

If a Nobel Price was Awarded  
for Best Weapon in 2022 the  
Shahed 136 would get it



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# The Weapon that could Determine the War

- ✓ **The weapon in mind** is not the US made M142 HIMARS rocket launcher but the Iranian made Shahed 136 long-range suicide drone
- ✓ **The drone is made by the Iranian company HESA** and officially entered service in the Iranian army in December 2021
- ✓ **Its main advantages are its low price and simplicity**
- ✓ **It can be mass produced by any industrialized country** using simple components that are easy to acquire even if country is heavily sanctioned
- ✓ 1) This presentation will take a closer look at **the weapon and its capabilities**
- ✓ 2) Secondly it will discuss **manufacturing costs and design features**
- ✓ 3) Thirdly it will discuss **what can be done to defend effectively against this drone weapon**
- ✓ 4) Finally some **humble advise to Ukraine/NATO** about how do deal with this forthcoming new capability of Russia to bombard Ukraine



# Drone Weapon: HESA Shahed 136



- **Source:** <https://mezha.media/en/2022/10/05/shahed-136-a-nasty-enemy-uav-that-terrorizes-ukrainians/>



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# Shahed 136 – Weapon Specks

- ✓ **Drone is made by Iranian company HESA** and officially entered service in the Iranian army in December 2021
- ✓ **Weight is 200 kg with a 40 to 50 kg warhead** (HIMARS warhead is 120 kg and rocket is 300 kg)
- ✓ **Size** is 3.5 meters long and wingspan is 2.5 meters wide (HIMARS rocket is 227 mm and it is 3.96 m long)
- ✓ **Cruising speed is 185 km/h** (HIMARS speed publicly unknown but likely over 1000 km/h)
- ✓ **Range is min 1000 km** possibly 2500 km but likely with much smaller warhead (HIMARS range is 70 km for the version Ukraine got)
- ✓ **Flight height is 60 to 4,000 meters**
- ✓ **Unit costs:** Unknown but various sources say 10k to 60k USD
- ✓ **Current Iranian monthly production capacity: 150 units**



# Sources for previous slides

- **HESA Shahed 136 and unit cost of 10,000 to 60,000 USD:** [https://en.wikipedia.org/wiki/HESA\\_Shahed\\_136](https://en.wikipedia.org/wiki/HESA_Shahed_136)
- **HIMARS:** [https://en.wikipedia.org/wiki/M142\\_HIMARS](https://en.wikipedia.org/wiki/M142_HIMARS)
- **HIMARS warhead weight 120 kg and other specs:** [http://www.military-today.com/artillery/m270\\_mlrs.htm](http://www.military-today.com/artillery/m270_mlrs.htm)
- **Spec sheet for Shahed 136 and lots of other info:** <https://mezha.media/en/2022/10/05/shahed-136-a-nasty-enemy-uav-that-terrorizes-ukrainians/>
- **More info on Shahed drone:** <https://www.timesofisrael.com/the-iranian-made-killer-drones-vying-for-supremacy-in-ukrainian-skies/>
- **Monthly production capacity in Iran for Shahed-136 is 150 units per month:**  
<https://www.technology.org/2022/11/05/reserves-of-shahed-136-drones-ending-in-russia-whats-next/>
- **Cost of anti tank mine 40 USD** (I know the source do not look great but only one I could find):  
<http://peacemagazine.org/archive/v12n4p08.htm#:~:text=Cheap%2C%20But%20Pricey%20To%20Remove,or%20disable%20an%20armored%20vehicle.>



# Manufacturing costs and design - Propulsion

- ✓ **Propulsion is low tech propeller design** using an old combustion engine 50hp Limbach L550E developed by VW and used in VW Beetles from 1936 to 2006
- ✓ **The engine is now made in China as the MD550 engine** and anyone could order it online until recently at Chinese web shops (it is probably a 400 USD engine)
- ✓ **Ukraine, Russia and Iran should easily be able to copy** and make that engine themselves
- ✓ **Warhead is also simple** to make and not costly (anti-tank mine with 10 kg of high explosives cost 40 USD a piece so probably 200 USD for warhead say 500 USD to be on the safe side)
- ✓ **It looks like Shahed frame and body use a lot of composite materials that are low tech** but not suited for mass production by the 10s or 100s of thousands per year



# Drone Weapon: HESA Shahed 136



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# Manufacturing costs and design - Frame/body

- ✓ **A design using stamped metal sheets and metal frame** is needed for mass production of drone by the 10s or 100s of thousands per year
- ✓ **With metal frame and body** those parts could be made for an additional 5000 USD including assembling cost (at 10,000 monthly rate they can be made much like autos with stamping machines and assembling robots)
- ✓ **I have no source for that cost** but you can make a cheap vehicle body that is 5 times more heavy and structurally more complex for same price
- ✓ **Using hand build composites** (like Iran seams to do at a rate of 150 per month) it is more likely the drone's body and frame will cost approximately 50,000 USD and this is also a slow manufacturing process
- ✓ **Metal drone would weight more** so range will take a toll (but if 1000 km is possible with composite frame you could probably make 600 km possible with a cheap metal frame and body. Iran's need for range is high)
- ✓ **Also with metal the radar signature** will be huge but that does not matter if you have 10s of thousands if not 100s of thousands to spend





# Manufacturing costs and design - Take off

- ✓ **A brilliant design feature** is that the Shahed takes off using an expendable rocket (my guess is it use a cheap solid-propellant rocket (say 300 USD) similar to a new years rocket just far more powerful)
- ✓ **That saves cost** because no complicated landing/takeoff gear needed
- ✓ **It also saves weight** and thereby increase range not to have landing/takeoff gear
- ✓ **More weight is saved** (i.e. better range) because drone gain altitude and obtain max speed using that takeoff rocket (gaining altitude and speed use lots of fuel)
- ✓ **If it was me I would also build a catapult launcher** for this drone similar to what is used by a navy air-craft carrier but powered by an electric motor winding-up a pull cable. That would save the cost of the launch rocket
- ✓ **I would also make such a catapult system portable** to be packed in a standard shipping container to be set up anywhere
- ✓ **Also I would decrease wingspan of the Shahed to 2.38 meter** so they could fit the 2.43 meter width of a standard shipping container (12 would fit a 40ft)



# Drone Weapon: HESA Shahed 136

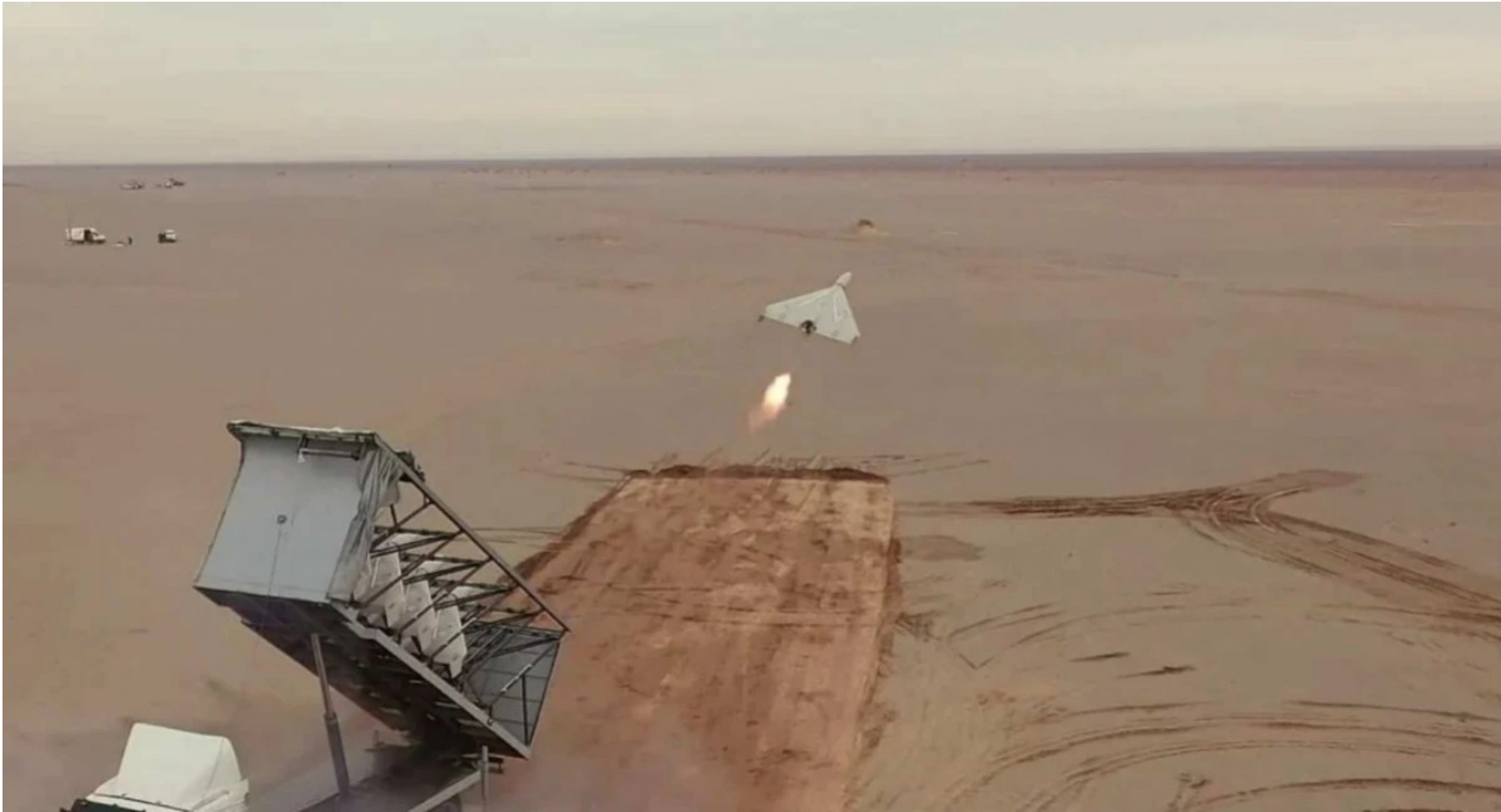


- **Source:** <https://mezha.media/en/2022/10/05/shahed-136-a-nasty-enemy-uav-that-terrorizes-ukrainians/>



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- **Source:** <https://mezha.media/en/2022/10/05/shahed-136-a-nasty-enemy-uav-that-terrorizes-ukrainians/>



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# Drone Weapon: HESA Shahed 136



- **Source:** <https://eurasianimes.com/russia-has-exhausted-its-favorite-weapon-to-strike-ukraine/>



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# Manufacturing costs and design - Aerodynamics

- ✓ **Another brilliant design feature of the Shahed** is its use of a cropped delta wing design (IMO the cropped design with perpendicular flap solve problem with flow separation at high angles of attack at low speed)
- ✓ **Delta wing design is know to be more efficient than a traditional airplane design** having a big fuselage with wings in the middle and flight control wings at the back
- ✓ **Traditional design is only used** because 1) the big fuselage is needed to accommodate passengers and cargo and 2) it is more weather robust
- ✓ **Delta wing design is best choice for making a long-range, affordable suicide drone** because it 1) obviously has no need for a large fuselage and 2) robustness/safety of flight is not a big issue either



# Manufacturing costs and design - Controls



From picture below it is easy to see the drone use 4 actuators to move 4 control flaps at back of delta wing. Such actuators may cost 30 USD each

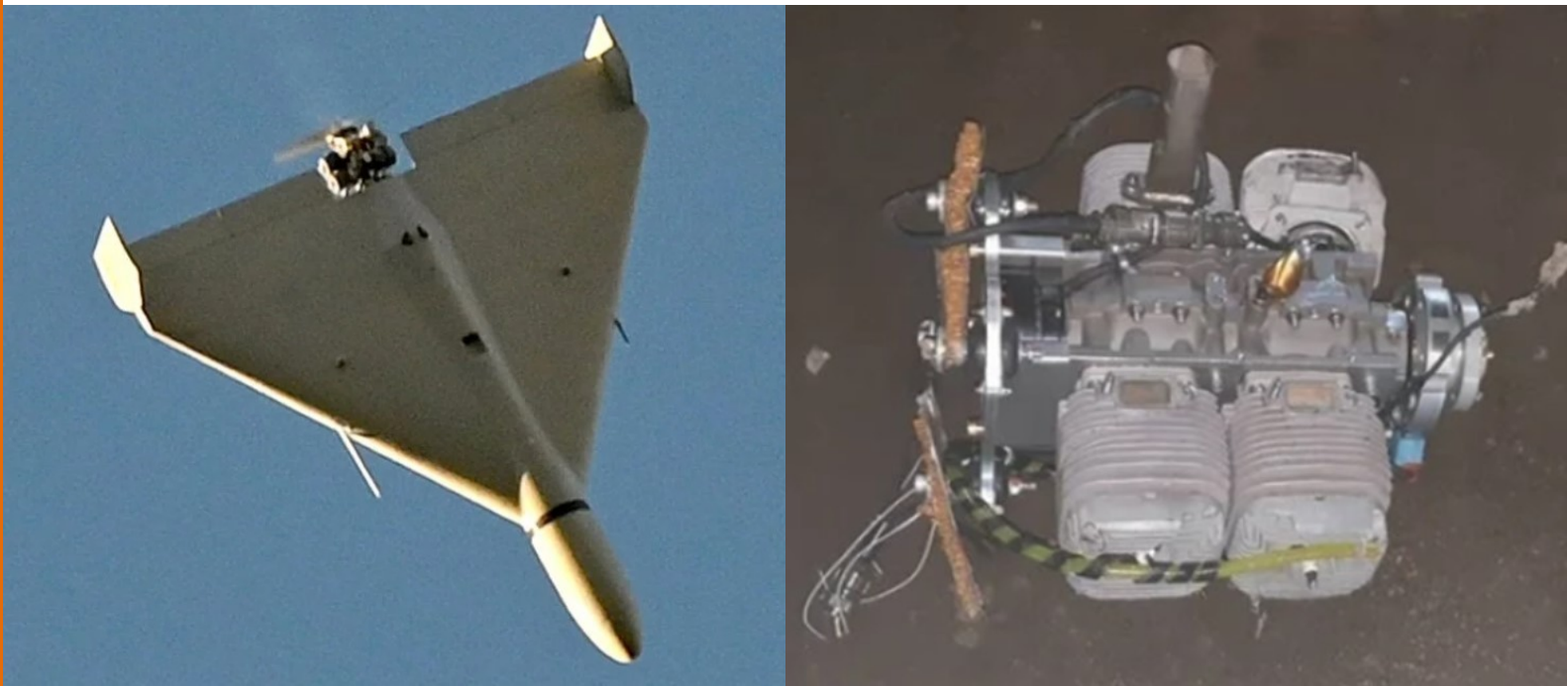


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# Manufacturing costs and design - Controls



**From pictures below** I also think that engine is mounted on a gimbal for additional control of aircraft. Gimbal plus actuators for gimbal may cost another 200 USD



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# Manufacturing costs and design - Navigation

- ✓ **A 3<sup>rd</sup> great design feature of the Shahed** is its dead simple navigation that is based on a combination of publicly available satellite navigation signals and inertial navigation
- ✓ Currently there are 4 global satellite navigation systems available from US (GPS), EU (Galileo), Russia (GLONASS) and China (BeiDou)
- ✓ If the satellite signal is jammed the drone can still find its target using **inertial navigation that uses motion sensors (accelerometers), rotation sensors (gyroscopes) and a computer to calculate** its new positions given its last known satellite position and subsequent movement of drone
- ✓ **To improve precision the inertial sensors** are often supplemented by a barometric altimeter and/or speed measuring devices
- ✓ **It is currently publicly unknown how accurate the Iranian Shahed is** but will not be far off to say it can hit target at +- 4 meters if it has a satellite signal and it may go to +-40 meters if it does not have a satellite signal and has not lost its satellite signal within say 30 kilometers from target
- ✓ **Needed computer, GPS chip and motion sensors** are all available in any Smartphone and could be acquired separately for less than 50 USD





# Manufacturing costs and design - Conclusion

- ✓ **Previous slides** estimated the costs of making the Shahed
- ✓ **Summed up the hand build composite version** that Iran build cost approximately 52,670 USD per unit (150 units/month)
- ✓ **The mass produced metal version** that any industrialized country could build will cost only 7,670 USD per unit (10,000 units per months)
- ✓ **Note making 120,000 Shaheds annually** cost less than 1 billion USD
- ✓ A spreadsheet with these calculations is available for download at [www.hmexperience.dk](http://www.hmexperience.dk)
- ✓ **Russia has gotten the blueprints** (nov 2022) for the Shahed drone and are now setting up their own production
- ✓ **It is unknown how big a production capacity Russia** is aiming to set up but 10,000 units per month is definitely doable within a rather short time say 14 months to full production



# Sources for previous slides

- **Solid propellant rocket:** [https://en.wikipedia.org/wiki/Solid-propellant\\_rocket](https://en.wikipedia.org/wiki/Solid-propellant_rocket)
- **Delta wing is efficient and light weight:** [https://en.wikipedia.org/wiki/Delta\\_wing](https://en.wikipedia.org/wiki/Delta_wing)
- **Aircraft design process:** [https://en.wikipedia.org/wiki/Aircraft\\_design\\_process](https://en.wikipedia.org/wiki/Aircraft_design_process)
- **Satellite navigation:** [https://en.wikipedia.org/wiki/Satellite\\_navigation](https://en.wikipedia.org/wiki/Satellite_navigation)
- **Inertial navigation system that can be used when GPS is not available:** [https://en.wikipedia.org/wiki/Inertial\\_navigation\\_system](https://en.wikipedia.org/wiki/Inertial_navigation_system)
- **Sources saying the Shahed 136 use a combination of GPS and inertial navigation:** <https://www.quora.com/How-are-the-Shahed-136-drones-guided-GPS-Inertial-What-are-the-possibilities-for-jamming-them>
- **Altimeter to measure altitude, the distance of a point above sea level:** <https://education.nationalgeographic.org/resource/altimeter>
- **Spreadsheet used by HM experience to calculate cost of making the Shahed drone both in mass production and in small scale production (MS excel file that contains all calculations):** Download link is available below video at [www.hmexperience.dk](http://www.hmexperience.dk)
- **Russia has got blueprint from Iran to make Shahed drone themselves:** <https://edition.cnn.com/2022/11/21/politics/russia-iran-drones-intel-assessment/index.html>

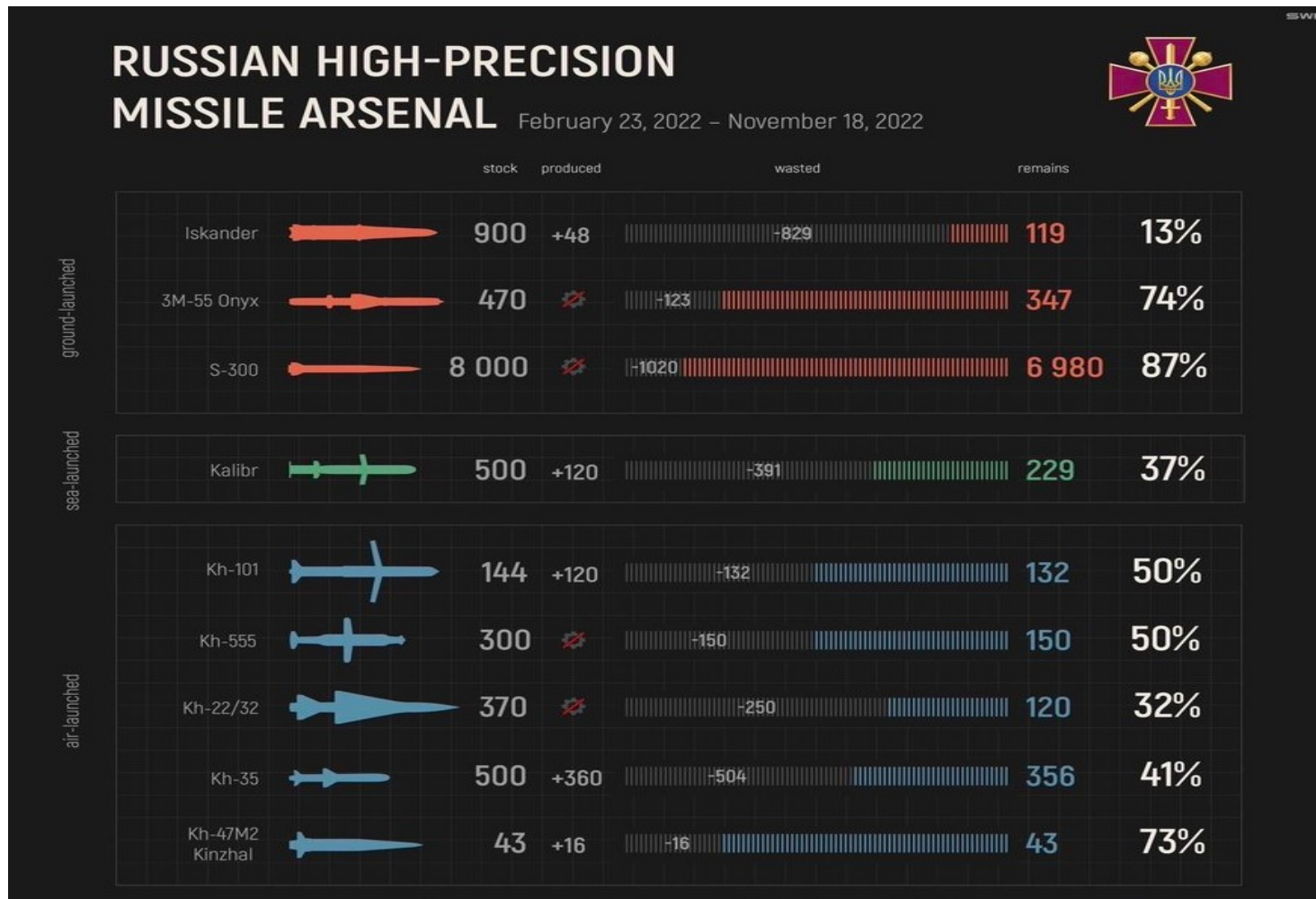


# How to defend against a drone like Shahed?

- ✓ **The reason the Shahed would win the “Weapons Nobel Prize in 2022”** is that there are no good defenses currently against 10,000 Shahed drones per months
- ✓ **The Shahed’s flight height is 4000 meter** and at that altitude most anti-aircraft guns and most short-range anti-aircraft missiles cant reach it
- ✓ At that height you need to use a **mid-range to long-range anti-aircraft missile** and they cost 200,000 to 3 million USD each
- ✓ Moreover, even if you used the entire stock of NATO’s mid to long-range anti-aircraft missile systems you would likely only be able to shoot down 30,000 drones or three months of attacks
- ✓ Also NATO very likely can’t make more than 500 new long-range to mid-range anti-aircraft missiles per month
- ✓ **Problem is current defenses are too limited and too expensive**



# Russia also unable to defend against 10,000 Shaheds per month



Source: <https://twitter.com/oleksiireznikov/status/1594998365170896896>



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# Alternative defenses against Shahed

- ✓ **Another way** to defend against Shahed drones is to jam all satellite navigation signals so drone will hit target with less precision and therefore do much less damage
- ✓ **The longer the drone is without satellite signal** before it reach its target the less accurate the attack
- ✓ **This defense** will also destroy all other satellite navigation around the cities and military positions you want to protect
- ✓ **The Shahed is low speed 185 km/h so another possibility is to use helicopters and airplanes with machine guns** to shoot them down
- ✓ **This defense is lower cost but require that you got a lot of helicopters and airplanes** if you need to gun down 333 per day of these drones ( $333 * 30 = 9,999$  monthly)
- ✓ **Best future defense system:** A fully automated system of radars and reusable drones with machine guns that can be send to shoot down the Shahed. Small automated suicide drones may also be a possibility



# Sources for previous slides

- **Stinger short range anti aircraft missile has max altitude of 3800 meters:** [https://en.wikipedia.org/wiki/FIM-92\\_Stinger#:~:text=It%20has%20a%20targeting%20range,at%20up%20to%203%2C800%20m.](https://en.wikipedia.org/wiki/FIM-92_Stinger#:~:text=It%20has%20a%20targeting%20range,at%20up%20to%203%2C800%20m.)
- **The Patriot anti-aircraft missile NATO's most common has been made in over 10,000 units:** [https://en.wikipedia.org/wiki/MIM-104\\_Patriot](https://en.wikipedia.org/wiki/MIM-104_Patriot)
- **The Patriot anti-aircraft missile NATO's most common cost 3 million USD per missile:** [https://en.wikipedia.org/wiki/MIM-104\\_Patriot](https://en.wikipedia.org/wiki/MIM-104_Patriot)
- **Russian rocket arsenal:** <https://twitter.com/oleksiireznikov/status/1594998365170896896>
- **Munro & Associates (company website):** <https://leandesign.com/contact/>
- **Munro YouTube channel:** <https://www.youtube.com/@MunroLive>



# Conclusion & humble advise to Ukraine/NATO

- ✓ **Russia is likely going to have some** production online for Shahed by Q2, 2023 but probably only about 1000 per months
- ✓ **By Q1, 2024 Russia should be able to do 10,000 per months** and it could easily go much higher from there because Shahed is much cheaper and easier to make than an automobile
- ✓ **There will not be any good defenses against the Shahed** until someone develops a fully automated radar/drone system that can shoot it down at low cost per kill
- ✓ **Such a system is almost exclusively a software development project** as the needed drones and radar tech already exist
- ✓ **It is far more likely that a NATO country will be first** to develop an effective defense against the Shahed
- ✓ **It will take much longer (likely several years more) for Russia to do this** because they have far less of the needed software developers than NATO countries have



# Conclusion & humble advise to Ukraine/NATO

- ✓ **An effective Shahed defense system is not likely to be available** from a NATO country until 2025 at the earliest
- ✓ **Therefore, the best thing Ukraine** can do is to set up their own factory for mass production of a reverse engineered Shahed drone and do it faster and at higher scale than Russia in order to overwhelm Russian defenses
- ✓ **Ukraine should not build that factory in Ukraine** because Russia will target it with everything they got to destroy it (1000s of Shahed drones)
- ✓ Factory should be set up in a very friendly NATO country like Poland or the Czech Republic (unlikely for to Russia attack a NATO country)
- ✓ **My favorite is Czech Republic** because they already got a large auto making industry and they also make military equipment
- ✓ **Also if I was Ukraine I would engage US company Munro & Associates** (see link above) to help with the reverse engineering of the Shahed drone and help with a redesign making it easy to mass produce at low cost





# Conclusion & humble advise to Ukraine/NATO

- ✓ **Full disclosure**, I have zero monetary connection to Munro & Associates
- ✓ **However, Munro & Associates** is the right company for this job
- ✓ **They have done countless of reverse engineering projects** on auto mobiles and they have also worked on airplanes and they have business with both private companies and the US military
- ✓ **I know this company because they have a popular engineering YouTube channel** where they disassemble products like automobiles in order to analyze and reverse engineer them and subsequently sell detailed engineering and manufacturing cost reports on to interested parties
- ✓ **To round up the Shahed drone is worthy of a “Weapons Nobel price”** because it is the cheapest high-precision long-range weapon in existence
- ✓ Everything else with similar precision and destructive power as Shahed starts at 110,000 USD and has much shorter range (say HIMARS at 70km)
- ✓ **Serious armies need to acquire** 100 of thousands or even millions of these Shahed type weapons and also acquire defense systems against them

