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Pakistan's Babur-3 Submarine Launched Cruise Missile (SLCM): An Assessment

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Pakistan's Babur-3 Submarine Launched Cruise Missile (SLCM) An Assessment

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Background:

Pakistan carried out the launch of Babur-3 cruise missile from an underwater platform on 09 January 2017. The missile test was claimed to be a success and the Inter Services Public Relations (ISPR) issued the following press release[1]:

No PR-10/2017-ISPR **Press Release** Rawalpindi January 9, 2017

Pakistan conducted its first successful test fire of Submarine Launched Cruise Missile (SLCM) Babur-3 having a range of 450 kilometers, from an undisclosed location in the Indian Ocean. The missile was fired from an underwater, mobile platform and hit its target with precise accuracy. Babur-3 is a sea-based variant of Ground Launched Cruise Missile (GLCM) Babur-2, which was successfully tested earlier in December, last year.

Babur-3 SLCM incorporates state of the art technologies including underwater controlled propulsion and advanced guidance and navigation features, duly augmented by Global Navigation, Terrain and Scene Matching Systems. The missile features terrain hugging and sea skimming flight capabilities to evade hostile radars and air defenses, in addition to certain stealth technologies, in an emerging regional Ballistic Missile Defence (BMD) environment.

Babur-3 SLCM in land-attack mode is capable of delivering various types of payloads and will provide Pakistan with a Credible Second Strike Capability, augmenting deterrence. While the pursuit and now the successful attainment of a second strike capability by Pakistan represents a major scientific milestone, it is manifestation of the strategy of measured response to nuclear strategies and postures being adopted in Pakistan's neighborhood.

The press release is accompanied by an image, which shows a missile in flight above the sea surface. The missile booster is thrusting and the tail fins are also seen. The missile shown in figure-1 is taken from the same ISPR website from which the text is reproduced.

[1] Text reproduced from https://www.ispr.gov.pk/front/main.asp?o=t-press_release&cat=army&date=2017/1/9 accessed on 13 July 2017.

Figure 1: Babur-3 SLCM
(*courtesy: ISPR Press Release*)

From the press release, the following information can be gathered:

	Information from press release		Comment
1	Babur-3	SLCM. Variant of Babur-2 GLCM	
2	Test date	09 Jan 2017	Wide media coverage of the event
3	Range	450 km	
4	Firing location	Undisclosed region in Indian Ocean	The firing region must be in the Arabian Sea. **Nav Area VIII warnings for missile firing could not be found in Pak Navy hydrographer notifications**
5	Platform	Underwater mobile platform	Pakistan Navy Agosta 90B (Khalid Class) submarine should be the underwater mobile platform. It is also possible the missile could have been fired from a submerged pontoon.
6	Technologies	• Underwater controlled propulsion • Global navigation augmented guidance and navigation • Terrain and scene matching • Terrain hugging and sea-skimming features • Stealth technologies	Not essential. If used, could be based on system used with EXOCET missile used by Pak Navy Standard feature Sea-skimming is an added feature Standard feature

Table 1: Babur-3 features

Additional claims in the press release indicate certain features like terrain hugging, sea skimming and stealth have been added to evade radars/air defence systems present in an **emerging ballistic missile defence environment**. It is further claimed that Babur-3 will provide:

- Capability of delivering various types of payload
- A credible second strike capability
- Augmented deterrence
- Measured response to nuclear strategies and postures being adopted in Pakistan's neighbourhood.

The information available in the public domain is rather limited but can still be used to get some insight and draw some useful inferences.

Submarine Launched Cruise Missiles Systems with Pakistan

According to Military Balance 2015, Pakistan has 5 attack submarines (SSK); 2 of them are of the Hashmat class based on French Agosta 70 and employ UGM-84 Harpoon anti-ship missiles; the remaining 3 are Khalid class based on French Agosta 90B with AIP and employ SM-39 Exocet anti-ship missile. Both the submarines are equipped with anti ship torpedo tubes (ASTT) with standard diameter of 533mm. Pakistan has sufficient experience with these missile system operations and it would not be surprising if they have borrowed ideas and engineered them for the indigenous Babur-3 SLCM. There were rumours[2] in 2009 that Pakistan had modified the Harpoon for targeting Indian cities and had carried out tests in April 2009. These were vehemently denied by Pakistan, but the underlying inference is Pakistan understands the missile system and has assimilated the technology adequately to modify them.

We believe the Babur-3 egress from the submarine could be on lines similar to either UGM-84 Harpoon or Exocet SM-39. This inference is drawn from the general scheme employed for submarine launch of cruise missiles from the submarine's torpedo tube. The SM-39 missile is equipped with aerodynamic surfaces for cruise purposes. For housing within the dimensional constraints of the torpedo tube, these surfaces have to be folded. Additionally, the missile is encapsulated in a canister, which fits into the 533 mm diameter submarine torpedo tube as shown in figure-2. The canister has a set of fins at the aft-end and is also equipped with a propulsion system. The canister propulsion system and control surfaces help the encapsulated missile to carry out under water maneuvers to obscure the launch platform location.

[2] Behind the U.S.-Pakistan Missile Spat: The Indian Threat, News item in Time Magazine (Omar Waraich / Islamabad Tuesday, Sept. 01, 2009). See http://content.time.com/time/world/article/0,8599,1919648,00.html accessed on 15 July 2017.

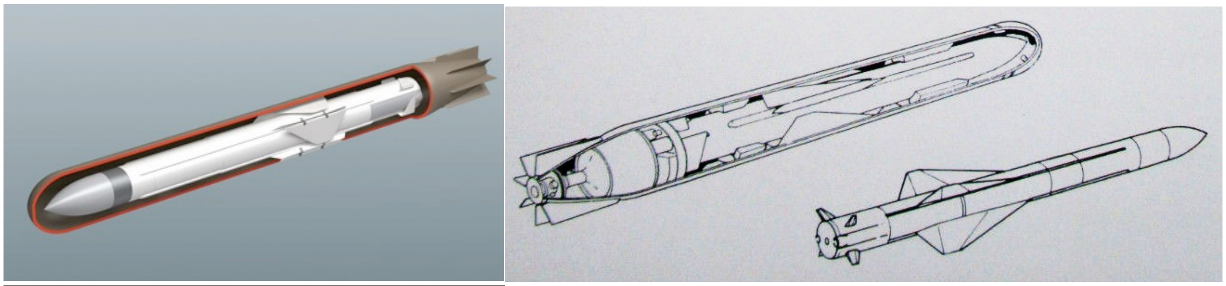


Figure 2: SM-39 SLCM

The right hand image depicts the missile in the stowed position inside the torpedo tube as well as in the aerial flight configuration with the aerodynamic surfaces deployed. The under water launch sequence of Exocet SM-39 is shown in the table below along with published details of Babur-3.

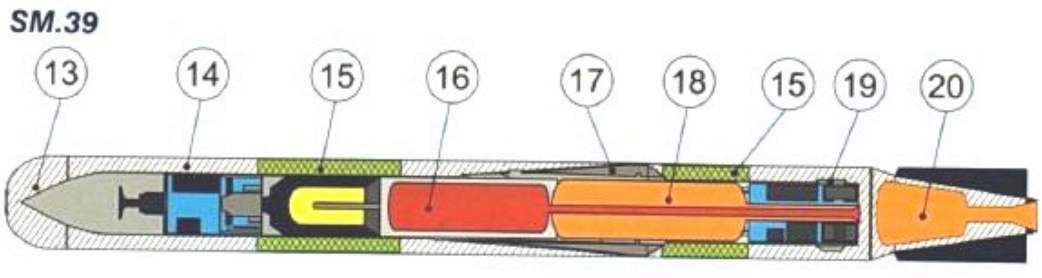
Exocet S-39[3]	Babur-3
The missile is housed in a watertight, highly resistant, propelled and guided underwater vehicle (VSM), which is launched, from the submarine's standard 21-inch (533 mm) torpedo tube. The VSM enables the launch submarine's position to be hidden from the enemy. The aerial missile is ejected as soon as it breaks the surface	The missile was fired from an underwater, mobile platform. Babur-3 SLCM incorporates state of the art technologies including underwater controlled propulsion.

Other features taken from the Exocet missile website are reproduced below:

- Submarine vehicle (VSM): Water-tight, highly resistant, propelled and guided underwater vehicle (VSM)
- Propulsion: Encapsulated missile with two-stage solid propellant motor
- Navigation: Inertial navigation
- Terminal guidance during cruise phase: Active RF homing
- Warhead: Insensitive warhead; optimized HE blast and pre-fragmented effects; impact fuze and proximity function
- Missile characteristics: **Weight: 655 kg; Length: 4.69 m; Diameter: 350 mm**; **Speed: high subsonic; Warhead: 165 kg shaped charge warhead**

[3] Reproduced from http://www.mbda-systems.com/product/exocet-sm-39/ accessed on 16 July 2017

The highlighted portion of the last bullet point provides some clue to the volume available in the torpedo tube for housing a missile. Figure-3 provides inner detailing[4] of the Exocet and this can be used as a guideline for drawing inferences relevant to Babur-3.



[4]

Figure 3: Cut away section of Exocet SM-39

Legend:

13: VSM Cover	*14: VSM Body*	*15: Launcher Shoes*	*16: Lift/cruising engine*
17: Folded Wings	*18: Acceleration Motor*	*19: Folded Fins*	*20: VSM Motor*

The Exocet S-39 SLCM length is given as 4.69 m and the diameter is 350 mm. The length to diameter (L/D) ratio works out to be 13.4. The L/D obtained from measurement from figure-3 tallies with this and hence figure-3 is taken as a scaled drawing of the Exocet S-39 missile. The following information is extracted from figures 2 and 3.

- Encapsulation shell inner diameter 516 mm
- Encapsulation shell outer diameter 533 mm
- Shell thickness 8.25 mm
- Encapsulation shell length 4920 mm
- VSM length 968 mm

Estimation of Babur-3 Dimension

The Babur-3 press release says that the missile is equipped with underwater control propulsion. This is not an essential feature as the underwater propulsion feature is more useful for short-range tactical missiles, where the underwater propulsion helps in obscuring the location of the launch platform. There are other missiles in the world not having underwater propulsion/guidance features where the capsule floats to the surface after ejection from the torpedo tube and the missile is fired on reaching the surface. For example, the Harpoon missile, also in service with the Pakistan Navy floats to the surface where a sensor initiates the separation of the nose and tail sections followed by ignition of the missile booster aiding the exiting of the missile from the canister. Besides there are technological issues associated with underwater propulsion system ignition and sustenance. An added advantage of dispensing with

[4] Details reproduced from http://sistemasdearmas.com.br/asv/exocet1historia.html accessed 16 July 2017.

the underwater propulsion is the space can be used more advantageously for the missile cruise propulsion system. Examination of the video footage also supports this point of view.

Exocet is provided with wings for cruise phase of flight and in the stowed condition it protrudes beyond the 350 mm missile body diameter. In the case of Babur-3, the main wings are deployed in flight and the body is cylindrical. Only the fins provided at the aft-end of the motor have to be made as 'wrap-around'. Allowing space for the thickness (chord) of the fin and the wrap-around hinge, the Babur-3 diameter would be less than the inner diameter of the encapsulation shell, i.e. 516 mm. For our estimation the diameter of Babur-3 can therefore be taken as **510 mm.**

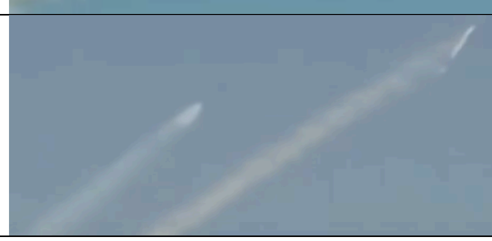
The length of the torpedo tube will need to be taken as a factor for arriving at the length of the missile. It is seen from literature[5] that the Agosta 90 submarine fields the ECAN F17 Mod 2 torpedo, which is 5.62 m long. The Mod 1 version of the torpedo used against surface ships was 5.9 m long and the actual length of the torpedo tube can be expected to be longer by 1m, i.e. 6.9 m. Making allowance for the encapsulation shell housing, release mechanism and clearance between the shell and the missile, the maximum length of the missile is estimated to be 6650 mm. This length should accommodate both the boost and cruise propulsion in addition to the other missile systems.

The propulsion for Exocet is composed of a two-stage solid propellant rocket. The missile is ejected from the VSM module as it breaks the water surface after which the ignition of the acceleration motor (1st stage) followed by the ignition of the cruise motor (2nd stage) takes place. The missile is equipped with inertial navigation system and active RF homing during the cruise phase of flight. The missile carries a warhead of 165 kg mass and has a range of 50 km. The aerial missile mass is 655 kg, while the total mass including the VSM shell and launch module is 1345 kg. The ejection of the nose cap as the missile clears the sea surface can be seen in figure-4 (*Courtesy: http://www.mbda-systems.com/product/exocet-sm-39/)*

Figure 4: Nose cap ejection

5 https://www.forecastinternational.com/archive/disp_old_pdf.cfm?ARC_ID=1731 accessed 29 August 2017

Video footage available with the Babur-3 launch[6] was studied. The ISPR released video is a blend of patched up footage from different cameras and a hotchpotch attempt at misinformation. However, assuming the videography/playback speed to be standard 25 frames per second, some information could be discerned from the video as detailed in table 2 below. Zero time is taken when the emergence of the missile at the sea surface is just seen.

Time	Event	Video Frame	Comment
T+0.2	Missile just clearing the sea surface		Rocket booster ignition
T+1.48	Missile moving upward with full thrust		Booster steady state operation
T+7.08 T+7.32	Disturbance in flame; change in orientation; elongated body;		Separation of the Booster?
T+7.72	Two images seen. The thrusting one on the left appears to be a patch from another video clip		Is the attitude of the body on the right correct for cruise flight? Is this an anomaly?

[6] Video footage screen shot taken at different time intervals from https://www.youtube.com/watch?v=aWauXyuSBHw&feature=youtu.be accessed 12 July 2017

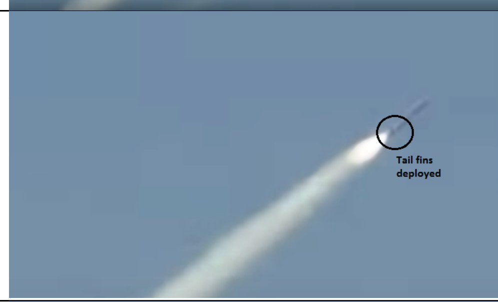
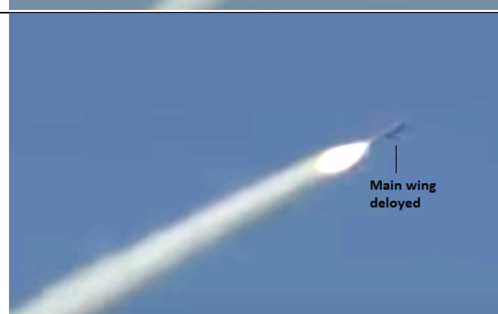
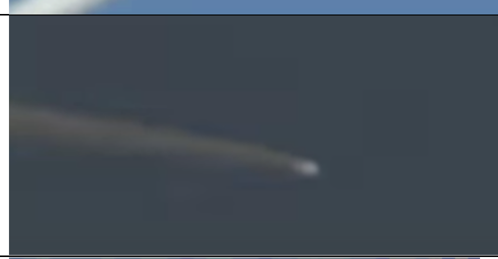
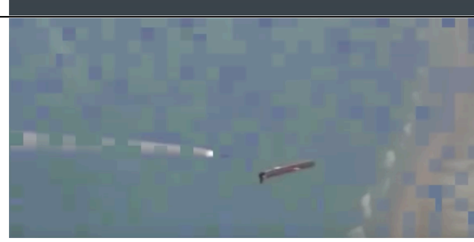
Time	Event	Video Frame	Comment
T+7.36 T+ 0	Two separate bodies seen		The brighter body on the right is the one tracked so far. What is the reference time for the image on left, which is still not thrusting fully
T+7.44 T+7.52 T+0.08-0.16	Full thrust developed		The full thrust missile propulsion system is at full thrust has developed.
T+7.6 T+0.4	Fin unwrapped		
T+9.0 T+2.66	Wings deployed		Rocket motor still operating on full thrust
T+14.64 7.28	Motor burnout		The missile booster burn duration is of the order of 7.24 secs.
No data 7.52	Another image appears		The superposition of Babur-2 flight is clear in this. The cruise phase was not tested? The missile image corresponds to Babur-1

Table 2: Babur-3 sequence of events

Discussion

The submarine launched cruise missiles need to be encased in a steel shell capable of withstanding the external water pressure experienced at the release depth from the submarine. The shell is normally jettisoned immediately after clearing the water surface as its function is over and if carried further into the flight, it unnecessarily degrades the missile performance. In the case of Exocet, the missile nose cone and the body are separated as the missile clears the surface. The encapsulation shell nose cone ejection, so prominently seen in Exocet is not observed from the frame-by-frame examination of the Babur-3 video.

The boost propulsion system operates for time duration of 7.2 seconds. An event is seen at this stage, which could be indicative of booster motor separation. In the subsequent frame two images are seen – one thrusting and the other non-thrusting. The non-thrusting body is almost as long as the adjacent flying body. It would appear video footage of another view of the Babur-3 boost phase flight is patched in here; and the reason for the same is not clear.

Our initial assessment examined if Babur-3 also employs a two-stage solid propulsion system and the event at 7.2 seconds is the separation of the stages as well as the encapsulation shell. This interpretation was ruled out, as it serves no purpose to carry the 500 kg dead mass of the encapsulation shell any distance into the aerial flight of the missile. The following possibilities emerge:

i. The mission ran into problem after the booster separation event. This is supported by the attitude of the cruise missile after separation. One would expect the cruise missile to be in a stable level flight attitude.
ii. The patch on of another video clipping supports the above hypothesis
iii. If the fin and wing deployment could be captured in the frame-by-frame analysis, why the encapsulating shell cap separation is not captured? Was there a problem with this, which led to a subsequent abort?
iv. The second patch video and abrupt patch of Babur-2 clipping shows hardly any reasonable time of cruise flight.

The following additional inferences are drawn:

1. Babur-3 does not employ underwater propulsion as claimed. The underwater propulsion feature is more useful for short-range tactical missiles; and there are other missiles in the world not having underwater propulsion/guidance features where the capsule floats to the surface after ejection from the torpedo tube and the missile is fired on reaching the surface. For example, the Harpoon also in service with the Pakistan Navy floats to the surface where

a sensor initiates the separation of the nose and tail sections followed by ignition of the missile booster aiding the exiting of the missile from the canister. Besides there are technological issues associated with underwater propulsion system ignition and sustenance.

2. The imagery of Exocet and Babur-3 as they emerge out of water is compared. The Exocet, which has an underwater propulsion scheme, shoots out of the water based on the push from the underwater propulsion system. In frame 1 and 2 below, the black portion in front is the missile and duller black portion behind is the exhaust of the underwater propulsion motor. The ignition of the booster occurs 10 frames (400 msec) after the missile emerges from under water and the exhaust impingement and spread on the water surface is seen, as can be seen in frame 3 probably simultaneous with the nose cone ejection. The very next frame shows the separated nose cone and further spread of the exhaust on the sea surface.

Figure 5: Exocet sequence of events

In the case of Babur-3, the booster exhaust jet appears at a shallow angle – almost parallel to the water surface – more indicative of ignition of a body, which has floated to the surface. The missile after ignition, lingers on the surface for a few frames before taking an upward trajectory as shown in figure-6. The ignition appears when the missile is on the water surface.

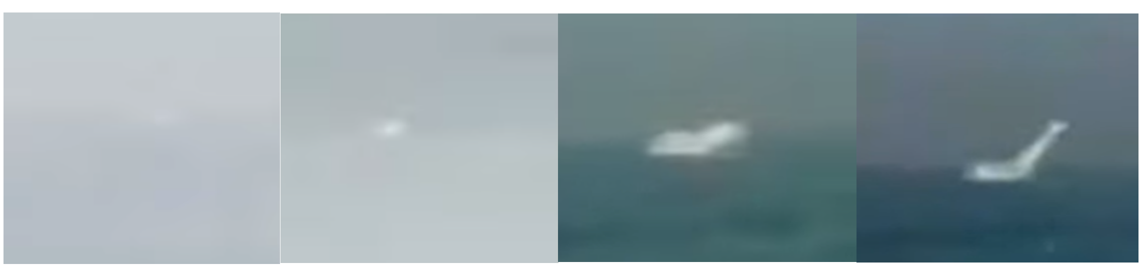


Figure 6: Babur-3 sequence of events

In the first frame, the missile can be just made out as a faint glow; clear glow is seen in the next frame indicating ignition; the third frame is 200-240 msecs later, but the flame is still parallel to the sea surface; The last frame at 600-680 msec shows the missile in an upward trajectory. Frame 2 and 3 are indicative of the missile being ignited after floating to the surface. Use of an under water propulsion would have rendered an image similar to frame 1 and 2 of the Exocet missile.

3. There appears to be some anomalous behavior near the booster separation.
4. At this time imagery from another video footage comes with a rapidly developing exhaust, which lasts for 7.24 seconds. The first image of this patch is seen at 7.36 secs with reference to the original powered phase of flight. In the time column, in addition to 7.36 a new time sequence T=0 is also introduced. Further frame timings are referenced with the initial time as well as with reference to T=0. During this phase, the deployment of fins and the main plane is also seen.
5. Assuming the Babur-3 missile (booster + cruise vehicle) occupy the total 6.9 m length available of the torpedo tube, a rough layout is presented in figure-7. The dimensions are estimated on the basis of a) cutaway sketch of Exocet SM-39 shown in figure-3, b) Tomahawk BGM 109A[7] cutaway section and c) estimate of Babur-1 dimensions carried our in an earlier NIAS report[8].

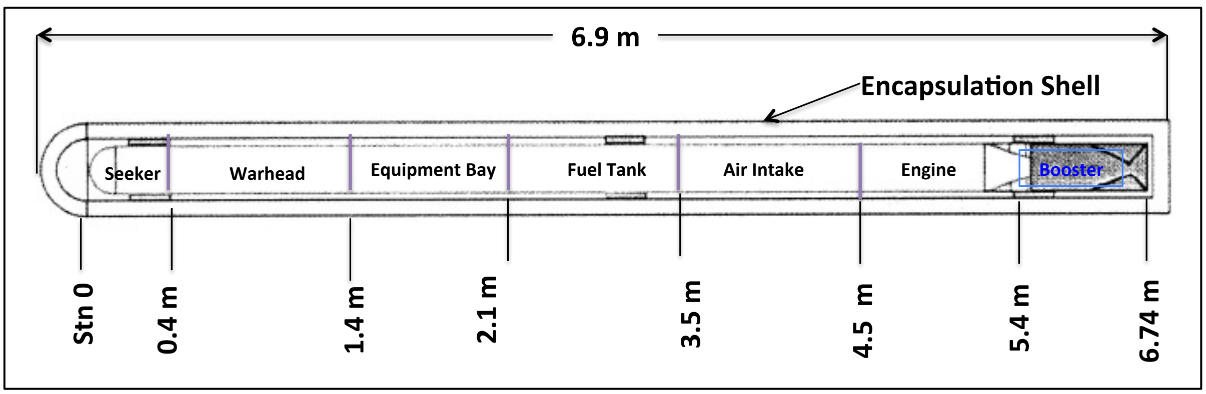


Figure 7: Babur-1 cruise missile estimated dimensions

6. The subsystem mass can be assessed using standard engineering parameters and the performance of the missile can be estimated as per applicable guidelines[9]. The missile subsystems and estimated mass are shown in table 3.

[7] Carlo Kopp, "Tomahawk Variants", Air Power Australia, Mar 01, 2007
[8] Rajaram Nagappa and S Chandrashekar, "An Assessment of Pakistan's Babur HATF 7 Cruise Missile", NIAS Report No. R5-07, National Institute of Advanced Studies, Bengaluru, 2007.
[9] Eugene Fleeman, "Tactical Missile Design", AIAA Education Series, AIAA, 2001

Encapsulation Shell Outer Diameter: *533 mm (= torpedo tube diameter)*
Encapsulation Shell Inner Diameter: *516 mm*
Encapsulation Shell Length: *4920 mm*
Missile Outer Diameter: *510 mm*
Mass estimate:

Subsystem	Length, m	Mass, kg
nose cone + EB	1.1	105
warhead	1.0	400
Airframe		300
Air intake	1.0	50
Cruise fuel	1.4	210
Cruise engine	0.9	100
fin section	0.3	Accounted in airframe mass
Cruise Missile	**5.4**	**1165**
Booster Propellant		310
Motor case	1.34	55
Total Babur-3	**6.74**	**1530**
Encapsulation shell	6.9	720
Total at launch		**2250**

Table 3: Subsystem Length/Mass

7. A list of torpedo tube launched cruise missiles is provided in Appendix II. It is seen that solid propellant propulsion is quite common for powering such missiles, though a few do use a turbojet engine for the cruise part. The warhead mass for Harpoon and Exocet are respectively 227 kg and 165 kg. The range of such missiles is between 40-100 km.
8. With a state of the art turbofan engine and a fuel load of 210 kg, it would be possible for Babur-3 to have a range of 450 km – calculation has not been carried out independently.
9. If however, an underwater propulsion module is used, the length of the cruise part of the missile will have to be shortened appropriately. As component lengths and masses are fixed, the only possible location for reducing the length will come from the fuel tank. With an underwater propulsion system, the tank length may have to be reduced by half with attendant penalty on the range. **In short Babur-3 range will be in the neighbourhood of 250 km if underwater propulsion is part of the design**.
10. No sophisticated stealth features other than radar absorbent paints and a low altitude flight profile can be envisaged for Babur-3.

Second Strike Threat Analysis

At the outset it must be recognized that Pakistan will work towards developing a second strike capability. The poser is does Pakistan possessing a second strike capability lead to the stabilization of among the two countries deterrence parameters? In the preceding lines, we have concluded that Babur-3 can at best take 400 kg warhead to a distance of 450 km. This would appear to be an optimistic estimate in comparison with the capabilities of some of the operational torpedo tube launched cruise missiles. The Harpoon missile on the Hashmat class of subs can carry 227 kg warhead to a range of 124 km; the Exocet SM 39 can carry a warhead of 165 kg to 50 km; and the Type 039A on order with China is equipped with C801 cruise missile, which can carry 165 kg warhead to 40 km.

The other question to ponder over is Pakistan's weapon miniaturization capability. In our earlier analysis of Hatf-IX/NASR[10] we had reported that miniaturized nuclear weapons will need to be plutonium based. We had estimated that each weapon would require 6 kg of plutonium. The important issue we had flagged was that Pakistan has not tested any Plutonium based weapon and the absence of a test is fraught with issues of design/performance confidence, reliability and then deterrence. The situation has not changed.

We had also estimated that the plutonium inventory as of 2013 with Pakistan could be 138 kg equivalent to 23 weapons; and Pakistan could add 5-6 weapons every year to the inventory if their total uranium annual production is used in the Khushab reactors. That means as of 2017 Pakistan may have stockpiled 45-50 plutonium weapons. Our report had assessed that the plutonium requirement for NASR weapon could be 12 kg resulting in even lower level of conversion to weapons. The candidate delivery platforms for the miniaturized weapons are:

1. Babur-2 Land attack cruise missile (LACM)
2. Raad Air launched cruise missile (ALCM)
3. NASR tactical nuclear missile
4. Babur-3 submarine launched cruise missile (SLCM)
5. Ababeel MIRV

If one has limited weapon stocks and limited annual production capacity what will be the basis for division and prioritization. Overall, the equipping of different platforms will be subcritical and the short range of Babur-3 adds to the system inadequacy.

In this scenario, it is pertinent to look for the rationale behind Pakistan's quest for a second strike capability, despite all the limitations. First Pakistan tried to lower the nuclear threshold by

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[10] Rajaram Nagappa, Arun Vishwanathan and Aditi Malhotra, "Hatf-IX/NASR – Pakistan's Tactical Nuclear Weapon: Implications for Indo-Pak Deterrence", NIAS Report No. R17-2013, July 2013

the induction of Nasr as battlefield weapon. This did not make any great impact in India's strategic thinking nor did it lead to any dilution in its response approach. On the other hand, India reinforced its *No First Use* approach using technological means – development of ballistic missile defence systems (BMD), multiple independent targetable reentry vehicles (MIRV) and submarine launched ballistic missiles (SLBM). Pakistan, therefore believes that a sea-based second-strike capability is necessary to negate India's massive retaliation doctrine.

For the time being, a nuclear deterrence parity, which Pakistan is aiming for may not be around. The 450 km range of Babur-3 hardly adds strategic strike depth. The range of Babur-3 along peninsular India is shown in figure-8. For targeting the locations in India, Pakistani subs have to come close to Indian territorial waters, which are intensely patrolled by the Indian Navy and Indian Coast Guard. Advanced warning systems (like AWACS and radar aerostats) and air defence systems will complicate penetration. As such, the ISPR statement "in land attack mode (Babur-3) is capable of delivering various types of payload and will provide Pakistan a credible second strike capability augmenting deterrence" is overstated

Figure 8: Babur-3 reach

Pakistan will need to invest in submarine launched ballistic missile capability, if it believes in achieving full-fledged sea based deterrence. It will need submarines with vertical launch system as well develop/modify ballistic missiles suitable for submarine launch. Pakistan seems to be working towards this from the available media reports. There is report of Pakistan negotiating with China for lease of a HAN class attack submarine. On the other hand NDTV report of 10

January 2017 speculates that Pakistani naval officers were taken aboard the Shang class SSBN, which docked in Karachi and Pakistan may be discussing with China for leasing this class of submarine. Riaz Haq's blogsite as early as February 2012 claimed that Pakistan was working on the indigenous development of a nuclear powered submarine. It would be interesting to follow this development in respect of VLS capability.

Both the Shang and Han class of submarines have only torpedo launched cruise missile – C 801 with range of 40 km and will not substantially increase Pakistani capability in this sphere, though it may help Pakistan to get the required familiarization of operating SSNs. Pakistan will obviously work towards long range sea-based second strike and deterrence capability, that goal appears to be sometime in the distance.

Conclusion

With the launch of Babur-3 on 09 January 2017, Pakistan has demonstrated the ability to launch a cruise missile from the Khalid class submarine torpedo tube. In our assessment, Pakistan has successfully demonstrated the capability of bringing the missile to the surface of the sea and igniting the aerial part of the missile. The subsequent gimmickry with the video patches is of no consequence, as Pakistan through its Babur-2 LACM has adequate experience in this phase of missile flight. Analysis of the Babur-3 submarine launched cruise missile based on limited information available in the public domain has been carried out. Based on experience with Harpoon and Exocet S39 cruise missiles in operation with the Hashmat and Khalid class of submarines in service with the Pakistan Navy it is quite conceivable that for Pakistan to indigenously engineer a submarine based cruise missile. The range of the missile and the uncertainty related to an appropriately miniaturized weapon system does not entirely satisfy a credible second-strike capability and enhanced deterrence. However, it is logical to assume that Pakistan would work towards strengthening its sea-based second-strike capability. Pakistan perhaps now believes that Babur-3 not only provides a second strike capability; the Pakistani perception is this capability nullifies India's massive retaliation doctrine. Thus for Pakistan, Babur-3 effectively undermines two major philosophical pillars of India's nuclear doctrine – "No First Use" and "Massive Retaliation." Babur-3 is thus not only aimed at creating a second strike capability for Pakistan, but also providing doctrinal space for Pakistan to undermine India's deterrence posture.

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Appendix-1

<u>Pakistan Submarine Fleet</u>

Tactical Submarines: 8

SSW (Midget submarines) 3

SSK: 5 (2 Hashmat Class + 3 Khalid Class)*

8 (On order with China)**

Name	Class	Builder	Missiles
Hashmat	Hashmat	Dubigeon Normandie, France	SSM: McD Sub Harpoon; active radar homing to 124 km at 0.9 Mach. Warhead 227 kg
Hurmat			
Khalid (S137)	Khalid	DCN, France	SSM: 4 Aerospatiale Exocet SM 39; inertial cruise; active radar homing to 50 km at 0.9 Mach; Warhead 165 kg
Saad (S138)		Karachi Shipyard	
Hamza (S139)			
Type 039A (export version of Type 041 SSG)	Yuan	Wuhan Shipyard Karachi Shipyard	SSM: C 801A; radar active homing to 40 km at 0.9 Mach; warhead 165 kg

**Details taken from Jane's Fighting Ships 2010-11*

***Pakistan, China finalize 8-Sub Construction Plan, Defense News, October 11, 2015. See: https://www.defensenews.com/naval/2015/10/11/pakistan-china-finalize-8-sub-construction-plan/ accessed 12 August 2017*

Appendix-1I

List of Torpedo Tube Launched Cruise Missiles

Missile	Dimensions, m			Weight Kg	Country	Powerplant	Range Km	Remarks
	Length	Span	Dia					
UGM84A	4.76	0.91	0.33	694	USA	Turbojet	111	Active Radar
Amethist (SSN7)	6.94	2.48	0.54	2890	Russia	SPR+TJ	83	Inertial/Active Radar
SM 39 Exocet	4.66	1.09	0.33	655	France	2 stage SPR	50	Active radar
C-801 (CSS-C4)	6.06	1.21	0.36	822	China	2 stage SPR	40	Active mono pulse radar seeker
RPK-2 Vayuga	6.45	0.53	0.53	1801	Russia	SPR	41	Inertial; nuclear w/h
3M14E (SS-NX-30)	6.15		0.52	1769	Russia	Boost + sustain	300	Inertial

Source: *Aerospace Source Book 2009, Aviation Week and Space Technology*