The Collapse of American Air Power: The Proliferation of Counter-Stealth Systems

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Stealth – America's Last Military Advantage

- For six decades the ability to dominate the skies has been the keystone of US military power.
- For three decades stealth technology has been the keystone of the advantage held by the US Air Force.
- For almost two decades, Russia's industry and research institutes have been developing new technologies to defeat the US stealth advantage.
- At this time the US is completely reliant upon stealth technology to penetrate advanced Surface to Air Missile (SAM) and fighter defences – Russian and Chinese industry have matched or overcome most US military technologies other than stealth.
- *As advanced Russian technology is now exported globally, "Counter-Stealth" presents a major risk.*

What Stealth Offers

- Well implemented and advanced stealth technology makes aircraft very difficult to detect and track.
- In combat, well implemented stealth offers the advantage of surprise, as an opponent can be attacked without prior warning.
- Well implemented stealth also frustrates defences by impairing sensors used to guide missiles, thus improving platform survivability enormously.
- Survivability of combat aircraft is critical because sustained combat losses as low as ~1 percent would cumulatively reduce the size of a combat force by >50 percent over a mere 100 sorties.
- *Any technology which can degrade or defeat stealth can produce disproportionate combat effect.*

What Stealth Does

- Stealth technology aims to reduce the radar, radio -frequency, infrared and visual signatures of platforms to reduce the ability of opposing sensors to detect and track them.
- In terms of importance, stealth techniques against radars are most valuable as radar is best able to penetrate adverse weather, compared to other sensors.
- Stealth techniques which aim to conceal radar and network equipment radio emissions are almost as important, for much the same reason.
- *Well implemented stealth can reduce the coverage area of hostile sensors 100 to 2,000 fold, leaving enormous gaps in air defence coverage*.

Stealth versus Detection by Radar

- Stealth designs built to defeat radar make use of two basic technologies – *shaping* and *materials*.
- *Stealth shaping* bounces radar signals away from the radar producing them, leaving it with only very weak reflections from the target aircraft.
- *Stealth materials* are then used to soak up the remaining reflections from the target aircraft.
- A conventional fighter aircraft might reflect as much a sphere of several yards in diameter, whereas a well designed stealth aircraft will appear the size of a golfball, marble or ball bearing.
- *Shaping produces much of the effect in a stealth design, with materials used mostly to further improve performance*.

Stealth versus Emitter Locating Systems

- Emitter Locating Systems track the radar and radio emissions from platforms, and can locate an emitting aircraft accurately in space, identify it by type and often divine its intent.
- Stealth techniques against Emitter Locating Systems aim to frustrate detection and tracking.
- Two basic technologies are used, based on *controlling emission direction* and *making the emission hard to discriminate against naturally occuring radio noise*.
- The former involves the use of *steered emissions*.
- The latter involves the use of "*noise-like*" *signals*, and *hopping between frequencies* over a wide band, while *minimising the number of emissions*.

Limitations of Stealth vs Radar Detection

- Contrary to the commonly held belief that "*stealth confers complete invisibility to all radars*", real stealth designs have numerous limitations, resulting from design optimisations.
- An aircraft's shaping and materials may be optimised to defeat some radar types or categories, and not defeat others.
- An aircraft may also be much less stealthy from some directions, compared to others.
- Stealth design optimisations result from the style of combat the aircraft is intended to engage in, and what kind of radars it is intended to defeat, but may also result from an intent to reduce the manufacturing cost or complexity of a design.

Categories of Stealth Design – *By Aspect*

- A stealth design which is built to be very hard to detect from all directions is termed an "all aspect" stealth design.
- "All aspect" stealth aircraft are intended to penetrate enemy defences, where they might be painted by hostile radars from any direction.
- A stealth design which is built to be very hard to detect from only one principal direction is termed a "directional stealth" design.
- "Directional stealth" designs are not intended to be flown deep into enemy defences, and their stealth is used to defeat one threat at a time.
- *"All aspect stealth" designs are much more survivable than "directional stealth" designs.*

Categories of Stealth Design – *By Radar Band*

- A stealth design which is built to be very hard to detect by radars operating in many frequency bands is termed an "wideband stealth" design.
- "Wideband stealth" aircraft are intended to penetrate enemy defences where they might be painted by a very wide range of radar types.
- A stealth design which is built to be very hard to detect in a small number of radar bands is termed a "narrowband stealth" design.
- "Narrowband stealth" designs are not intended to be flown deep into enemy defences, and their stealth is used to defeat one threat at a time.
- *"Wideband stealth" designs are much more survivable than "narrowband stealth" designs.*

Threat Radar Types by Frequency Band

- Typical air defences acquire targets with search radars and guide missiles with engagement radars.
- "Metre" bands (VHF band, G/P-bands, low UHF band) are mostly used for search radars
- "Decimetre" bands (mid UHF band, L-band, low S -band) are mostly used for search radars.
- "Centimetre" bands (high S-band, X/Ku/K/Ka-bands) are mostly used for engagement radars used to guide missiles, airborne fighter radars, and homing missile guidance seekers.
- "Millimetre" bands (above Ka-band) are used for some engagement radars and missile seekers.
- *Most stealth designs perform best in the centimetre bands as these are used for weapon guidance.*

US Stealth Designs – Lockheed F-117A

Wideband All-Aspect Stealth

Designed 1970s for deep penetration

Small size – most effective mid/upper radar bands

Only 60 deployed, 1 lost in combat 1999

Recently retired, the F-117A was the first operational stealth aircraft, replaced by F-22A Raptor

Internal payload two laser guided bombs

US Stealth Designs – Northrop B-2A Spirit

Wideband All-Aspect Stealth

Designed 1980s for deep penetration

Large size – effective down to VHF band

Ku-band radar upgrade to X-band AESA

Only 16 combat coded, 21 built out of 132 initially planned, 1 lost in accident

Provides nuclear and conventional all weather long range strike capabilities

Large internal payload of guided bombs for conventional strike operations

Only stealth design capable of internally carrying large bunker busting bombs

Only US heavy bomber capable of penetrating modern air defences

US Stealth Designs – LM F-22A Raptor

Wideband All-Aspect Stealth

Designed 1990s for deep penetration

Small size – effective mid/upper bands

Supersonic cruise capable

Capable ISR suite

Only 187 currently planned

Provides conventional all weather strike and air dominance capabilities

Internal payload of 8 air-air missiles or 4 air-to-air missiles and 2-8 guided bombs for conventional operations

Only US fighter capable of penetrating modern air defences, optimised to defeat long range SAM systems

Replaces the F-117A and some F-15Cs

US Stealth Designs – LM F-35A/B/C JSF

Narrowband Directional Stealth

Defined for battlefield strike and close air support, promoted as "multirole"

Small size – most effective upper bands, forward hemisphere

Uncompetitive aerodynamic performance

Capable ISR suite

2,000+ currently planned

Provides conventional all weather battlefield strike capabilities

Intended payload of 4 air-air missiles or 2 air-to-air missiles and 2-8 guided bombs for conventional operations

JSF stealth optimised to defeat short and medium range SAMs, not built for deep penetration of modern air defences

US Stealth Designs – GA Predator C UAV

Narrowband All Aspect Stealth

In development for armed ISR role

Small size – effective upper bands

Slow/persistent aerodynamic design

Provides all weather ISR and limited conventional strike capabilities

Predator C / Avenger stealth optimised to defeat short and medium range SAMs, not built for deep penetration of modern air defences

US Stealth Designs – NG X-47 Naval UCAS-D

Wideband All Aspect Stealth

Demonstrator for Strike/ISR role

Small size – best mid/upper bands

Intended for all weather ISR and conventional strike capabilities

Stealth design based on B-2A concept, optimised for deep penetration of modern air defences

Planform design maximises stealth bandwidth for given aircraft size

Summarising US Stealth Capabilities

Type	All Aspect Stealth	Wideband Stealth	Penetration Capability
B-2A Spirit	YES	YES	Excellent
F-22A Raptor	YES	YES / but limited	Excellent
UCAS-D	YES	YES / but limited	Excellent
Predator C	YES	NO	YES / but limited
F-35 Lighting II	NO	NO	Very Limited

Assessment based on airframe geometry and shaping detail dimensions; ranked by survivability

Russian Technological Strategy for Counter-VLO Sensors

Evolution of Russian Counter-Stealth

- During the Cold War, Russian military commanders did not believe that US stealth worked.
- The 1991 defeat of legacy Soviet radars by the F-117A resulted in a fundamental reassessment.
- After 1991, Russian research institutes set about developing radar technology to defeat stealth.
- In 1999 the Russians acquire technologies from the F-117A shot down over Serbia; Eastern European sources credit kill to digital upgrades performed on legacy Cold War P-18 Spoon Rest VHF radars.
- Post 2000 new VHF-band Nebo SVU, Nebo U, Resonans N radars disclosed.
- In 2008, Nebo M multi-band radar disclosed.
- *New radar designs and upgrades to legacy radars.*

Russian Counter-VLO Technological Strategy

- Russia's technological strategy is well articulated publicly, especially in interviews with researchers and engineers developing counter-stealth radars.
- *US strategy for stealth design has been to target the basic physics of radar design – Russian strategy has targeted the basic physics of US stealth shaping and materials technology.*
- Russian strategy exploits several effects:

1. Shaping loses effect in VHF-band and L-band, due to radar scattering physics vs feature size.
2. The "skin effect" makes it very difficult to use stealth materials in the VHF-band and L-band.
3. Fusion of detection and tracking data from multiple sensors using computer networks.

Russian Counter-VLO Technological Strategy

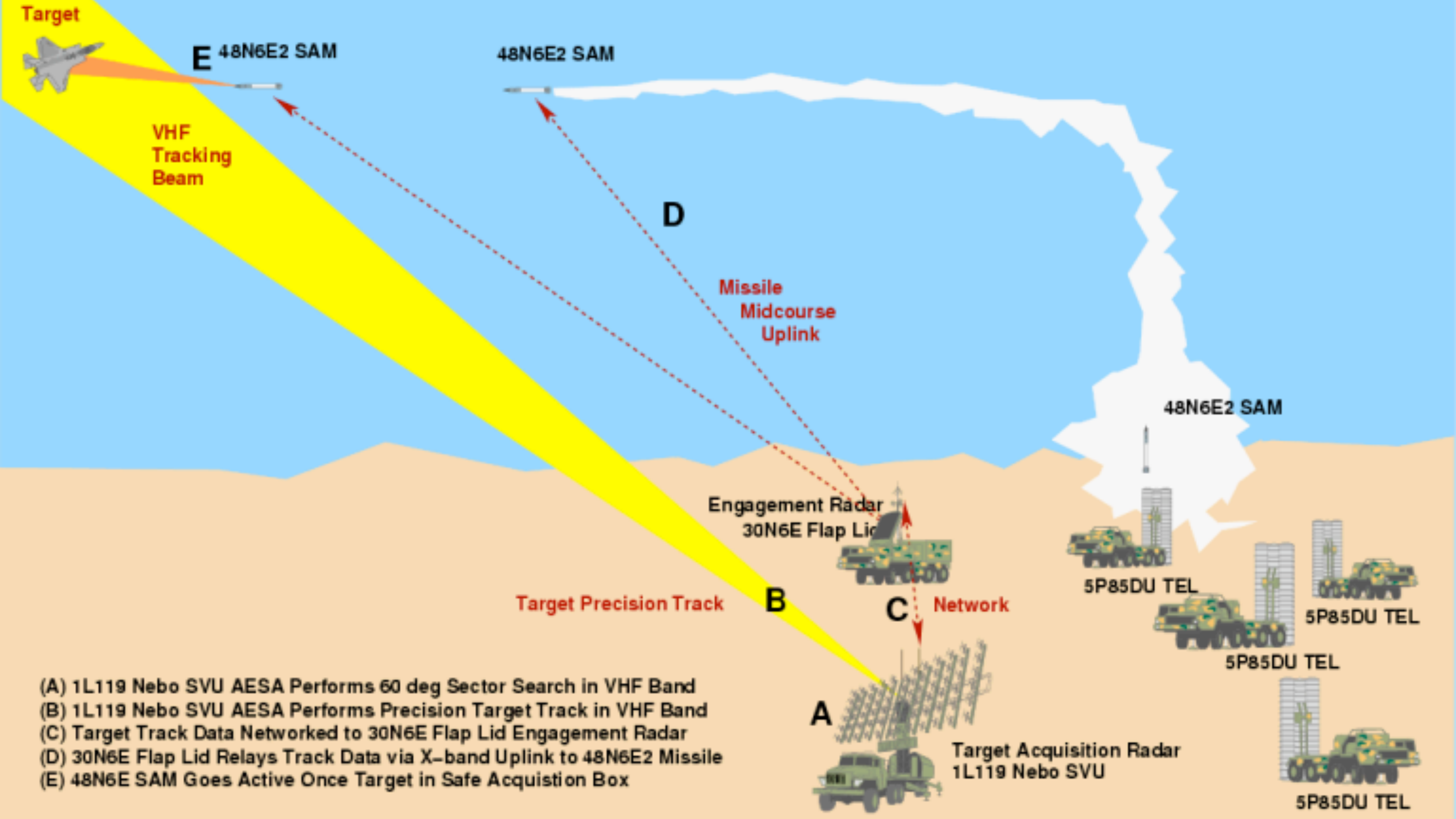
- Russian reasoning on counter-stealth is rooted in basic physics, and the systems they have developed will demonstrate varying degrees of effectiveness against specific US systems.
- The greatest enabler for Russian counter-stealth has been free access to advanced Western commercial computer and radio-frequency electronic components, open-source software and computer networking technology.
- Russia's NNIIRT institute has been designing VHF radars since the 1950s, producing most recent designs; KB Radar in Minsk, ByeloRussia, recently developed their own radar; the VNIIRT institute has been developing L-band designs.

Russian Counter-VLO Technological Strategy

- Russian counter-stealth designs can be broadly divided into *detection/tripwire systems*, and *precision tracking systems*.
- The former are intended to provide warning of stealth aircraft, but cannot support targeting.
- The latter are intended to provide sufficiently accurate tracking to provide cueing and in some instances midcourse tracking and targeting data for Surface to Air Missile batteries.
- *In missile engagements, or intercepts by fighter aircraft, the precision counter-stealth sensors would guide the attacking missile or fighter close enough to attack the stealth aircraft, overcoming the limitations of the missile or fighter sensors.*

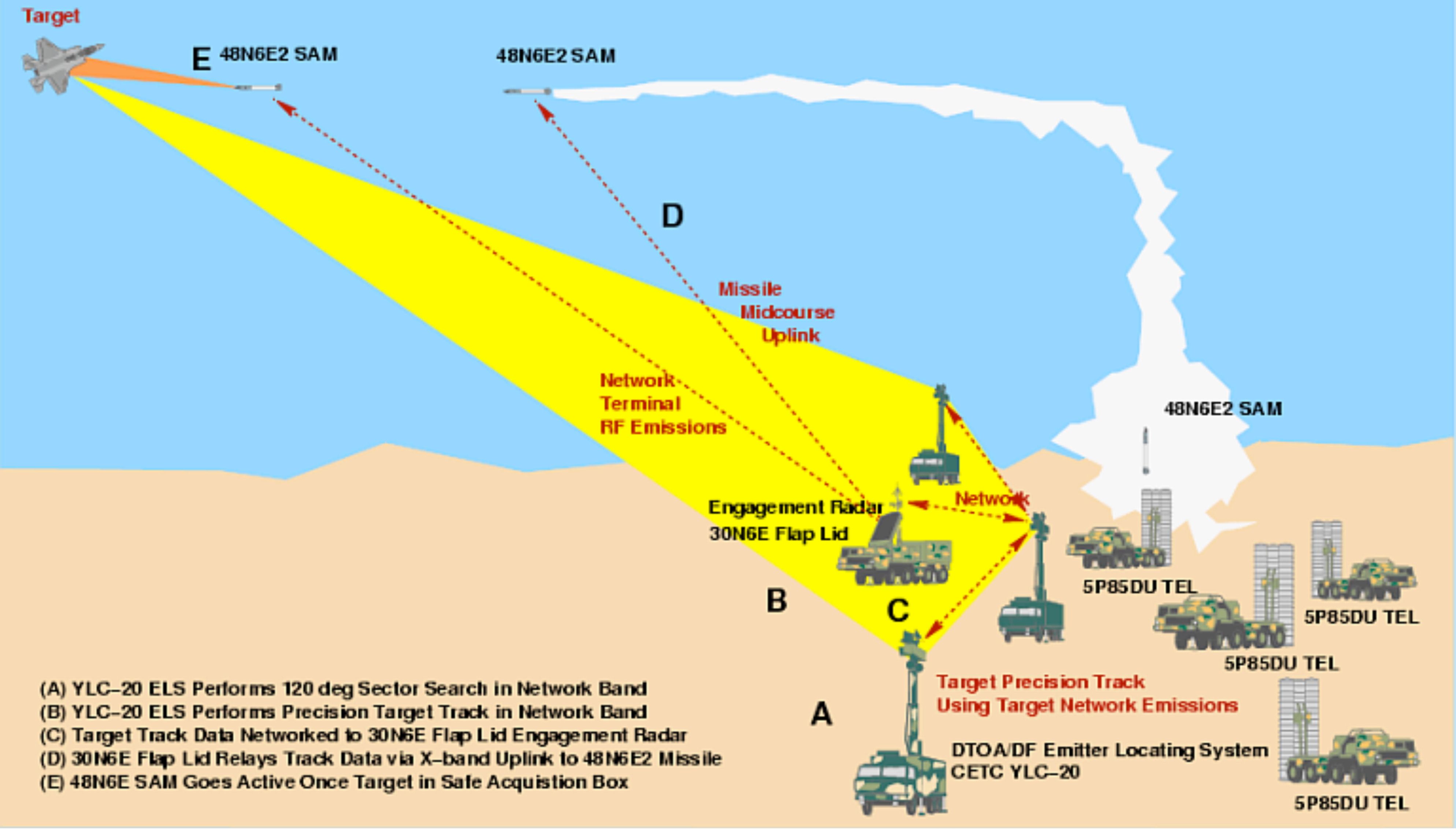
Counter-VLO VHF-Band Radar CONOPS

Example Integration of Nebo SVU and S-300PMU2 / SA-20



Passive Emitter Locating System CONOPS

Example Integration of YLC-20 and S-300PMU2 / SA-20



Russian Counter-VLO - Basic Technology

- Mature and entirely new technologies employed, some indigenous and some Western:

1. AESA radar technology for agile beamsteering, monopulse angle tracking and heightfinding
2. STAP (Space Time Adaptive Processing)
3. Data fusion (cf US Navy CEC system) via networks
4. Multi-static and bistatic radar systems
5. Multi-band radar systems
6. Mature 3/8 dipole/Yagi, and new antenna element designs such as the Kharchenko square loop.
7. DTOA (Differential Time Of Arrival) and interferometric emitter location techniques.
8. COTS digital processing and software

Russian Counter-VLO - Effectiveness

- The effectiveness of Russian counter-stealth systems will vary widely, between systems and specific types of target, and deployment.
- Digital upgrades to legacy Cold War VHF-band radars are likely to provide some detection or tripwire capability, but only a limited capability to support fighters and missile batteries.
- New design high power VHF-band radars such as the Nebo U, Nebo SVU, and Nebo M RLM-M will be much more effective due to better detection range and precision 3D tracking capability.
- Emitter Locating Systems are potentially very effective against network terminals and aircraft AESA radars operating in high duty cycle modes.

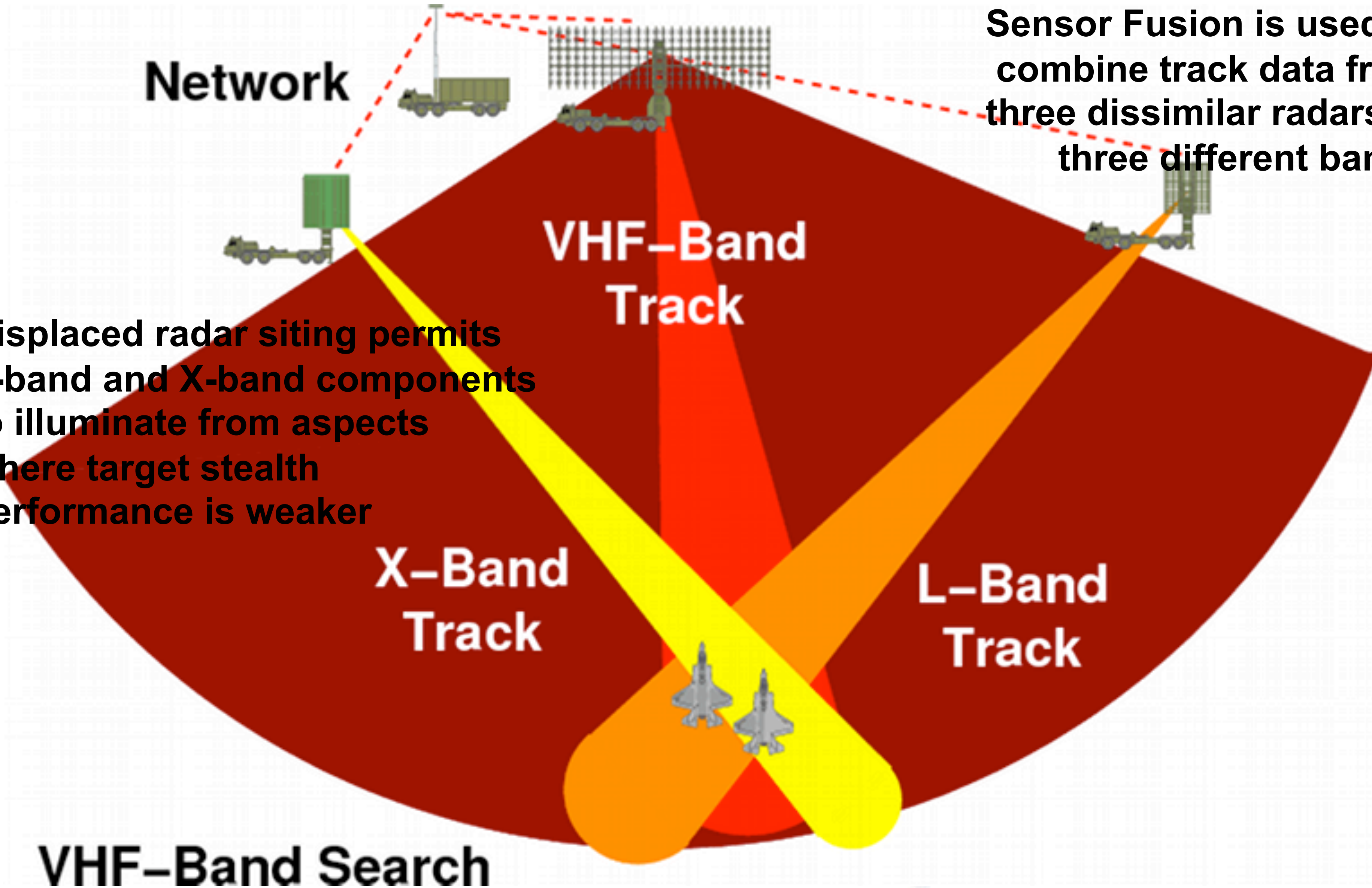
Russian Counter-VLO – Sensor Fusion

- Western computer and network technology is the key "enabler" for sensor fusion technology.
- Sensor fusion allows a system to combine intermittent and often poor quality tracking data from multiple sensors, such as several radars (US Navy CEC) and/or Emitter Locating Systems.
- *While each individual sensor track may be of poor quality, "fusing" multiple sensor tracks permits an often good quality track to be produced, overcoming the limitations of individual sensors.*
- Sensor fusion is being introduced in Russian designs, i.e. the integration of Emitter Locating Systems with the S-400/SA-21 SAM system, or the new Nebo M networked multiband radar system.

NNIIRT Nebo M Multiband C-VLO AESA Radar

Sensor Fusion is used to combine track data from three dissimilar radars in three different bands

Displaced radar siting permits L-band and X-band components to illuminate from aspects where target stealth performance is weaker



Russian Counter-VLO – Deployment

- Currently disclosed Russian deployment strategy has been to integrate counter-stealth sensors with their highest performing long range Surface to Air Missile system, the S-400 / SA-21, which is now entering the global export market.
- Once integration with the S-400 is completed, Russian practice would be to offer such sensors as upgrades to related missile systems such as the heavily exported S-300PMU/1/2 / SA-10/20.
- ByeloRussia's KBR is targeting users of Cold War legacy SAM systems with their Vostok E radar.
- *A package of networked counter-stealth sensors integrated with legacy Soviet era missile systems would overcome the limitations of legacy radars.*

Russian Counter-VLO vs US Systems

- The US B-2A heavy bomber is the least vulnerable to counter-stealth technology, as it is large enough for its shaping to be effective against new technology long range VHF-band radars.
- All other US systems are likely to be detected at useful ranges by new technology long range VHF-band radars – their survival then depends on how good their stealth performance is against centimetre band fighter radars, SAM engagement radars and missile seekers, and whether they are fast and agile enough to evade such threats.
- *This will present survivability problems for US designs in which stealth performance has been intentionally compromised to meet other aims*.

Russian Counter-VLO vs F-35 Lightning II

- *Of all US designs, the F-35 will be most susceptible to Russian counter-stealth technologies.*
- The F-35's stealth design was compromised from the outset, by assuming sufficient F-22As would always be available to kill the most capable threat systems, thus exposing the F-35 only to much less capable threat systems, such as battlefield SAMs.
- The result of this is that the F-35 lacks the stealth performance in the rear hemisphere to survive against advanced threat systems, and many legacy threats, if cued by counter-stealth systems.
- *Because the F-35 is much slower than the F-22A, it cannot retreat quickly enough to escape a SAM shot or evade a hostile fighter attack.*

Russian Counter-VLO - Operational Impact

- Counter-stealth sensors will render US legacy aircraft unusable, as they will easily overcome any applied radar absorbent materials.
- The stealth limitations of the F-35 will make it unusable in situations where counter-stealth sensors have been deployed to support advanced SAM systems, and in some instances, also legacy Cold War era SAM systems.
- Only the B-2A and F-22A can penetrate such air defences with acceptable loss rates.
- *All other US systems will need to be generously supported by F-22A escort fighters to deter fighter and SAM system attacks. The number of available F-22A squadrons will bound US capability*.

Russian Counter-VLO – Strategic Impact

- Counter-stealth sensors will severely limit US capability to deal with hostile air defence systems, unless the US fundamentally changes planning for its future combat fleet.
- As most of the new design counter-stealth systems are highly mobile, they will be very difficult to find and kill off during an air campaign, if found they will be difficult to attack successfully due to defensive countermeasures and defensive weapons directed against US smart munitions.
- *The currently planned number of 187 F-22As will severely limit the size of contingencies the US can handle with acceptable combat losses – whether F-22As are used as bombers or used as escorts.*

Russian Counter-VLO – Conclusions

- Over the coming decade, counter-stealth sensors will fundamentally change the balance of global conventional military power, at the expense of the United States and its allies, unless current OSD mandated fighter force planning is abandoned.
- Motivated by commercial interest, Russian and Chinese industry will proliferate such equipment worldwide, to exploit the available opportunity.
- Many more F-22A Raptors need to be built and deployed over the next decade, to provide a robust capability to overcome this technological advance.
- *The United States cannot wait another two decades to develop and deploy a new "sixth generation fighter". The time to act is now.*

Counter-VLO Sensors in the Global Marketplace

NNIIRT Nebo M Multiband C-VLO AESA Radar

Integrated Multiband System VHF-Band / L-Band / S/X-band Operation

CEC style Track Fusion via Networking of Component Radars

High Angle/Range Accuracy to Support SAM Batteries

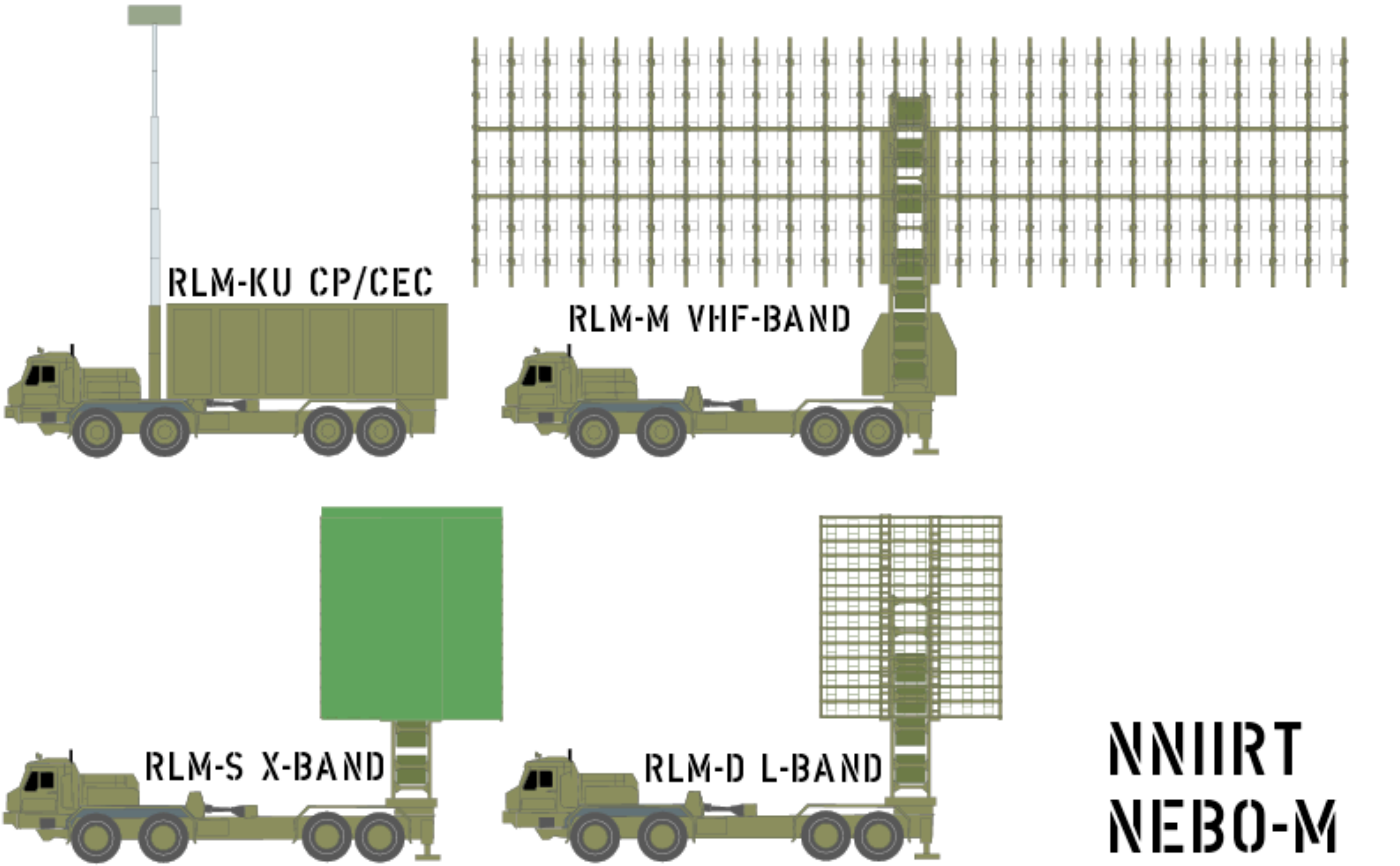
Frequency Diversity to Defeat VLO Shaping and Defensive Jamming

All Component Radars Digital AESA

Derived from existing Gamma S1, Protivnik G and Nebo SVU / U Designs

All Components Self Propelled for High Mobility and Survivability

NNIIRT Nebo M Multiband C-VLO AESA Radar



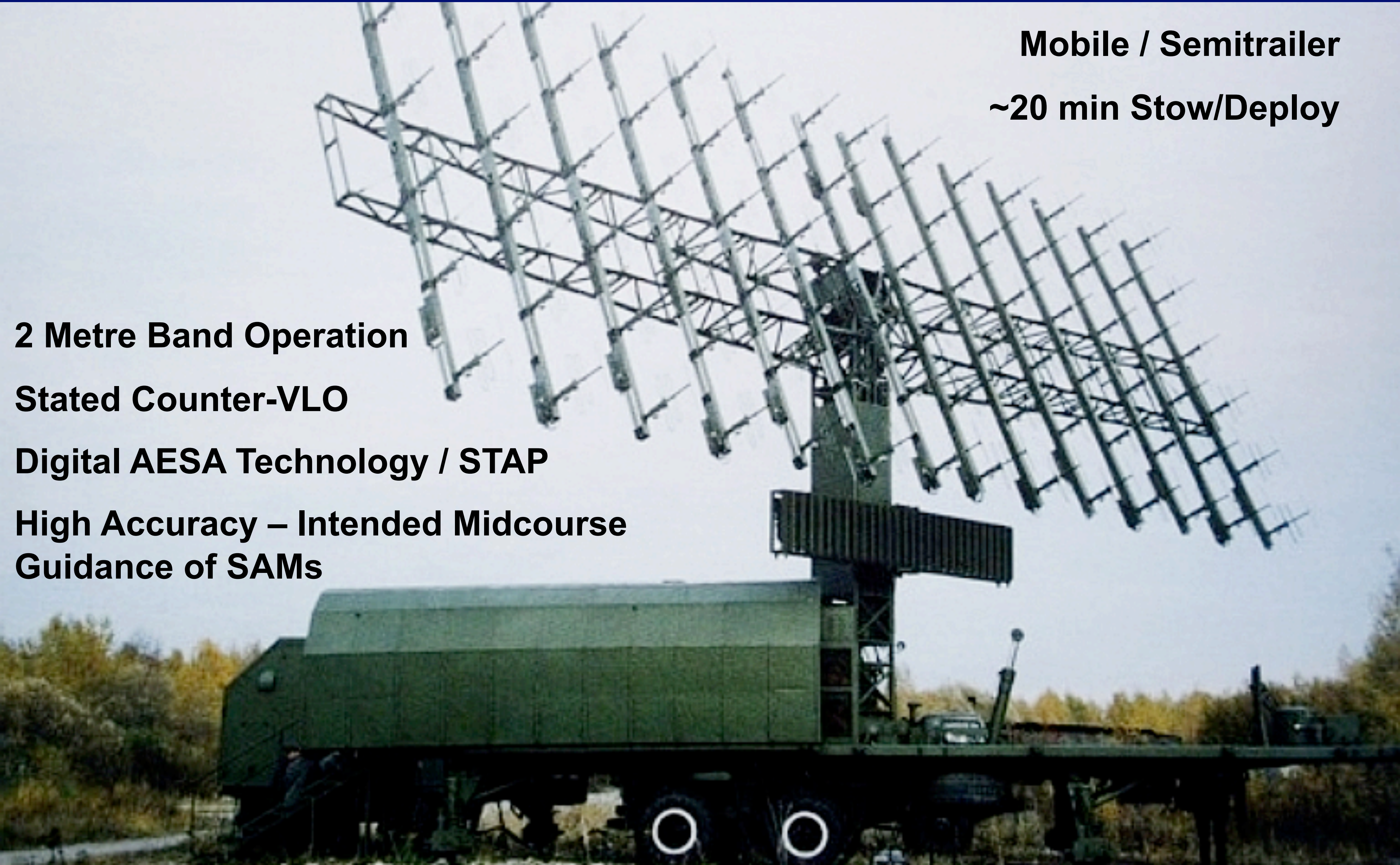
NNIIRT RLM-M Nebo M 3D VHF AESA Radar

2 Metre Band Operation / Digital AESA Technology / STAP / Stated Counter-VLO

High Accuracy – Intended Midcourse Guidance of SAMs

Self Propelled / High Mobility

NNIIRT 1L119 Nebo SVU 3D VHF AESA Radar



Mobile / Semitrailer

~20 min Stow/Deploy

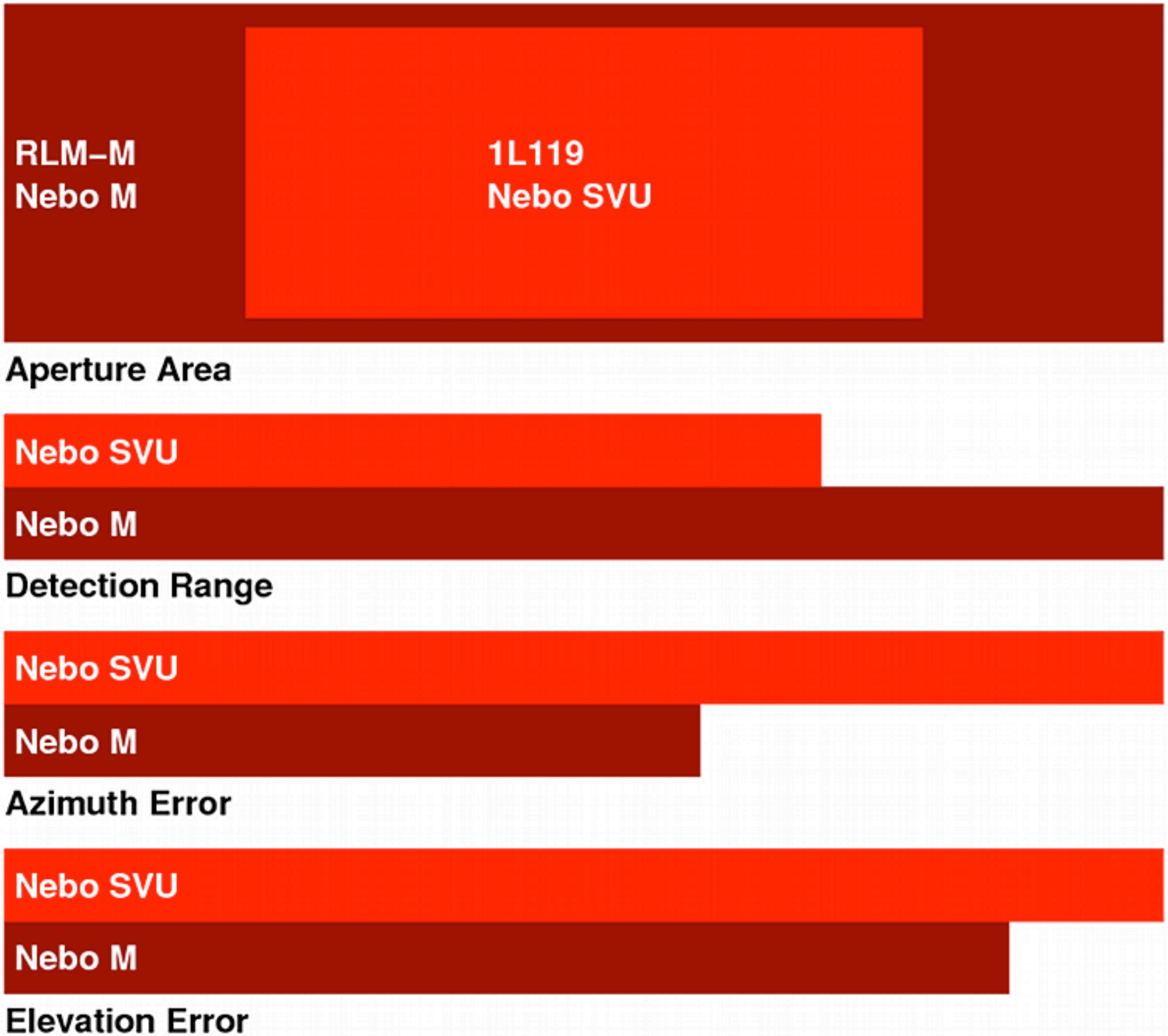
2 Metre Band Operation

Stated Counter-VLO

Digital AESA Technology / STAP

High Accuracy – Intended Midcourse Guidance of SAMs

Nebo M RLM-M vs Nebo SVU Performance



4 X Power-Aperture

Improved

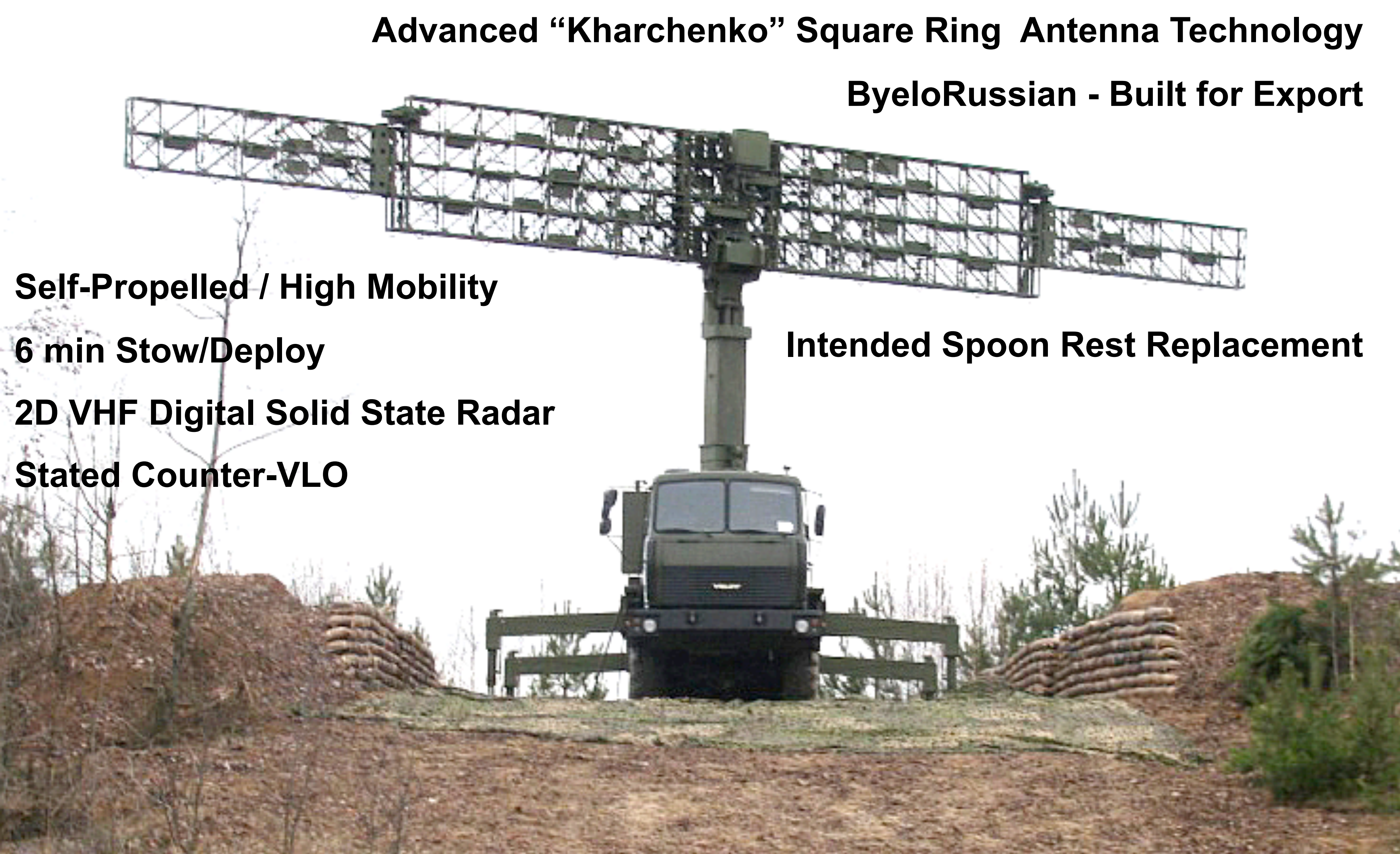
Angular

Resolution

KBR Vostok E 2D VHF C-VLO Search Radar

Advanced "Kharchenko" Square Ring Antenna Technology

ByeloRussian - Built for Export



Self-Propelled / High Mobility

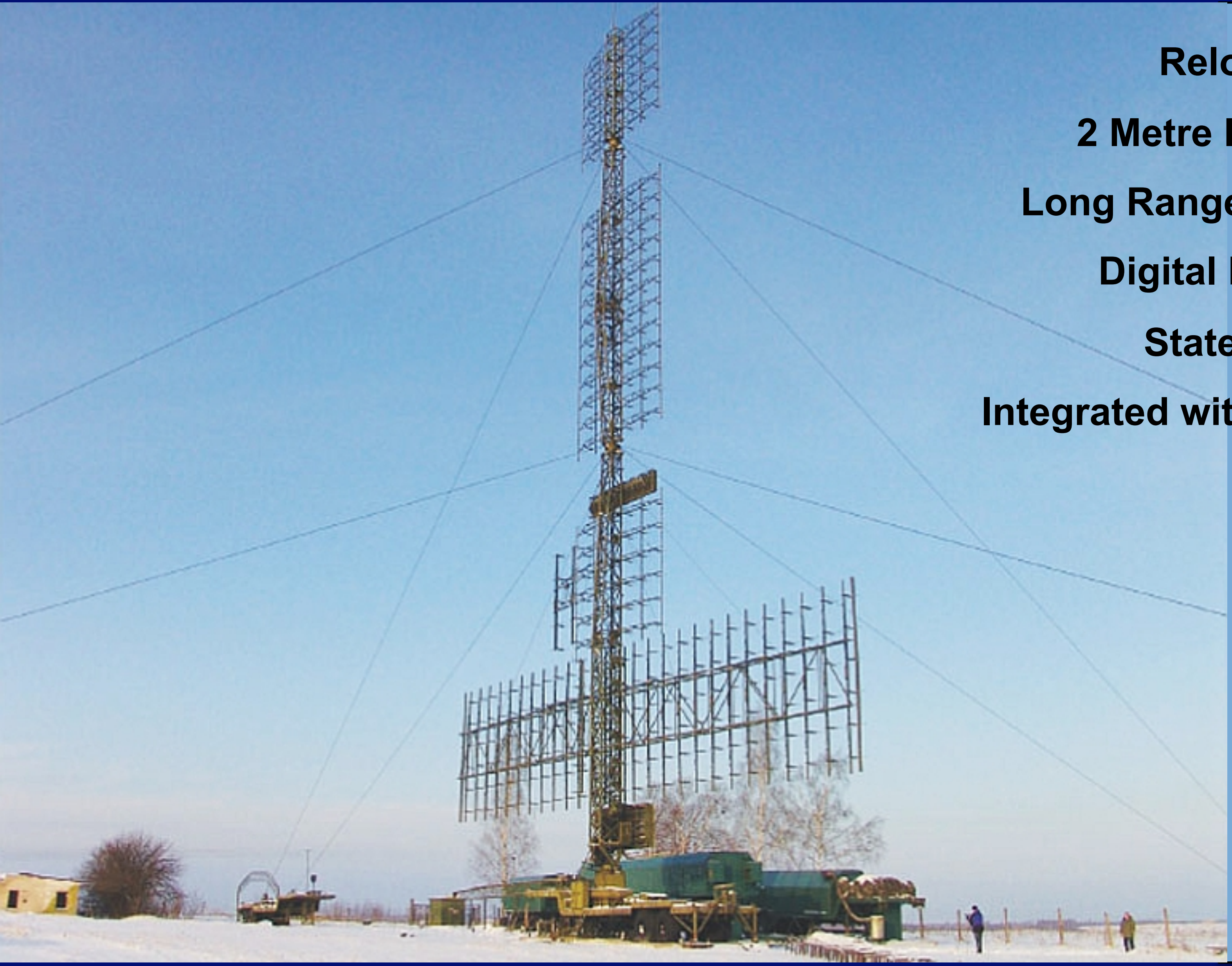
6 min Stow/Deploy

2D VHF Digital Solid State Radar

Stated Counter-VLO

Intended Spoon Rest Replacement

NNIIRT 55Zh6 Nebo UE 3D VHF CVLO Radar



Relocatable / Static

2 Metre Band Operation

Long Range 3D VHF Radar

Digital MTI Processing

Stated Counter-VLO

Integrated with S-400 / SA-21

Rezonans N/NE 3D VHF Bistatic Radar

- Relocatable
- Long Range 3D VHF Bistatic Radar
- Digital MTI Processing
- Stated Counter-VLO

CETC YJ-27 Long Range 2D VHF CVLO Radar

- Semi-Mobile ~1 hr Deployment
- Long Range 2D VHF Radar
- Digital MTI Processing
- Stated Counter VLO
- PLA Deployed

NNIIRT 1L13 Nebo SV 2D VHF Radar

NITEL P-18 Spoon Rest 2D VHF Search Radar

2D VHF Radar – Widely Exported Analogue Variants

Legacy / Upgraded to Digital MTI Processing / Mobile ~45 min Stow/Deploy

CETC YLC-8/8A VHF 2D Surveillance Radar

2D VHF Radar – Development of P-18 / Mobile ~30 min Stow/Deploy

PLA Deployed

NITEL 5N84AE Oborona-14 / Tall King

Long Range 2D VHF Radar

Legacy / Upgraded to Digital MTI Processing

Relocatable 24 hr / Static

Barrier E Bistatic Early Warning Radar

Short Range 1D VHF Bistatic Radar

Remote Sited Low Power Tripwire System

Stated Counter-VLO

Relocatable / Static

67N6E GAMMA-DE L-Band 3D AESA Radar

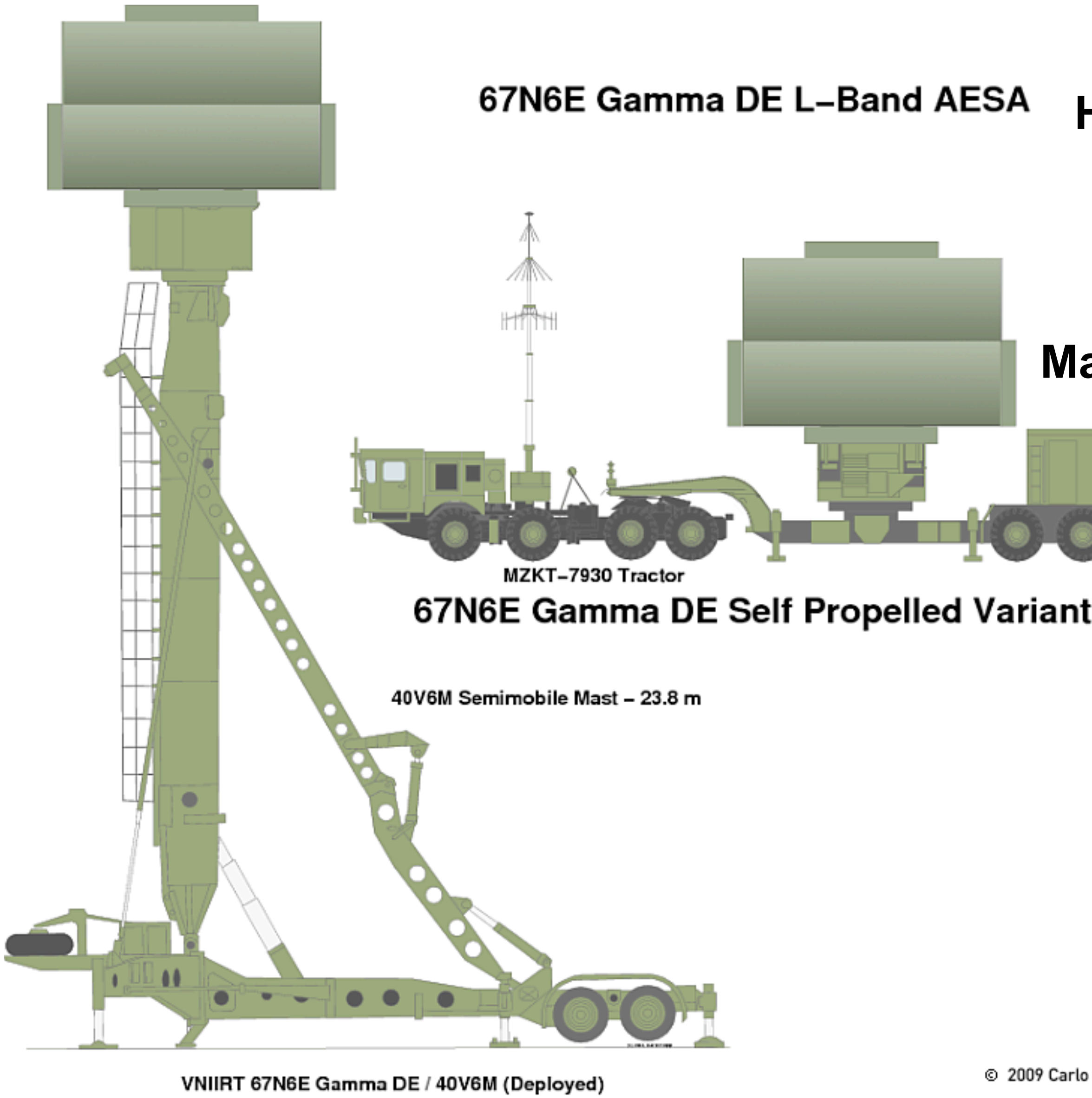
L-Band Operation

High Accuracy AESA Technology

Integrated Countermeasures

High Mobility Variant Available

Mast Mounted Semi-Mobile Variant



NNIIRT RLM-D L-Band 3D AESA Radar

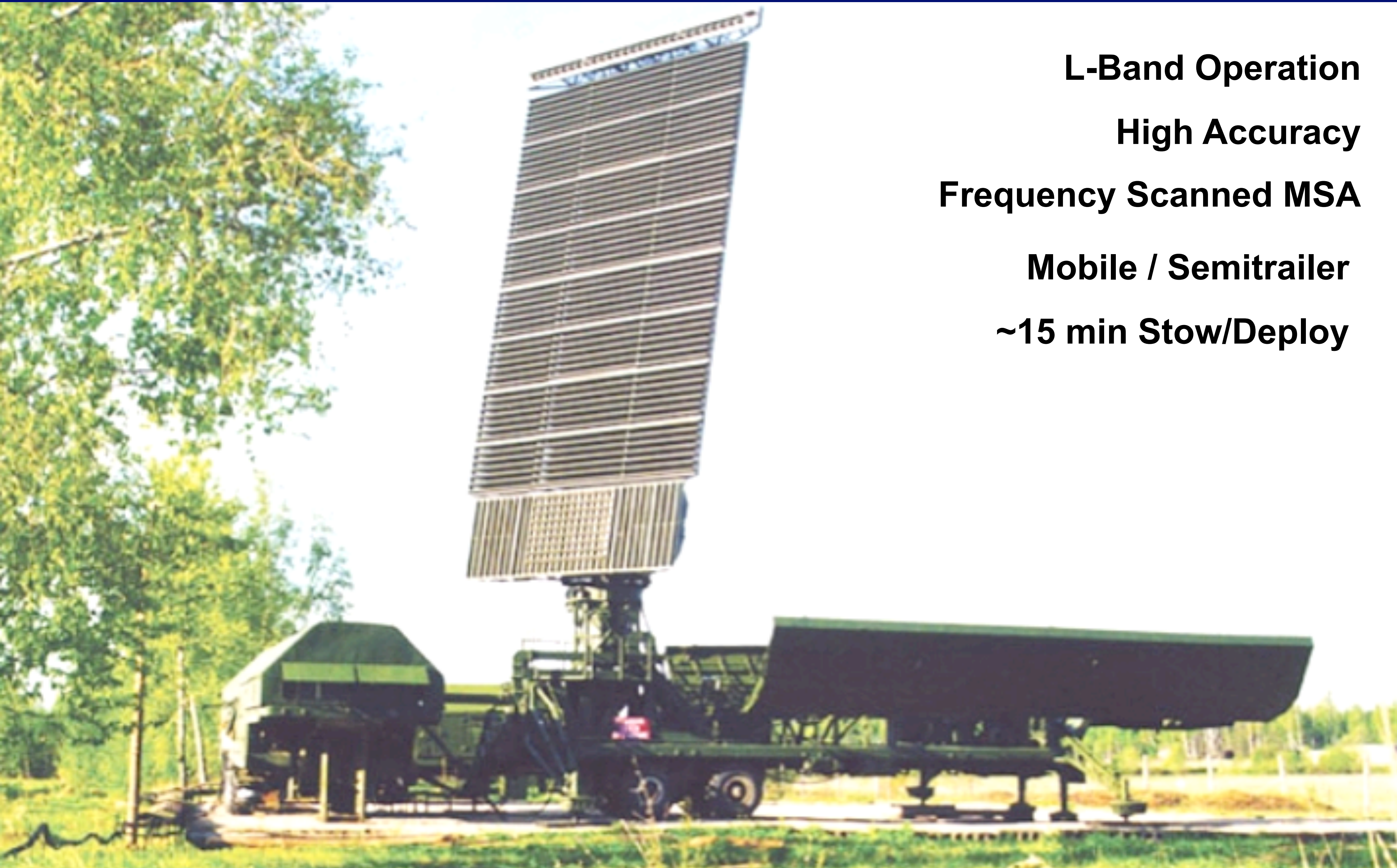
L-Band Operation / High Accuracy

Digital AESA / DMTI / STAP

Based on Protivnik GE

Self Propelled / High Mobility

VNIIRT 59N6E Protivnik GE L-Band 3D Radar



L-Band Operation

High Accuracy

Frequency Scanned MSA

Mobile / Semitrailer

~15 min Stow/Deploy

29N6 Delta L-Band Bistatic Radar

L-Band Operation

Static Automated 3D Surveillance Radar

Bistatic Design

85V6 Vega/Orion Emitter Locating System

Russian Design – Export/Domestic

Passive Detection / Geolocation

DTOA/Interferometer Technology

Networked Operation

Integrated with S-400 / SA-21

Effective Against:

Datalink Terminals

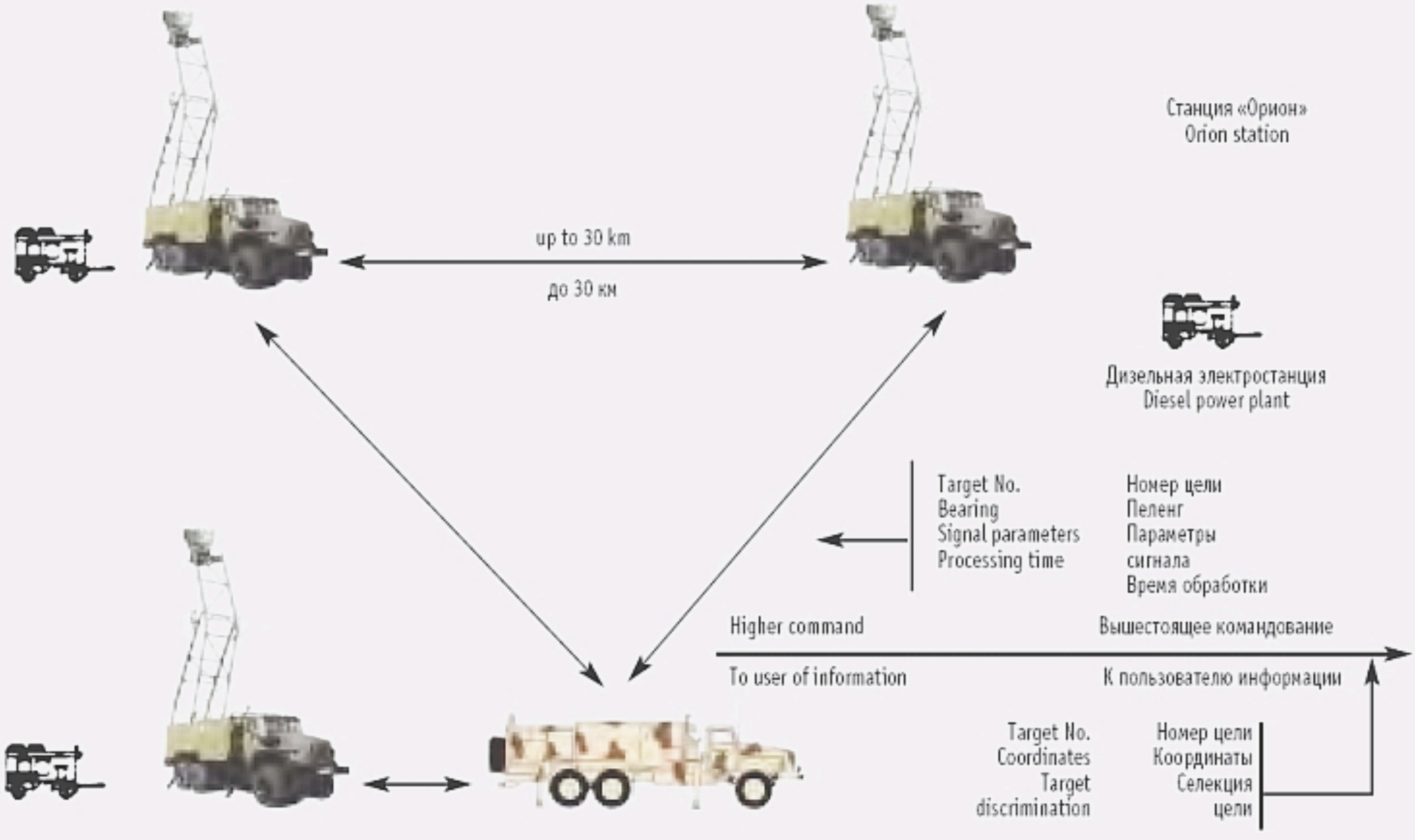
Link-16 Network Terminals

Multimode Radars

IFF Transponders

Navaids (TACAN)

85V6 Vega/Orion Emitter Locating System



1L222 Avtobaza ELINT System

Russian Design – Export/Domestic

Passive Detection

Interferometer Technology

Networked Operation

Integrated with S-400 / SA-21

Effective Against:

Datalink Terminals

Link-16 Network Terminals

Multimode Radars

IFF Transponders

Navaids (TACAN)

Topaz Kolchuga M Emitter Locating System

Ukrainian Design - Exported

Passive Detection / Geolocation

DTOA/Interferometer Technology

Networked Operation

Effective Against:

Datalink Terminals

Link-16 Network Terminals

Multimode Radars

IFF Transponders

Navaids (TACAN)

CETC YLC-20 Emitter Locating System

Passive Detection / Geolocation

DTOA/Interferometer Technology

Networked

Chinese Design Based on

Kolchuga M and Tamara/Vera E

Advanced Russian and Chinese Air Defence Weapons

S-400 Triumf / SA-21– 130-200 NMI

92N2E Grave Stone Engagement

4/16 Round 5P85TE1 TEL

96L6 Cheese Board – Acquisition

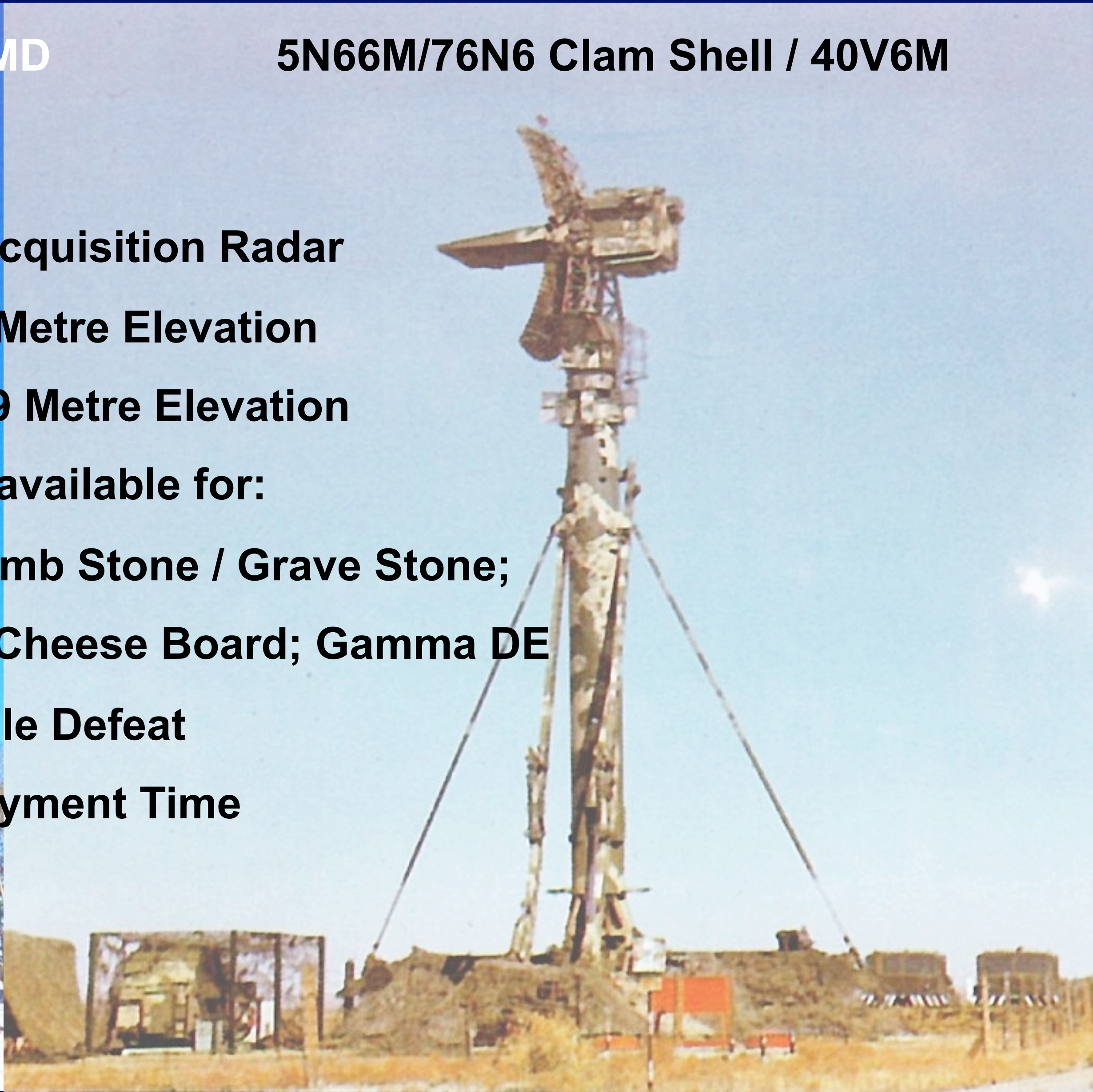
Missiles 48N6E3, 40N6, 9M96E/E2

Equivalent Patriot PAC-3 / ERINT

S-300PMU1/2 / SA-20 Gargoyle – 80-110 NMI

S-300PMU1/2 / SA-20A/B Gargoyle Radars

5N66M/76N6 Clam Shell / 40V6MD



5N66M/76N6 Clam Shell / 40V6M

Low Level Acquisition Radar

40V6M – 24 Metre Elevation

40V6MD – 39 Metre Elevation

Both masts available for:

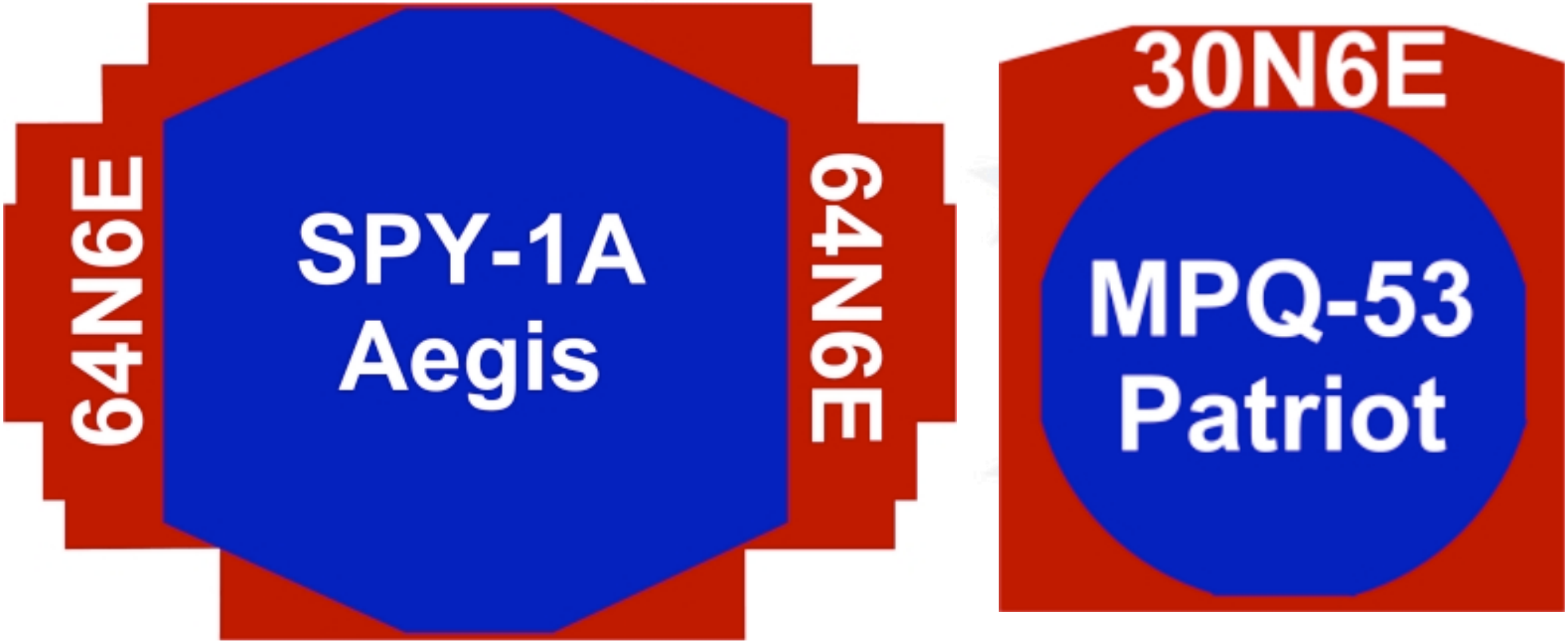
Flap Lid / Tomb Stone / Grave Stone;

Tin Shield ; Cheese Board; Gamma DE

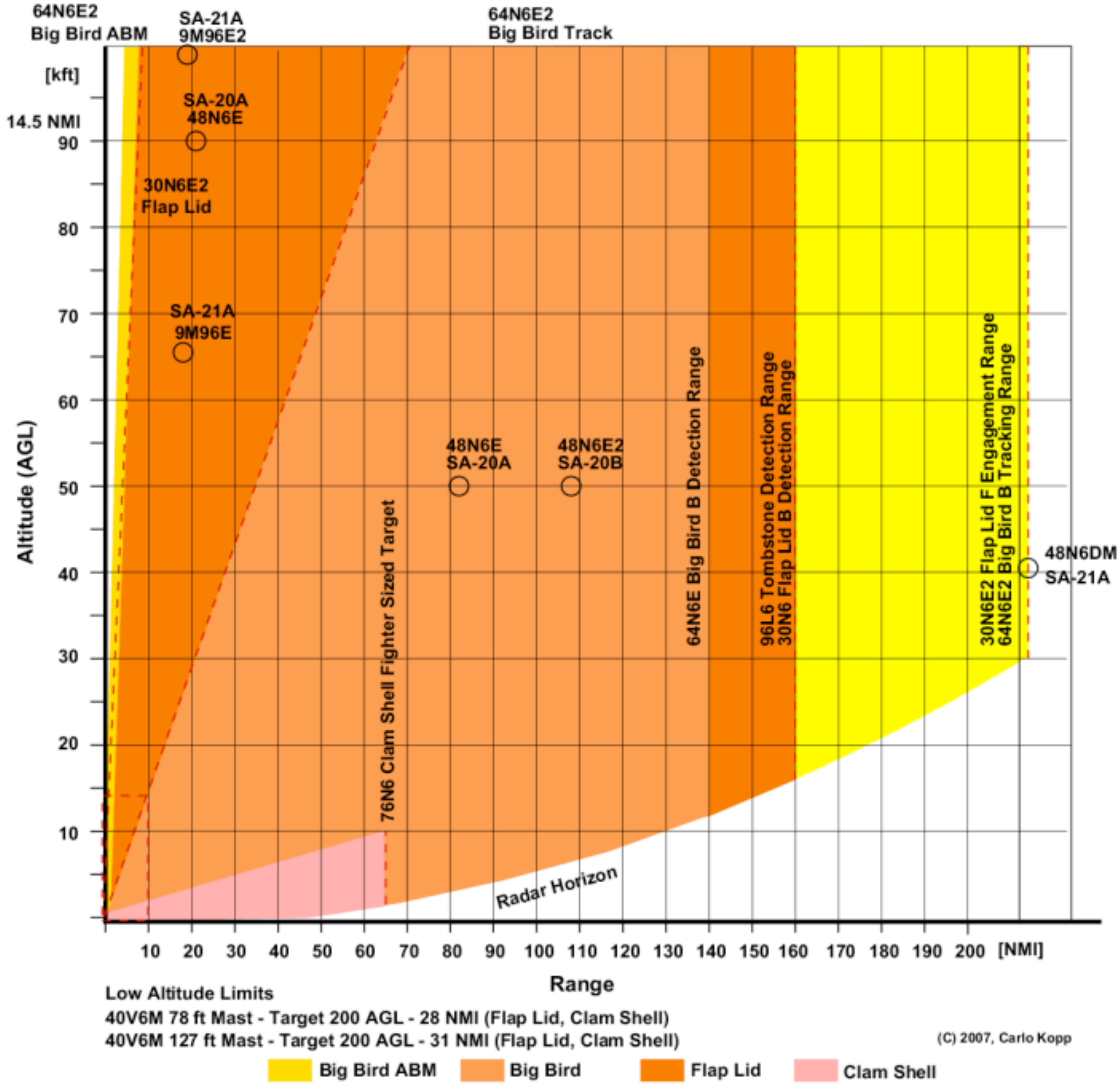
Cruise Missile Defeat

2-4 hr Deployment Time

S-300PMU2 vs Aegis/Patriot - Comparisons



S-300PMU-2 Favorit (SA-20 Gargoyle) Engagement Envelope
S-400 Triumf (SA-21 Growler) Engagement Envelope



Low Altitude Limits
40V6M 78 ft Mast - Target 200 AGL - 28 NMI (Flap Lid, Clam Shell)
40V6M 127 ft Mast - Target 200 AGL - 31 NMI (Flap Lid, Clam Shell)

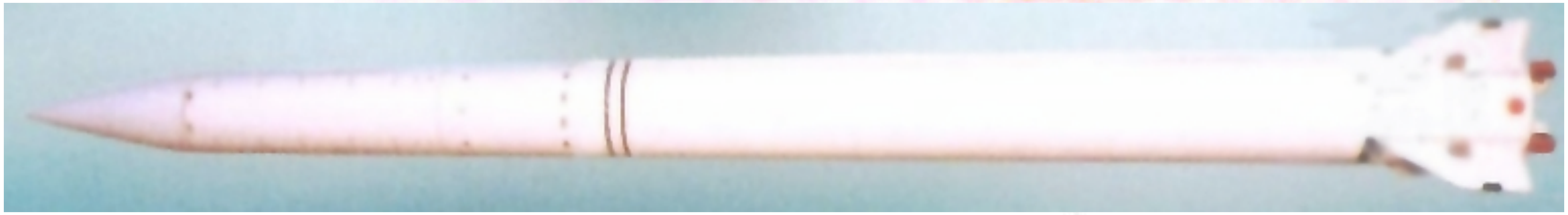
CPMIEC FD-2000 / FT-2000 / HQ-9

HT-233 Engagement Radar

YLC-2V Acquisition Radar

SA-10/20 technology

FT-2000 anti-radiation round 2-18 GHz



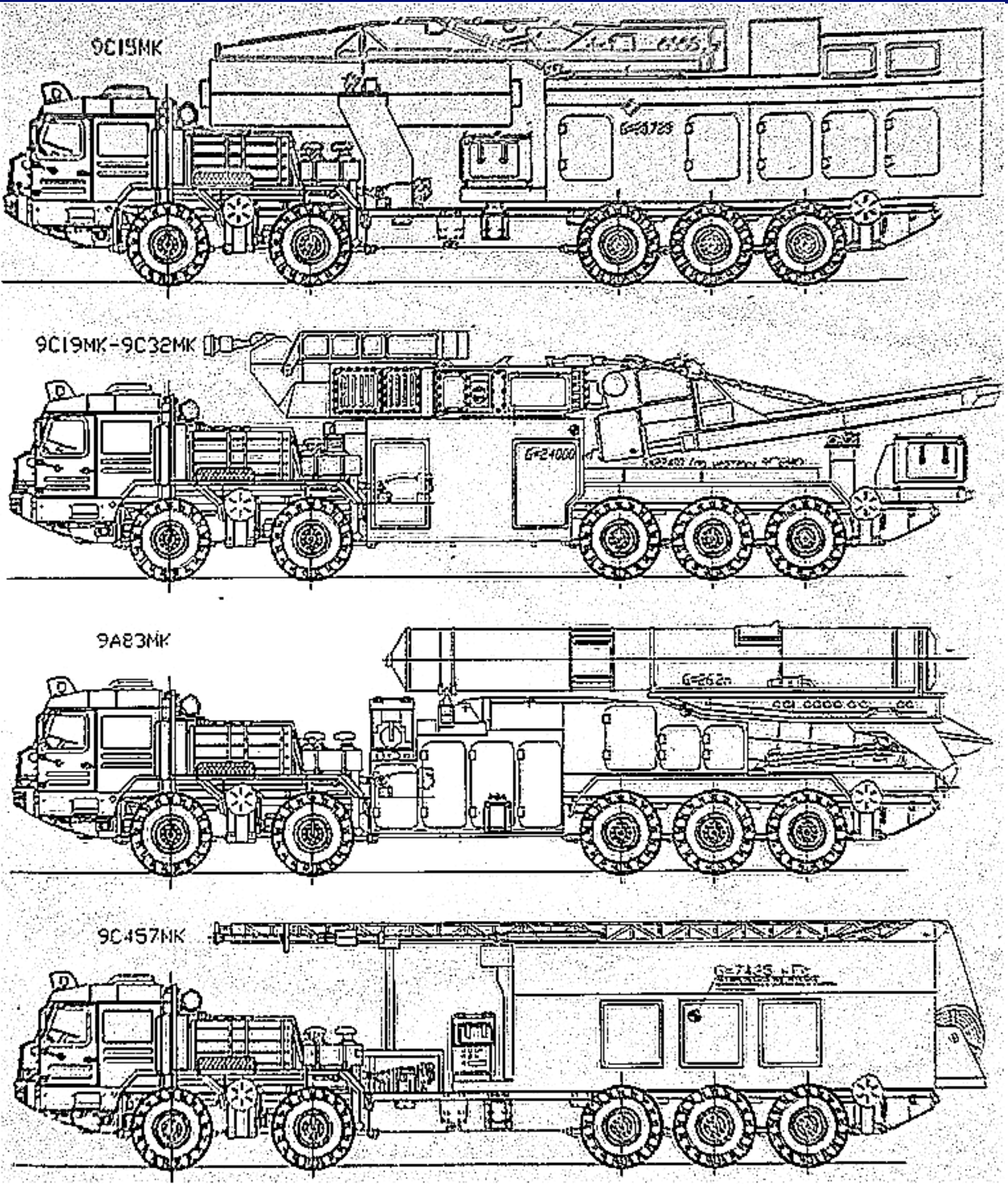
S-300VM / SA-X-23 ~110 NMI

- 9S32M Engagement Radar
- 9S15MT2 Acquisition Radar
- 9S19M ABM Radar
- High Performance SAM/ABM
- Growth 9S19-based Antenna in 9S32M

Image © Miroslav Gyűrösi

Image © Miroslav Gyűrösi

S-300VMK / SA-X-23 ~110 NMI



Wheeled High Mobility Variant

9S32M Engagement Radar

9S15MT2 Acquisition Radar

9S19M ABM Radar

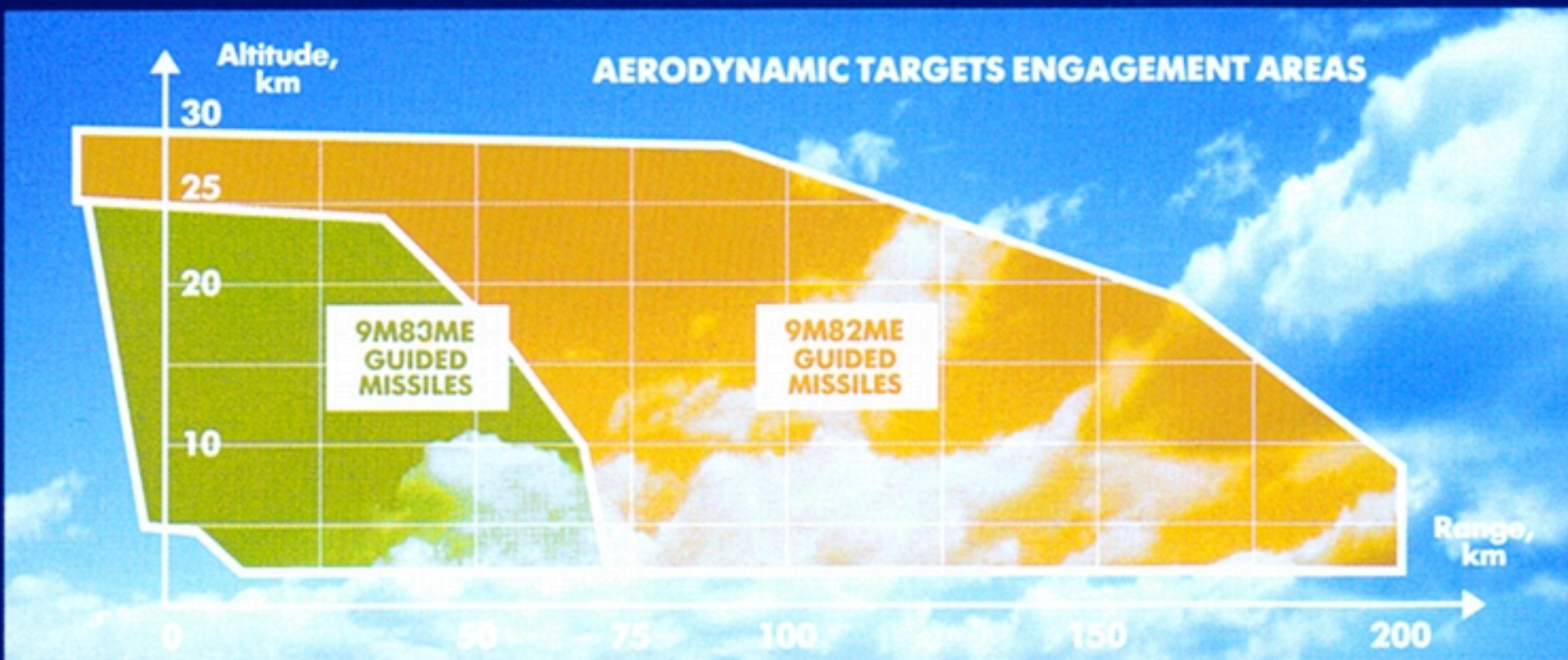
High Performance SAM/ABM

Growth Antenna in 9S32M

PERFORMANCE

S-300VM / SA-X-23 Envelope [km]

AERODYNAMIC TARGET ENGAGEMENT RANGE, km	75	200
TBM ENGAGEMENT RANGE, km	40	40
BM SPEED (MAX), m/s	3000	4500
BM LAUNCH RADIUS, km	1100	2500
ENGAGEMENT ALTITUDE (MAX), km	25	30
MISSILE STOCK	24	36
SPEED OF GUIDED MISSILE (MAX), m/s	1700	2600
SET UP TIME, min	5	5



S-300V / SA-12 Giant/Gladiator ~40 NMI

9S32 Engagement Radar

9S15 Acquisition Radar

9S19 ABM Radar

High Performance SAM/ABM

Tor M2E / SA-15D Gauntlet D

Primary Role:

Interception of HARM and JDAM PGMs in Flight

Interception of Cruise Missiles

Phased Array Engagement Radar

Tor M1 / SA-15C Gauntlet C

Pantsir S2 / SA-22B Greyhound B

2S6M1 Tunguska M / SA-19C Grison C

LR66 / Type 347G / LD-2000 SPAAG

Primary Role: Interception of HARM and JDAM in Flight

Interception of Cruise Missiles

Based on naval CIWS with 30 mm Gatling

Almaz-Antey Laser Directed Energy Weapon

Beam Director on MAZ-7930

Development Project

Modelled on US THEL, but mobile

Demonstrator with CO_2 GDL

SA-2 Guideline Mobility Upgrades

- Fully Mobile Deployment
- PLA developed HQ-2 TEL
- Cuba rehosted Soviet SA-2 on T-55 chassis

SA-3 Goa Mobility Upgrades

Fully Mobile Deployment

ByeloRussian Wheeled TEL

Cuban, Polish T-55 chassis TEL

SA-5 Gammon/SA-20 Hybridisation

Square Pair controlled by modern Tomb Stone / Grave Stone phased array

Improve jam resistance and lethality of SA-5 Gammon

HQ-2/SA-2 Guideline Hybridisation

H-200 phased array engagement radar for KS-1A SAM

Candidate Fan Song replacement in hybrid SA-2 batteries.

End Presentation