COUNTER IMPROVISED EXPLOSIVE DEVICES
CENTRE OF EXCELLENCE

CTRA M·618 KM 14. 28240 HOYO DE MANZANARES - MADRID. SPAIN

NAME: Improvised Batteries for Man Portable Air Defense (MANPAD) systems Report

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BRANCH: Defeat the Device

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DISCLAIMER: Information valid until 31.12.2017

IMPROVISED BATTERIES FOR MANPADs

0. Targeting audience

Public release.

1. Executive Summary

After Cold War, the subsequent "small wars", and the last conflicts resulting from the so-called “Arab Spring”, there is an impressive lack of control regarding the military depots from fallen regimes, weapons trafficking through their boundaries or captured military materiel. Accordingly, and reinforced by the suspected & potential transfer from externally-supportive governments, there are huge amounts of Man Portable Air Defense (MANPAD) systems all around the world (but especially inside conflict areas, e.g. Libya, Syria…), although they would be almost un-useful without operating batteries and other essential parts.

Although initially designed for military use in air defense at low altitude, the potential availability of shoulder-fired surface-to-air missile systems under the hands of threat networks is a persistent threat to not only military forces in the battlefield but to fixed & rotary wing aerial vehicles outside areas of operations (e.g. areas surrounding airports at homeland).

Several official and unofficial sources are reporting/showing the intents of designing/using improvised power sources with portable missile systems, in order to substitute the officially-issued batteries needed to fire the referred land-to-air missiles.

2. State of art

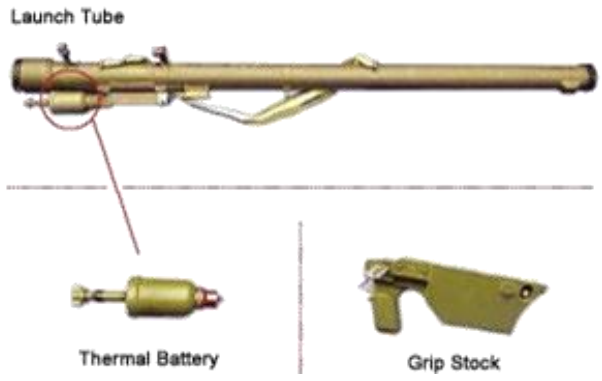
2.1 Understanding the MANPAD system and its functioning

The design of the first Soviet MANPAD was merely following USA *FIM-43 "Redeye"* system's one, and it suffered a lot of engineering problems, especially regarding the miniaturization of infrared seeker device, and gyroscope. In that manner, the 9K32 "Strela-2" system (Russian: Стрела, "arrow"; NATO reporting name SA-7 "Grail") firstly entered service in 1968, five years behind schedule, due to choosing a simpler (and less effective) seeker concept than *Redeye*'s one.

The first combat experiences quickly proved that the system was very far from ideal. Its small impact warhead (1,17 Kg/370 gram TNT charge inside a pre-fragmented case) was designed for chase attack, directly affecting the aircraft engine, as based on the poor infrared seeker design. Even when fired within the strictly limited engagement envelope, the hit probability was low (0.19-0.25). Furthermore, it turned out that a hit did not necessarily mean a kill, but only damage. There were other factors limiting its combat effectiveness; it could only engage a target moving at an altitude of between 50-1,500 meters, at speeds below 220 m/s (790 km/h or 425 knots), and not maneuvering more than 3.5 G.

In September 1968, it was decided to develop an improved model called the 9K32M Strela-2M, which trials were conducted quickly, being accepted into service in 1970, and replacing the 9K32 on production lines. The 9M32M missile had a modernized guidance system that added the capability of engaging targets head-on, but only when moving slower than 150 m/s (540 km/h or 290 knots). Practically, only slow transport aircraft and helicopters could be attacked from the front hemisphere. Moreover, the tail-shot engagement performance was improved so target could be moving up to 260 m/s (940 km/h or 505 knots), the engagement range raised to 4.2 km, and the target-altitude limits expanded to 50-2,300 m. Along with that, the grip-stock was improved, and the triggering/firing system was quicker and easier.

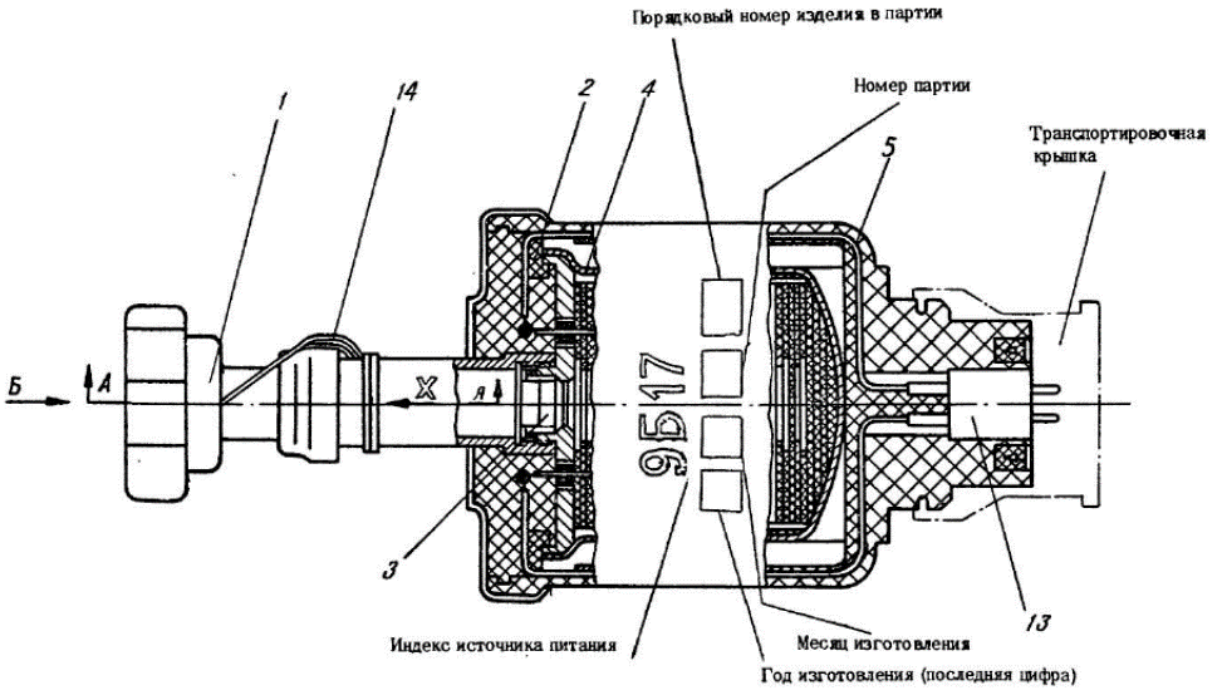
NAME	SYSTEM	MISSILE	LAUNCHING TUBE	GRIP-STOCK	BATTERY
Strela-2 (SA-7)	9K32	9M32	9P54	9P53	9B17
Strela-2M (SA-7B)	9K32M	9M32M	9P54M	9P58	9B17



Essential components required to fire a first-generation MANPAD derived from Strela-2 series.
(Source: http://www.state.gov/t/pm/rls/rpt/walkearth/2008/105805.htm*)*

As first generation systems, both 9K32/9k32M systems count on a thermally activated chemical battery, uncooled PbS (lead sulfide) infrared detector, spin-scan optical modulation, high background noise, increasing tracking error close near target, vulnerability to flares, and single-shot kill probabilities between 0.19 and 0.53. Several copies from them were developed by China (HN-5A), Pakistan (Anza Mk I), Former Yugoslavia (Strela 2M/A, 2M2J Sava), Romania (CA-94, CA-94M), Egypt (Ayn al Saqr), and North Korea (Hwasung-Chong).

The thermal battery consists of an electrolyte and two electrodes. Unlike a conventional battery, however, the electrolyte (molten salts) is in solid state at room temperature and the battery is inert until the electrolyte is melted by a pyrotechnic device situated between the electrodes. Upon activation, the battery generates heat as a byproduct of the chemical reaction, leading to temperatures of more than 200°C at the surface of the battery unit. The battery should supply then power enough for gyroscope spin-up, the activation of the on-board thermal battery or generator, eject motor ignition, as well as some less energy extensive pre-launch processes. Due to its characteristics, the battery can be stored in their solid state at room-temperature for long periods (when protected from moisture and oxygen, they can stay operational for 25 years and even longer, although systems´ life used to be officially limited to 10- 20 years).

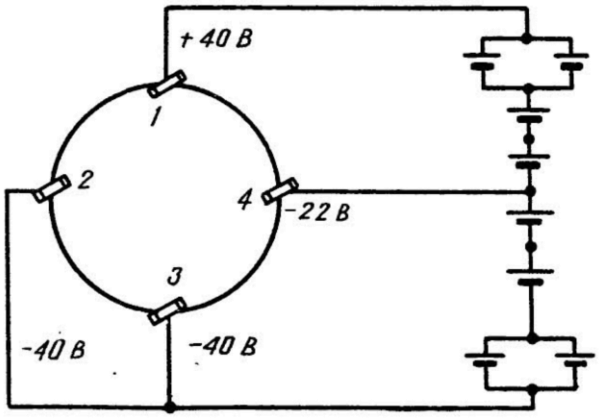


Technical cut scheme of the 9B17 battery from Strela-2/2M (SA-7/7B) MANPAD system

In the specific case of those referred first generation MANPADs, the battery is not including a cooling substance for the seeker, like next generations are, in which “battery” is called Battery Coolant Unit (BCU).

With regards the Strela-2, the process for a good performance in shooting the missile comprises: 1) spot the target & put launcher over shoulder; 2) turn the gunner percussion cap mechanism of the arrow printed on the battery end so the firing pin prick primer and the pyrotechnic mixture goes (battery takes 5 seconds to start powering); 3) the gunner waits for electricity supply and gyros to stabilize, puts the sights on target and tracks it smoothly with the launch tube's iron sights; 4) once full power is ready, a sound from the grip-stock and a light signal in the sights informed the operator; 5) push trigger to half-position, which activates the seeker electronics and the missile attempts to lock onto the target; 6) when the missile was ready for launch, the target is producing a strong enough signal and the angular tracking rate is within acceptable launch parameters, another sound and light signal aware of it; 7) if the target be outside acceptable parameters, then the light cue in the sight and the buzzer signal tell the gunner to re-aim the missile; 8) if everything is OK, the trigger is fully pushed, so the operator then has 0.8 seconds to provide lead to the target while the missile's on-board power supply is activated and the throw-out motor ignited; 9) the missile took off from the launcher

Each battery only has enough of a charge for 30-40 seconds, which sometimes could not be enough to complete a single engagement sequence, if there is any problem or just the operator is not well-trained.



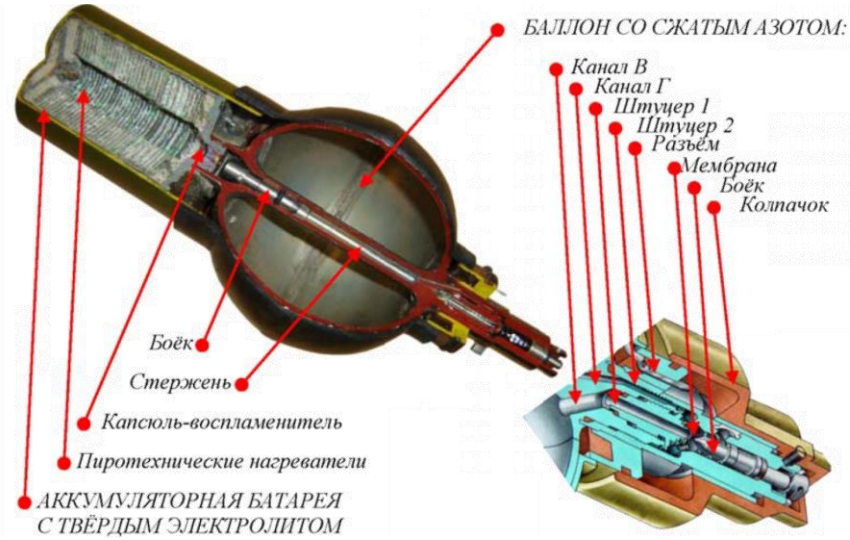
Electronics scheme of the 9B17 battery from Strela-2/2M (SA-7/7B) MANPAD system

The manufacturer lists reaction time measured from the carrying position (missile carried on a soldier's back with protective covers) to missile launch to be 13 seconds, a figure that is achievable but requires considerable training and skill in missile handling. With the launcher on the shoulder, covers removed and sights extended, reaction time from fire command to launch reduces to 6–10 seconds, depending greatly on the target difficulty and the shooter's skill.

In the case of Strela-2M (SA-7B), the grip-stock was slightly improved; accordingly, the new more automated grips-tock provided a simplified firing method against fast targets: a single trigger pull followed by lead and super-elevation replacing the separate stages of releasing the seeker to track, and launching the missile. The only problem was that the new version of grip-stock was not compatible with Strela-2, the previous model.

2.2 Cases studies regarding design and/or use of improvised batteries for MANPAD systems

Initially, only first generation missiles could be potentially able to get used with improvised batteries, due to next generations of MANPADs unavoidably need of cooling methods (mostly liquefied gases) for the seeker functioning along with the battery, which is not impossible for homemade techniques but almost (at least in a portable version).



Cut scheme of the 9B238 Battery and Coolant Unit (BCU) for 9K38 "Igla" (SA-24) MANPAD .
(Source: ТЕХНИЧЕСКАЯ ПОДГОТОВКА КОМАНДИРА ВЗВОДА ПЗРК 9К38 «ИГЛА», Akylov/Baydakov/Vasiliev, 2011)

There are several intents of designing and producing alternate power sources for SA-7 series/copies missile systems during last years, as shown;

1- **(November 2012, LEBANON)** Hamas al-Qassam Brigades (https://youtu.be/B9nfqViBofk)

BATTERY	LAUNCHED	TARGET	IMPACT	REMARKS
Car batteries (no fully visible, so estimated) wire-connected to MANPAD battery case	YES	UNKNOWN	NO	Malfunction of rocket engine makes propellant charge to deflagrate on air after booster functioning

2- **(April 2013, SYRIA)** Syrian Islamic Liberation Front (https://youtu.be/Uic9bfUMgxg)

BATTERY	LAUNCHED	TARGET	IMPACT	REMARKS
Military type batteries (6) in series connected to MANPAD battery case	NO	-	-	Showing the design, and explaining operating process. No evidence of practical functioning.

3- **(May 2013, SYRIA)** Free Syrian Army FSA – MANPAD powered with an external battery (motorcycle one?) - **successful shooting against a helicopter** (https://youtu.be/aXGuUXbS3eo)

BATTERY	LAUNCHED	TARGET	IMPACT	REMARKS
Motorcycle battery (no fully visible, estimated) connected to MANPAD battery case	YES	HELICOPTER	YES	The shooter's mate is transporting the power source in a holster.

4- (September 2013, SYRIA) "Al-Maghawir" (The Commandos) – (https://youtu.be/lK15ggIWTYw)

BATTERY	LAUNCHED	TARGET	IMPACT	REMARKS
Car battery (no fully visible, estimated) connected to MANPAD battery case	YES	HELICOPTER	NOT PROBABLY	The group celebrates the success, although it seems self-destruction after 20 seconds (it takes about 14-16 seconds)

5- (October 2013, SYRIA) "Al-Maghawir" (The Commandos) – (https://youtu.be/V-7Z3No7GzA)

BATTERY	LAUNCHED	TARGET	IMPACT	REMARKS
Car battery (no fully visible, estimated) connected to MANPAD battery case	YES	NOT CLEAR, LOOKS LIKE AIRPLANE	MAYBE YES	The group celebrates the success very quickly, but no images about effective targeting are evidenced

6- (April 2014, SYRIA) Jaysh al-Thuwar, 99th Infantry Brigade – (https://youtu.be/bQPzhmG4pl4)

BATTERY	LAUNCHED	TARGET	IMPACT	REMARKS
Motorcycle battery (no fully visible, estimated) inside a leg holster and connected to MANPAD battery case	NO	-	-	No show of practical functioning

7- (April 2014, SYRIA) Jaysh al-Thuwar, 99th Infantry Brigade – (https://youtu.be/4yDYRaHEizQ)

BATTERY	LAUNCHED	TARGET	IMPACT	REMARKS
Motorcycle battery (no fully visible, estimated) inside a leg holster and connected to MANPAD battery case	NO	-	-	No show of practical functioning

8- (June 2014, SYRIA) Ahrar al-Sham – (https://www.youtube.com/watch?v=sA8nmUd2iFA)

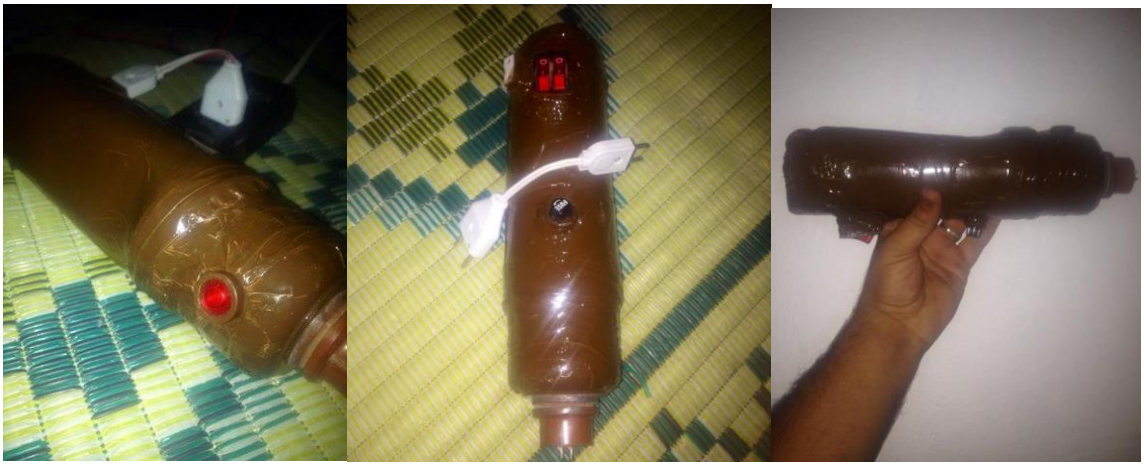
Picture showing Ahrar al-Sham's improvised battery design in Syria
(Source: http://armamentresearch.com/wp-content/uploads/2014/07/MANPADS_improvised.jpg)

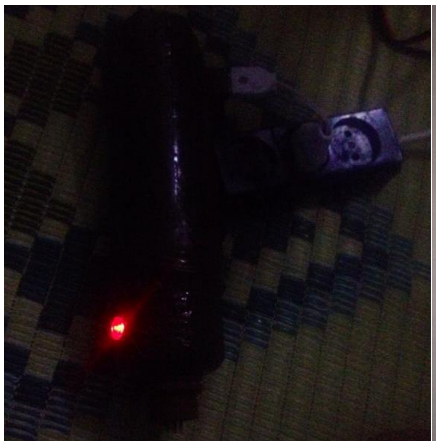
BATTERY	LAUNCHED	TARGET	IMPACT	REMARKS
Portable (and rechargeable?) battery (no fully visible, estimated) inside a leg holster and connected to MANPAD battery case	YES	UNKNOWN	NO	Failure maybe due to bad engagement (the "ready-to-shot" sound not clearly listened), or just quick drop of power

9- **(July 2014, SYRIA)** Free Syrian Army FSA – (http://nyti.ms/2hPmnW5)

BATTERY	LAUNCHED	TARGET	IMPACT	REMARKS
Portable and rechargeable battery (it contains 3 laptop batteries, capacitor & other electronic components)	-	-	-	No show of practical use, although the designer indicated a frustrated use of it. Designer is called as "Abu al-Baraa".

10- **(July 2014, SYRIA)** Free Syrian Army FSA - Facebook images showing a self-contained rechargeable battery pack. (http://armamentresearch.com/improvised-manpads-batteries-employed-in-syria/)






BATTERY	LAUNCHED	TARGET	IMPACT	REMARKS
Portable and rechargeable battery (made with batteries for cameras?)	-	-	-	No show of practical use. Designer is "Abu al-Baraa". 370 grams & about 30 minutes of working window reported.

11- (June 2015, SYRIA) Jaysh al-Yarmouk – (https://youtu.be/AHbO_09AKmI)

BATTERY	LAUNCHED	TARGET	IMPACT	REMARKS
Car battery (no fully visible, estimated) connected to MANPAD battery case	YES	NOT CLEAR, LOOKS LIKE AIRPLANE	NO	Bad engagement of target, maybe too far away or too fast one

12- (July 2015, SYRIA) Jaysh al-Yarmouk – (https://youtu.be/_enYMQh2y1Q)

BATTERY	LAUNCHED	TARGET	IMPACT	REMARKS
Car battery (no fully visible, estimated) connected to MANPAD battery case	YES	HELICOPTER	YES	It looks like a possitive destruction of the target, although the image is not clear.

13- (January 2016, SYRIA) Da'esh training school - (https://youtu.be/A9tlDIhpMHo?t=298)

BATTERY	LAUNCHED	TARGET	IMPACT	REMARKS
Estimated as designs & prototypes of "thermal batteries"	-	-	-	It is not fully clear if they could be functional homemade batteries, or just parts recovered from a missile

14- (October 2016, SYRIA) Free Syrian Army FSA 46th Infantry Division – (https://now.mmedia.me/lb/en/NewsReports/567418-daraa-rebels-deny-receiving-anti-aircraft-weapons)

BATTERY	LAUNCHED	TARGET	IMPACT	REMARKS
Car batteries (no fully visible, estimated) connected to MANPAD battery case	YES	HELICOPTER	NO	Reported failure as a consequence of target using countermeasures against infrared guided missiles. Picture is not already confirmed as real & thrutful.

2.3 Limitations to the use of improvised batteries for first generation MANPAD systems

Merely a minority of the reported attempts were successful against slow aerial platforms like helicopters, all of them using power apparently from external batteries for vehicles.

If there were any other successful targeting with a MANPAD, it would always be widely exposed to public knowledge in benefit of visibility and influence efforts.

In order to shoot a 1st generation MANPAD system, the potential limitations /problems to face are;

- Need of appropriate grip-stock too (different versions of missiles with specific required tools);
- Not very high effectiveness, even against helicopters or transport airplanes;
- Limitations in directional attack, altitude, speed of target, vulnerability to countermeasures;
- Lack of adequate training (no good instructors, no previous shooting, no tactical training…);
- Evaluation of ageing missiles functionality requires technical skills and knowledge;
- Bad storage conditions & no maintenance affecting all components of the systems;
- Sometimes, the energy would be only enough for propellant charge but not to power seeker;
- The use of car batteries transform the MANPAD system into not effectively man-portable;
- Although possible, the design & manufacture of homemade thermal batteries is a hard task;
- In most of cases, the manufacturer has no accurate knowledge about battery requirements;

After analyzing the information collected from the Internet and once the videos are carefully watched, the real targeting success seems not to always be as evidenced as declared.

Even the supposed “thermal battery design from Da’esh” could be a miss-understanding of some kind of manipulation over a thermal battery recovered from the body of another missile (info is partially given).

3 Conclusions

C-IED COE Assessment: the threat regarding the use of 1st generation MANPADs with improvised batteries against commercial airplanes & helicopters is someway realistic; although it is not easy at all to achieve a good design & manufacture of the power source, but mainly to obtain good results with improvised batteries powering old missile systems with inadequate storage and maintenance. Some potentially functional ways of using external Commercial-on-the-shell (COTS) batteries to power 1st generation MANPAD systems have been identified by DtD Branch, but that information is recommended to be discussed through classified networks.

4 Recommendations

1. **Conduct a technical study about potentially available, reliable and effective designs or modifications able to make a 1st generation MANPAD system to work.**

5 Publications and references

- “Thermally activated (“thermal”) battery technology” series of articles written by R. A. Guidotti and P. Masset, and published in “Journal of Power Sources” Vol. 161-164-177-178-183, from June 2006 to April 2008.

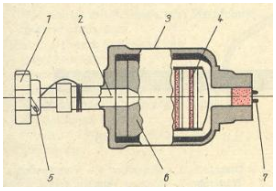
- Переносный зенитный ракетный комплекс "Стрела-2М" (9К32М) / Техническое описание и инструкция по эксплуатации (9К32М ТО), 1972

- ТЕХНИЧЕСКАЯ ПОДГОТОВКА КОМАНДИРА ВЗВОДА ПЗРК 9К38 «ИГЛА», Akylov/Baydakov/Vasiliev, 2011

- Наставление войскам ПВО - ПЗРК Стрела-2, 1969

- http://armamentresearch.com/improvised-manpads-batteries-employed-in-syria/

- https://www.nytimes.com/2014/07/26/world/middleeast/a-syrian-rebel-advance-off-the-battlefield-a-longer-lasting-rechargeable-battery-for-the-sa-7b-a-shoulder-fired-missile-system.html?_r=0



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- https://fas.org/wp-content/uploads/2013/10/The_MANPADS_Threat.pdf

- https://fas.org/programs/ssp/asmp/issueareas/manpads/black_market_prices.pdf