Asia's Advanced Precision Guided Munitions

by Dr Carlo Kopp

The arrival of large numbers of potent Sukhoi fighters in the Asia Pacific region has attracted the attention of analysts and media alike.

Less visible but no less important is the recent proliferation across the region of Russian and indigenous precision guided munitions (PGMs). In many respects the Sukhois are both a delivery vehicle and marketing vehicle for Russian cruise missiles, standoff missiles and guided bombs. With Russian and indigenous PGMs now finding their way on to all manner of regional fighters, over the next decade Asia Pacific is likely to end up with a larger aggregate warstock of modern PGMs than that held by the European NATO nations.

What is no less important is that many Russian PGM sales involve technology transfer via licence assembly or mass production, which given historical precedents could see many of these munitions in regional production runs lasting decades. Once established in production, regional manufacturers will follow the well established pattern of tweaking the designs, spawning in turn a wide range of derivative weapons with various design improvements. China's evolution of the Russian P-15/P-21 Styx/Silkworm and 9K32/HN-5 Grail present excellent case studies. Electronic and optical countermeasures to these evolved and evolving weapons will present a problem in their own right.

The emergence over time of large warstocks of modern PGMs in Asia Pacific will fundamentally change the strategic balance across the region as the decisive advantage held by US aligned regional nations with existing PGM warstocks will be narrowed if not eliminated eventually. Major regional players like India and China observed the Desert Storm, Desert Fox, Allied Force, Enduring Freedom and Iraqi Freedom campaigns very carefully and the lesson they carried away is much the same as articulated by Australia's existing doctrine – PGMs are decisive war winners.

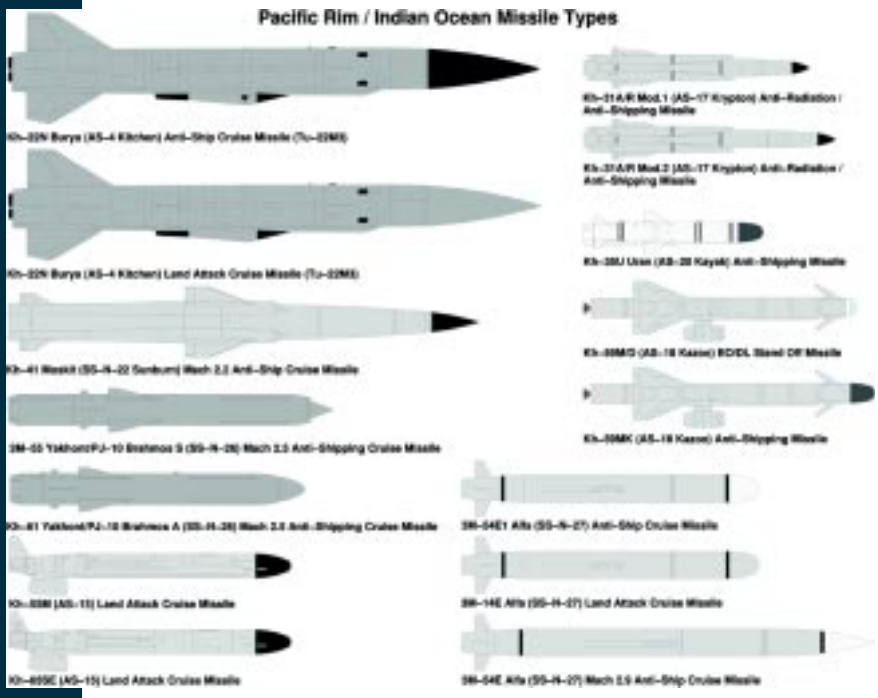
Lesser regional players in turn emulate these major players. Asia today sees military power primarily in terms of modern air and missile power, and budgets permitting, we are seeing a pattern of investment directly copied from that followed by the US – air forces getting what they want ahead of naval surface fleets and armies.

The commodification of modern computing and imaging technologies will see increasing use in Russian and indigenous designs of third generation microprocessor, signal processor and imaging chips. With technology controls now largely nonviable, as Asian nations become subcontract manufacturers for western consumer technology giants, we can expect to see increasing use of chips such as the Pentium and TMS320 in weapon seekers.

Similarly the unrestricted availability of good open source software development tools will see regional PGMs rival the capabilities of US, European and Israeli products over the next decade – nobody has a monopoly on brains in this game.

Basic guidance/navigation technologies like Kalman filters, digital scene matching area correlators (DSMAC) and terrain contour matching (TERCOM) have been mastered by the Russians and more recently China, with India easily having equal engineering talent for this. Russia is now developing state-of-the-art QWIP thermal imaging arrays.

(title photo) The Kh-31R is now actively marketed as a 'counter-ISR' weapon for the Su-27/30 series. This KNAAPO Su-27SKU MLU prototype was photographed with a pair of Kh-31s on stations 9 and 10, fitted with AKU-58 adaptors.



A 1950s, 1960s, 1970s or 1980s technology Russian cruise missile, if retrofitted with a modern guidance package, will match the lethality of an existing BGM-109 Tomahawk, AGM-86C CALCM, Storm Shadow/Apache or AGM-158 JASSM – even if it lacks the flexibility, survivability or standoff range of newer western weapons. Reports of China cloning the US Tomahawk add a dimension all of its own to this issue. A fleet of 1950s designed Bear or Badger bombers armed with inertial/satellite/TERCOM/DSMAC guided cruise missiles yields a similar regional strategic effect to a 1950s designed B-52H carrying ALCMs or JASSMs. Stating that 'our cruise missiles are better than theirs' misses the essential point – you will be just as dead if hit by any of these weapons.

Targeting ISR (Intelligence Surveillance Reconnaissance) capabilities will remain a near term issue for Asia's modernising air forces. But the established trend to emulate US investment patterns is likely to see the deployment over the next two decades of ISR platforms with long range optical and radar imaging capabilities. What the US did during the 1970s and 1980s is being emulated very closely in Asia.

Asia's force structure investment patterns will have a major strategic impact on US aligned Asian nations, the US and Australia, all of whom will be presented with a region which in technology and numbers compares closely to the European NATO nations. An environment rich in long range third generation fighters, often supported by tankers, with land, sea and air launched cruise missiles, standoff missiles and smart bombs is an environment unforgiving to air forces without the ability to rapidly achieve air dominance and maintain it.

This puts a premium on air superiority fighters with good counter-air and cruise missile defence capabilities, plus long range strike fighters, AEW&C and tanker capabilities. Numbers will matter as even a small number of smart bomb equipped Sukhois or cruise missile equipped bombers can cause enormous mayhem if they can bypass defences.

To appreciate the magnitude of this fundamental strategic change it is illustrative to explore the characteristics of weapons now deployed, deploying or being marketed within the region.

NPO Mashinostroyenia 3K-55/3M-55/Kh-61 Yakhont/PJ-10 Brahmos A/S

The shining star in the current export lineup of Russian weapons is the Yakhont, recently licenced by India as the Brahmos A (Air) and Brahmos S (Surface) 'Supersonic Cruise Missile'.

The OKB-52 3K-55/3M-55 Yakhont (SS-N-26) is, like the Moskit, a complete family of supersonic rocket-ramjet missiles. Ship, submarine, air and ground launched variants exist. The missile weighs three tonnes at launch, and uses a liquid propellant for the ramjet which propels it at speeds between Mach 2.0 and 2.5. The Yakhont typically cruises to the target area at high altitude, and then descends for a sea skimming attack from beneath the horizon. The distance at which it begins its descent can be programmed before launch, this determining the achievable range which is between 65 and 160nm (120 and 295km).

Indian sources indicate indigenous DRDO (India's DSTO) designed guidance improvements to the Brahmos over the original design, and the intent to deploy shipboard, mobile coastal defence and air delivered variants. There has also been speculation about a land attack or 'dual role' variant, requiring a more accurate midcourse navigation system. Indian sources also speculate about range extension via additional fuel, currently limited by the Missile Technology Control Regime protocol.

At 2725kg (6000lb) plus launch weight, up to three Yakhont/Brahmos would be carried by Su-27/30 on a centreline adaptor and wing stations.

Raduga 3M-80, 3M-82 and Kh-41 Moskit

The Raduga 3M-80, 3M-82 and Kh-41/ ASM-MSS Moskit (SS-N-22 Sunburn) are all variants of the same 4.5 tonne supersonic rocket-ramjet missile. This weapon is the primary armament of the Chinese navy's new 956E Sovremennyy class destroyers and is credited with a range between 50 and 120nm (95 and 220km). An air launch centreline tunnel adaptor enables Su-27/30 family strike fighters to carry a single round and this configuration has been displayed on the navalised Su-33. Inertial midcourse guidance is supplemented with an Altair active radar seeker – there are no reports to date of land attack derivatives.

Unlike subsonic western anti-ship missiles such as the Harpoon and Exocet, the Moskit is a supersonic sea-skimmer. It can be programmed to fly a high altitude trajectory at Mach 3, or a sea skimming trajectory at Mach 2.2. If the sea skimming mode is chosen, the missile will be first detected by a warship under attack when it emerges over the horizon at a distance of about 15 to 25nm (28 to 45km). This provides the defences on the ship with about 25-60 seconds of warning time before impact.

The raw speed of the Moskit makes it a challenging target for shipboard defences.

Novator 3M-54 Alfa/Club/Kalibr

The Novator 3M-54 Alfa or Club (SS-N-27) comprises a complete family of ship (Club N), submarine (Club S) and air launched weapons. Unlike warship launched Moskit and Yakont variants, the Alfa is designed for launch from a 533mm torpedo tube, or a vertical launch tube.

Five distinct variants of this weapon exist. The basic 3M-54E1 and 3M-14E most closely resemble the US Navy's anti-ship and land attack Tomahawk missile. This weapon has a range of 160nm (295km) and is subsonic. The 3M-54E1 uses an ARGS-54 active radar seeker and Glonass satellite and inertial guidance, the 3M-14E Glonass satellite and inertial guidance alone. The more advanced 3M-54E combines the subsonic cruise airframe of the 3M-54E1/3M-14E with a Mach 2.9 rocket propelled guided payload.

Like its subsonic sibling, it approaches from beneath the radar horizon using the same radar seeker to detect its target. Once locked on, it discards the cruise airframe, fires its rocket motor, and accelerates to Mach 2.9 at a sea skimming altitude of 15 feet. Novator claims the missile follows a zig-zag flightpath to defeat defences. Both the 3M-54E1 and 3M-54E are small weapons which are difficult to detect on radar, especially should even basic radar signature reduction techniques be applied to them. The 91RE1 and 91RE2 are rocket boosted homing torpedoes, most closely resembling the US ASROC and Sea Lance weapons. All five weapons in this family share a common launch system and thus any ship, submarine or aircraft equipped for these weapons can carry an arbitrary mix.

Press reports indicate that India has fielded this weapon, and there are claims China also ordered in a 'tit-for-tat' deal for planned Kilo class subs. The air launched variant has been marketed on the Su-32FN/34 but there are no reports as yet of hard sales.

Raduga Kh-22M Burya

The mighty Kh-22 (AS-4 Kitchen) was the weapon which stimulated the development of the SPY-1 Aegis system. Designed during the 1960s for dual role use as a nuclear armed standoff weapon equivalent to the RAF's Blue Steel, and as an anti-shipping missile with either radar or anti-radiation seekers, the Kh-22 remains in service as the primary armament of the Russian air force's residual fleet of Tu-22M3 Backfires. While the Tu-95K-22 Bear G was equipped to carry up to three Kh-22s, its retirement has now limited use to the Backfire.

The Kh-22 is a formidable weapon by any measure, powered by an Isayev R-201-300 (S5.33) liquid rocket delivering 83kN full thrust and 5.9kN cruise thrust, it is claimed to exceed 4.6 Mach in cruise at 80,000ft AGL. Around three tonnes of fuel and oxidiser are carried. The highly toxic propellant mix presents serious handling problems in fuelling and defuelling the missile, contemporary Isayev engines ran with AK-20K oxidiser (80% nitric acid, 20% dinitrogen tetroxide with fluorine or iodine additives) and TG02 fuel (50% xylidine and 50% triethylamine). Cited range varies between 145nm (270km) and 300nm (550km), subject to variant and launch speed/altitude. Russian sources claim the 900kg shaped charge warhead will blow a five metre diameter hole, penetrating 12 metres deep, when impacting a large warship.

C-601 (above) and (below) C-801K (PLA)

Seven variants have been reported to date, and a mid life upgrade for the APK-22 guidance package has also been recently reported. Nuclear armed variants included a TERCOM system to supplement the inertial unit. If India proceeds with the Backfire lease, the Kh-22 is likely to be supplied as the basic weapon for the aircraft – the missile has produced much excitement in the Indian press. The Backfire carries up to three rounds, although typical payloads are one or two, on BD-45K/F adaptors.

CHETA HY-1/HY-2/HY-4/C-601/C-611 'Silkworm'

When the Raduga bureau designed the P-15/4K-40 Termit (SS-N-2 Styx) anti-ship missile during the late 1950s, little could they have imagined that it would remain in production a half century later. The original Styx was powered by an Isayev P-15 liquid rocket rated at 1.2-0.5 tonnes thrust, using toxic AK-20K/TG-02 propellant, armed with a 515kg (1100lb) shaped charge warhead and fitted with a conscan active radar seeker. The weapon's first kill was the Israeli warship *Eilat* in 1967.

Cloned Chinese Styxes entered production in 1974 as the HY-1/SY-1 or CSS-N-1 Silkworm coastal defence and shipborne ASM. The Chinese soon improved the design, the stretched 3000kg (6600lb) HY-2 (C-201) or CSS-N-2 Seersucker carrying more propellant and achieving a range of up to 73nm (135km). Many derivatives followed, including models with infrared homing seekers, television seekers, monopulse active radar seekers and the turbojet powered HY-4.

The air launched YJ-6/C-601 or CAS-1 Kraken entered production during the mid 1980s, based on the HY-2 variant, and is carried by naval H-6D Badgers. It was superceded in production by the YJ-61/C-611 with improved 110nm (200km) range via higher energy propellant. Iran acquired several hundred HY-2s and used the missile extensively during the 'tanker war'. It is now claimed that Iran is manufacturing its own clones of the HY-2 and HY-4.

While the Silkworm/Seersucker is a subsonic sea skimmer, its sheer size adds significant lethality. While it is often not regarded to be a serious threat to surface warships, it has the killing power to be a very effective blockade weapon against civilian shipping and naval transports. Iraq used the HY-2 as a land attack cruise missile prior to the fall of Saddam, five were launched and most were neither detected nor engaged by Patriot batteries due to their low level cruise profile over flat terrain.

Papers by US analyst Dennis Gormley repeatedly note the ease with which the land mobile turbojet powered HY-4 could be stretched to provide a 380nm (700km) class cruise missile, equipped with GPS/IMU accurate enough to present a genuine risk to coalition ground forces. With thousands of cloned Styx derivatives worldwide, this early Cold War relic may remain a viable weapon in coming decades.

Chinese Strategic Land Attack Cruise Missiles

China has had a long running program aimed at developing land attack cruise missiles suitable for aerial, sub and ship deployment. Many sources claim that the Chinese army now operates the indigenous HN-1 (320nm/600km), HN-2 (800nm+/1500km+) and the HN-3 (1350nm/2500km) cruise missiles.

Air launched Kh-41 Moskit. (Rosoboronexport)

Kh-59M/D. (Rosoboronexport)

Su-30MKK with Kh-31R, Kh-59M and KAB-1500Kr. (KNAAPO)

NPO Mashinostroyenia Kh-61 Yakont (Su-33)

(above) Kh-35U Uran/Kharpunski. (below) The ramjet Kh-31R/MR/A/MA family includes anti-radiation, anti-shipping and anti-AWACS variants.

Reports abound claiming China has actively shopped around South Asia for debris from expended or failed Tomahawk rounds. A report in *The Guardian* (October 20 2001) citing an al-Qaeda source claimed that two failed Tomahawk rounds fired in 1998 were sold by Bin Laden to China for several million dollars. The sole good quality image of a Chinese cruise missile to emerge suggests it is a clone of the BGM-109 Tomahawk – a 1999 report in Hong Kong's *Sing Tao Jih Pao* claimed a 'Tomahawk-like' cruise missile with 1080nm (2000km) range, accuracy of 5m using high technology "map matching", topography matching, inertial guidance, GPS auxiliary correction, other auxiliary guidance'. The missile was claimed to cruise at 15-20m/49-65ft AGL.

More recently reports have emerged claiming China has purchased tooling for the Raduga Kh-65SE, the reduced range export variant of the Kh-55 (AS-15 Kent) which is Russia's answer to the Boeing AGM-86B ALCM carried by the B-52H. Reverse engineering the Kh-65 to make an Kh-55 clone involves mostly fuselage plugs for more fuel.

Given the availability of Russian TERCOM, DSMAC, Glonass, western GPS and computer technology, the only issue for China will lie in good quality turbofan availability to power a genuine AGM-86/BGM-109 class strategic cruise missile. If the reports on the HN-1/2/3 series and Kh-65SE are correct, the only obstacle to the large scale deployment of genuine cruise missiles will be funding.

With submarines, surface warships and second generation H-6H Badgers, there is no shortage of launch platforms. The recently unveiled H-6H variant with four wing pylons carrying what appear to be four Kh-55/65 ALCMs is clearly intended for such a role.

CHETA YJ-8/YJ-81/C-801, YJ-82/C-802 and YJ-83/C-803

China's indigenous response to the Exocet and Harpoon lies in the YJ-8 (CSS-N-4 Sardine) family of missiles, available in ship, sub, land and air launch variants. The basic air launch rocket powered YJ-8K achieves 27nm (50km) range, the improved YJ-81 range 43nm (80km), the turbojet YJ-82 (CSS-N-8 Saccade) range 65nm (120km), and the recently trialed YJ-83 variant around 135nm (250km). These are the primary weapons of many Chinese warships, and the FH-7 maritime fighter carries four rounds.

Zvezda-Strela Kh-31R/A/MR/MA

Dubbed the 'Mini-Moskit', the supersonic Turayev ramjet powered Kh-31R (AS-17 Krypton) was originally designed as an anti-radiation missile to suppress NATO Patriot and IHawk batteries, entering use in 1988 on MiG-25 Foxbats, with an L-111E seeker. Since the end of the Cold War it has evolved with an extended range airframe (Kh-31MR/Type 2 – 100nm+/185km+ range). An anti-ship variant equipped with an active radar seeker, the Kh-31A/MA, was recently introduced, adaptation of this seeker permitting 'counter-ISR' roles as an 'AWACS killer'. At altitude the Kh-31 achieves Mach 4.5, at sea level Mach 2.7. An Su-30MK fitted for the Kh-31 series can carry up to six rounds on wing stations 3, 4, 11, 12 and inlet stations 9 and 10, using AKU-58 adaptors, the Su-27SKU four rounds on 3, 4, 9 and 10.

It has no equivalent in the western inventory, while the US Navy has used it as the MA-31 target drone. The PLA is reported to be using this weapon with recent claims of plans for licence production.

Raduga Kh-59/59M/D Ovod

The 920kg (2000lb) 62nm (115km) range Kh-59M/D (AS-18 Kazoo) standoff weapon is a direct equivalent to the AGM-142 missile now being integrated on the RAAF's F-111C. Evolved from an anti-radiation missile, it shares the common Granit 7TM1 optical seeker and Raduga APK-9 Tekon DL pod with the KAB series, the D model fitted with a thermal imager, and uses an RDK-300 jet sustainer.

The Chinese navy is reported to have ordered an anti-ship variant equipped with a radar seeker, designated the Kh-59MK2, for the Su-30MK2, concurrently with Chinese air force buys of the basic variant for the SU-30MKK.

An Su-27SK or Su-30MK fitted for the Kh-59M/MK2 can carry two rounds on wing stations 3 and 4, using AKU-58 adaptors, the APK-9 is carried on inlet station 9.

Zvezda-Strela 3M-24/Kh-35U Uran

Dubbed the 'Kharpunski', the Kh-35U Uran (AS-20 Kayak/SS-N-25 Switchblade) is the Russian equivalent to the US RGM-84/AGM-84 Harpoon. The missile is available in surface launched and air launched versions (AKU-58 adaptor) and was publicly canvassed as an option for India's Tu-142 Bear upgrade. It is already deployed on the New Delhi class destroyers, and reports indicate China ordered it in 2001. An ARGS-35 active radar seeker is used, and there are claims of a 'SLAM-like' land attack variant, although no images are as yet available.

GNPP KAB-500/KAB-1500 Precision Guided Bombs

Russia's family of KAB-1500 and KAB-500 smart bombs are an equivalent to the US Paveway II/III and GBU-15 family. Sharing common design modules with unique seeker designs, and a range of standard warhead types, this family of weapons

encompasses all of the baseline capabilities in their US equivalents.

The KAB (Korrektiruyeskaya Aviatsionnaya Bomba) family of weapons was developed during the 1970s by Moscow based GNPP, and it is believed that warstocks of the Paveway, Walleye and HOBOS captured in South Vietnam during 1975 played an important role in the design process. The basic configuration of the earlier 500kg weapons is common to the GBU-8 HOBOS TV guided bomb family using tail controls and fixed canards, less the GBU-8's lift enhancing strakes. The 1500kg weapon is closer to a hybrid of the Paveway II and HOBOS configuration, with steerable canards and spring deployed cruciform tail.

Two common seekers are currently available across the product range. The first seeker is the '27N' semi-active laser homing seeker using a ring airfoil and optical path similar to the Paveway II series (KAB-500L, KAB-1500L). It will provide similar characteristics to the baseline Paveway II seeker. The cited four metre Circular Error Probable is however consistent with a proportional control algorithm rather than the bang-bang design in the Paveway II. A laser designator such as the Klyon PM/PS, Kaira 24M, I-25 Shkval, or a targeting pod such as the Sapsan-E would be used, or an Israeli pod with the laser exciter configured with Russian seeker coding.

The second '7TM1' seeker bears a striking resemblance to the GBU-8/15 configuration, with a gimballed TV camera under a hemispherical dome, and is largely common to the Kh-29TE and Kh-59M standoff missiles. The seeker field of regard would be in excess of 45 degrees off boresight, permitting some flexibility in bomb release.

The daylight TV seeker is available with two different guidance packages. The first, designated 'Televizionno-Komandnaya' is a 'man in the loop' command link arrangement similar in concept to the GBU-15 (KAB-1500TK). A Raduga APK-8 or APK-9 datalink pod common to the Kh-59M is used to send steering commands to the bomb, and receive video from the seeker during flight for display in the cockpit. This seeker will achieve similar effect to the GBU-15 and will be extremely accurate.

The second guidance package designated 'Korrelatsionaya' employs a Scene Matching Area Correlator package (KAB-500Kr, KAB-1500Kr), which guides the bomb to a set of coordinates within a preprogrammed image surrounding the target – it is similar technology to the DSMAC in the BGM-109 Tomahawk. European sources claim this guidance package can hit completely hidden targets providing their location is well known relative to visually prominent features surrounding the aimpoint. It is likely the bomb needs to be programmed on the ground, although this is apt to change now with the added computing power in recent Su-30 variants. Multiple rounds can be released in a single pass at multiple aimpoints, not unlike the JDAM.

While European sources speculate on the existence of a thermal imaging variant, this cannot be confirmed as no photographs are available showing the Zinc Sulphide or Fluoride glass nose windows required. As Russia's industry is now experimenting with QWIP Focal Plane Array imaging chips, a day/night thermal imaging variant is a likely future prospect. The design changes would be in a revised gimbal with a cooling assembly and an infrared transmissive window.

To date there have not been any widely publicised reports of GPS/Glonass aided inertially guided or hybrid variants ie JDAM/EGBU-15/EGBU-10/16 or EGBU-15 equivalents. But the voluminous nose section would be well suited to such an evolution.

The 1500kg (3000lb) class KAB-1500 bombs are the heavyweights, with blast, blast fragmentation and subcalibre bunker busting warhead options, the latter claimed to be capable of penetrating up to 20 metres of soil and two metres of reinforced concrete. The 500kg (1000lb) class KAB-500 bombs are GBU-16/32/35 equivalents, with blast, submunition dispensing, blast fragmentation and fuel-air explosive warhead options.

The Su-27/30 is cleared to lift up to six KAB-500s or three KAB-1500s on wing stations 3 and 4, inlet stations 9 and 10, and centreline tandem stations 1 and 2. The KAB-500 is carried on a BD-3U adaptor, the KAB-1500 on a BD4 adaptor.

Conclusions

The region is now seeing the introduction of a diverse range of PGMs, from smart bombs to cruise missiles, many technologically equivalent to in-service US, European and Israeli weapons. These will fundamentally change the strategic environment Australia operates in over the coming decade, as warstocks build up across the wider region.

The Defence Department's seeming pre-occupation with maritime ballistic missile defence and its shift away from top tier airpower are both trends which fly in the face of a clearly observable reality.

There is an urgent need for the Department to fundamentally change its priorities, and shift long and near term investment to provide for robust cruise missile defence, air superiority and long range strike capabilities in the force structure.

KAB-500Kr

KAB-500L

KAB-1500TK/Kr

KAB-1500L

A rare image of a prototype Chinese strategic land attack cruise missile (above), bearing a remarkable resemblance to the Tomahawk. Many reports claim China acquired a pair of failed Tomahawks from al-Qaeda after the 1998 US strike. Recent reports also claim China acquired tooling and engineering data for the Russian Kh-65SE ALCM, depicted (below) the longer ranging Kh-55M variant of this missile. (China Defense Forum, RuMoD)

(below) India has licenced the supersonic ramjet Kh-61 Yakhont as the Brahmos. (NIC)