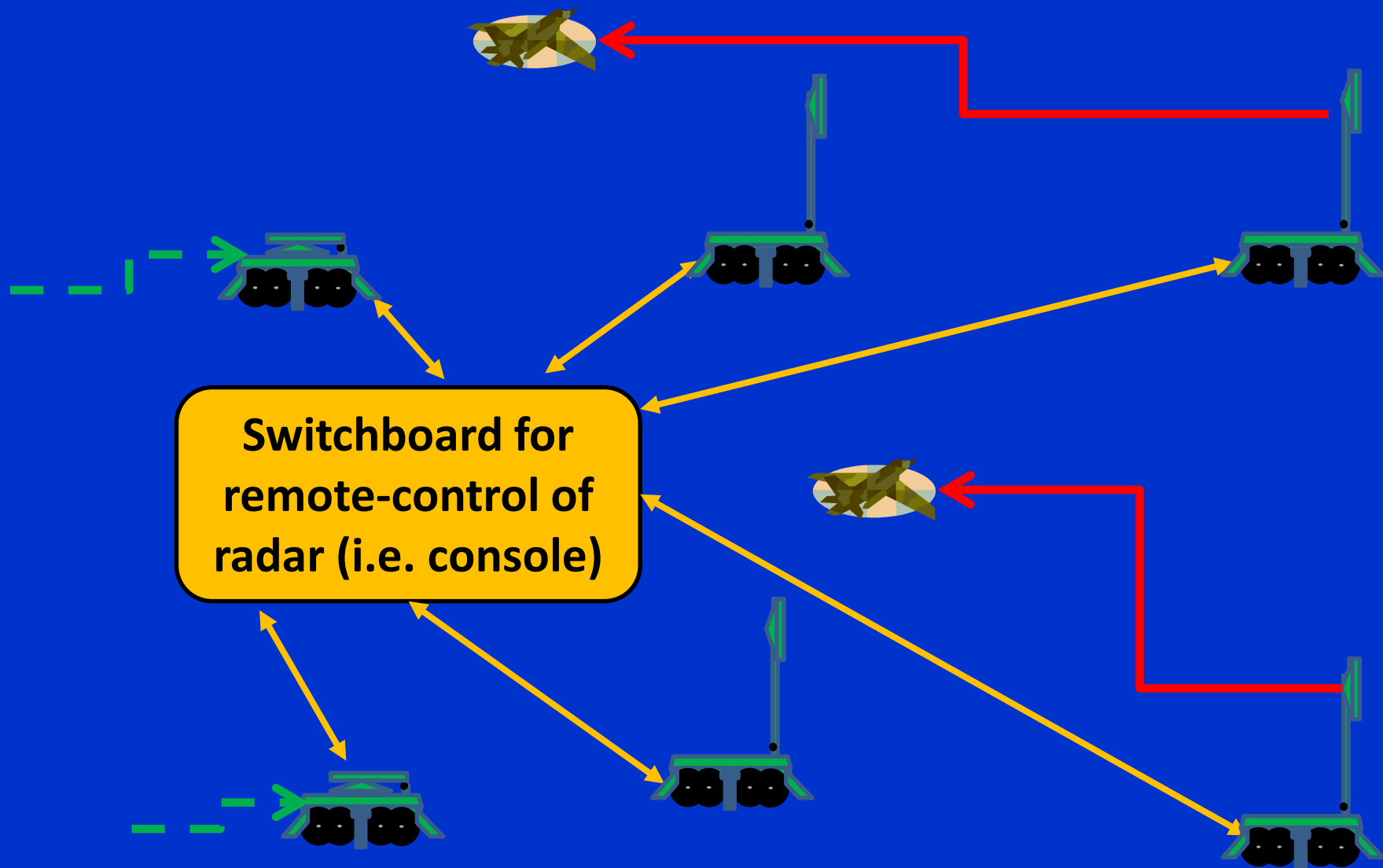

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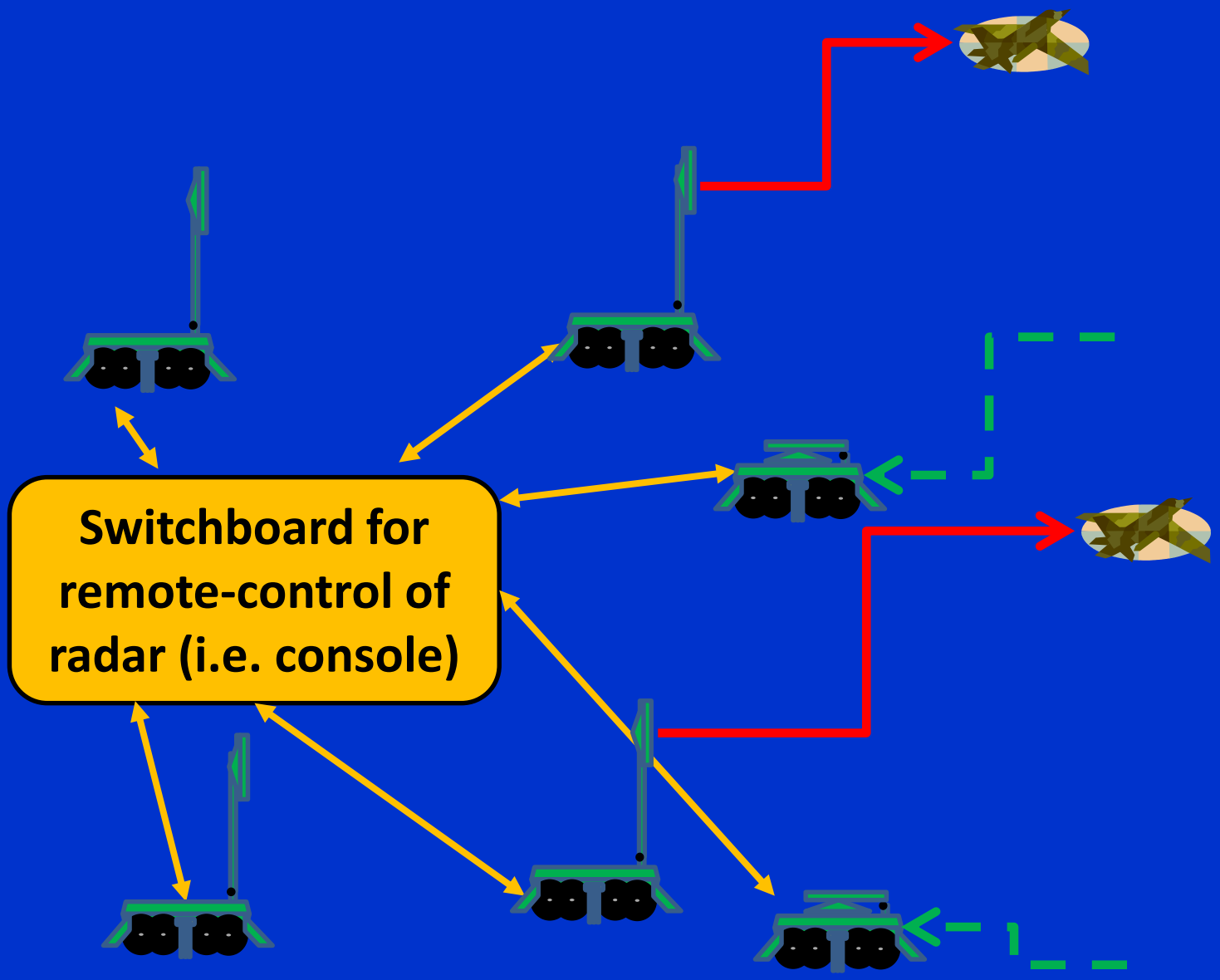

9. Maneuverability of radars

FLOT

FLOT - Forward Line Of Own Troops

9. Maneuverability of radars

FLOT

FLOT - Forward Line of Own Troops

PCL - PET

Conclusions concerning the construction of modern radars:

1) **while constructing radars one must take into consideration all the factors, which influence their maneuverability;**

2) **in order to keep control over the continuity of the air target detection with usage of the passive radars, it is necessary to construct and possess one's own transmitters for the passive radars, located on separate and very mobile platforms;**

3) **because of the construction aspects, the passive radars provide greater potential of effective tactical usage of them on the modern-day battlefield than the active radars;**

Conclusions concerning the construction of modern radars:

4) due to lower maneuverability and higher value of the active radars as a whole (transmitter and receiver in one device), active radars should to be lightly armored;

5) passive radars do not need armor, because they have separated receiver and transmitter, which are used at different locations (the receiver and transmitter are mounted on two distinct platforms);

6) to reduce the time of folding the radar and leaving the combat position (picket) with the active radars and transmitters of the passive radars is the absolute necessity on the modern-day battlefield.

The most important requirements concerning a modern radar surveillance subsystem of Air Defense System include the following:

1) **very high maneuverability of active radars and transmitters of passive radars;**

2) **the limited time of radars' radiation on the combat position (picket), with short time of electromagnetically emission up to 10-12 seconds;**

3) **high survivability of the active radars, resulting, among others, to light armoring;**

The most important requirements concerning a modern radar surveillance subsystem of Air Defense System include the following:

4) **detecting all types of air objects;**

5) **supporting the tactical and operational situation analysis with the aid of “intelligent” software;**

6) **full cooperation with other surveillance and command systems;**

7) **possibility of controlling the radar from different levels (fully flexible operation).**

SUMMING-UP

Course of last military conflicts proved that the existing radar surveillance systems of the Air Defense system has very little chance of surviving the first phase of a military conflict, not to mention surviving its whole duration, which was proved by the few recent ones.

These experiences motivate to seek new solutions in this field, which would be resistant to the destructive effects of the modern combat assets.

12. Summing-up

Formula I

The mechanic of McLaren Mercedes team during last Grand Prix of Germany rally show class. They change wheels in Jensona Buttona's bolid in 2,4 second.

2.4 BUTTON

VETTEL 3.4

Thank You very much !!!