GENERAL ASTRONAUTICS
ARCA SPACE

The A1 Ballistic and Hypersonic Missile Interceptor

USER GUIDE

15 January 2024, pre-release version 2

The test facility for the A1 interceptor.
Four units of A1 derived-rockets are shown in the photo below.

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Abbreviations

A1A - Antiballistic interceptor, Type 1, Version A
A1B - Antiballistic interceptor, Type 1, Version B
BM - Ballistic Missile
CEP - Circular Error Probable
CM - Cruise Missile
DA - Defended Area
FS - Firing Solution
HE - High Explosive
HM - Hypersonic Missile
ICBM - Intercontinental Ballistic Missile
IRBM - Intermediate Range Ballistic Missile
IRST - Infrared Search and Track
MAD - Mutually Assured Destruction
MGSE - Mechanical Ground Support Equipment
MIRTV - Multiple Independent Reentry Target Vehicle
MIRV - Multiple Independently-Targetable Reentry Vehicle
MRBM - Medium Range Ballistic Missiles
RTV - Reentry Target Vehicle
RV - Reentry Vehicle
SCM - Supersonic Cruise Missile
SLBM - Submarine Launched Ballistic Missile
SRBM - Short Range Ballistic Missile
STM - Supersonic Target Missile
TBM - Tactical Ballistic Missile
TTT - Time to Target
UPM - Universal Propulsion Module

Artist impression of the A1B interceptors defending against an air burst MIRV attack.

1. Introduction

The latest military developments from conflicts like the one in Ukraine and Gaza have clearly shown that missiles will feature heavily in tomorrow's warfare.
A vast range of missile categories are involved in these conflicts, ranging from small rocket artillery and cruise and hypersonic missiles to Short Range Ballistic Missiles (SRBM).
We have witnessed the devastating effect of artillery rockets, cruise, hypersonic and ballistic missiles attacks against military targets, civilian infrastructure and energy facilities.
We have also witnessed the massive and prompt response of anti-missile defence forces, which significantly limited the damaging effect of these attacks.
There is undeniable proof that low-tech rockets as well as highly sophisticated missiles can be intercepted.
There are however three main reasons for concern:

- the high cost of missile defence systems;
- the availability and affordability of systems suitable against Intercontinental Ballistic Missiles (ICBM), Submarine Launched Ballistic Missiles (SLBM), Intermediate Range Ballistic Missiles (IRBM), Medium Range Ballistic Missiles (MRBM), Short Range Ballistic Missiles (SRBM), Hypersonic Missiles (HM) and Supersonic Cruise Missiles (SCM). There are a few such systems out there, but their availability outside Israel, Russia and the US is limited, or possible at prohibitive cost. Furthermore, these systems are specialised, so in the vast majority of cases they are only able to respond to very specific threats;
- the efficiency of current anti-missile systems against MIRV-ed ICBMs, SLBMs and hypersonic missiles;

These are exactly the problems that the A1 rocket aims to tackle by fielding an interceptor that is:

- extremely cost effective;
- available in large quantities;
- efficient against a broad class of ballistic, hypersonic and supersonic cruise missiles, filling the defensive gaps the current anti-missile systems have in regard to ICBM, IRBM, MRBM, SLBM, HM and SCM. Unlike these systems, the A1 interceptor takes a different approach. Instead of chasing the target, it lets it hit a dense cloud of pellets, chaff and flare that it deploys on its trajectory at extremely low (A1A interceptor version) and low altitudes (A1B interceptor version). In this scenario, there is no avoidance action available to the incoming missiles and MIRVs;
- able to work in conjunction with existing higher altitude missile defence systems, as A1 interceptors operate at extremely low and low altitudes. The A1 engages the incoming missiles in their terminal phase, just before warhead detonation, which makes all other, higher altitude, existing anti-missile systems complementary to the A1 as part of a layered defence approach. As such, A1 interceptors are the very last layer of defence, bridging a gap not covered so far by any other antiballistic system.

2. The A1 system

2.1 Overview

The A1 interceptor is a single stage, liquid fuel rocket using IRST detection and existing air defence radar detection capabilities.

The rocket derives from ARCA's EcoRocket Universal Propulsion Module (UPM). The engine's exhaust gases are only water vapours and oxygen, at temperatures of 80°C. This makes the interceptor immune to IR tracking, while allowing the launch from the DA centre with minimal impact on the surrounding assets and personnel.

The A1 interceptor is built entirely from composite materials that are radio transparent, and therefore have a low radar signature.

Another interesting feature of the A1 interceptor is the generation of a substantial amount of water vapours. Because of the interceptor's close proximity to the defended area, these vapours could provide a welcomed added decoy against the attacking vehicles that use optical guidance systems.

The interceptor have no onboard electronics, and the whole firing sequence and flight is performed via electromechanical systems. This makes it virtually immune to electronic warfare action.

Also, salvos of A1 interceptors could be fired to increase the kill and deception probability.

The A1 will work in conjunction with higher altitude anti-missile defence systems and could even use their detection and tracking capabilities for a higher range detection, even with no hardware interaction between these systems.

A1 interceptor technical characteristics:

Characteristic	A1A	A1B
Diameter (m)	1.2	1.2
Length (m)	11.4	12
Empty weight (kg)	400	450
Propellant weight (kg)	2,300	4,800
Thrust (kgf)	34,000	34,000
Engine run time (s)	3.9	8
Active altitude (m)	150	1,200
Apogee (m)	480	4,100
Time to apogee (s)	12	29
Max speed (Mach)	0.28	0.89
Start acceleration (g)	2.7	3
Max acceleration (g)	3.5	5.2
Warhead weight (kg)	10,000	6,000

As the A1 is launched from the centre of the defended area, it is equipped with its own recovery parachute, for safety and reusability purposes.

A1 operators can thus ship their interceptors back to General Astronautics for technical check-ups and warhead refits, generating significantly cost reductions when compared to the purchase of a brand new unit.
There are two A1 interceptor versions. The A1A executes interceptions at extremely low altitudes (100-200m) to combat ground and underground detonations of conventional and nuclear warheads. The A1B executes interceptions at low altitudes (1,000-2,000m) to combat air burst warheads of conventional and nuclear warheads.
The A1A and A1B can work individually or in conjunction, creating a layered defence system.
This option is required by the Defended Area (DA) type featuring underground or surface assets, which determine the incoming missile warhead detonation height, at ground or underground level, or air burst.
Another criterion for choosing between A1 version over a DA is the incoming threat type, conventional or nuclear.

2.2 The A1A

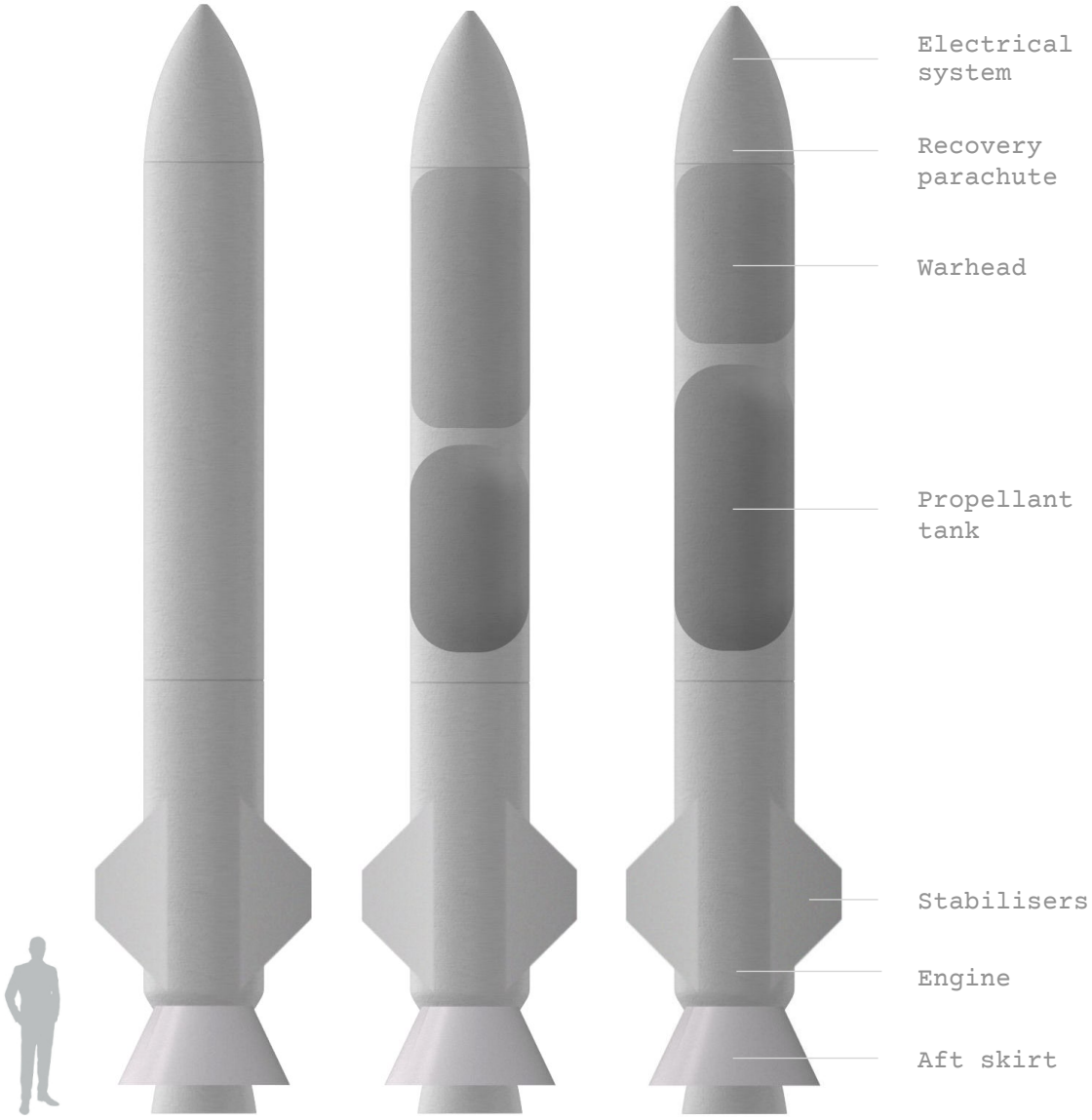
The A1A is an extremely low-altitude, anti-ballistic, hypersonic and supersonic missiles interceptor, designed to protect small, high value assets, by deploying a dome, or a high density dome sector, consisting of 10 tons of pellets, chaff and flare, at altitudes of up to 200m, in the path of the incoming targets. The targets are destroyed or diverted through kinetic impact, or by deceiving them with chaff and flare.
The A1A interceptor has the capability to engage incoming MIRV-ed ICBM, SLBM, IRBM, MRBM, RV-ed SRBM, HM and SCM carrying ground detonation warheads, both conventional and nuclear.

2.3 The A1B

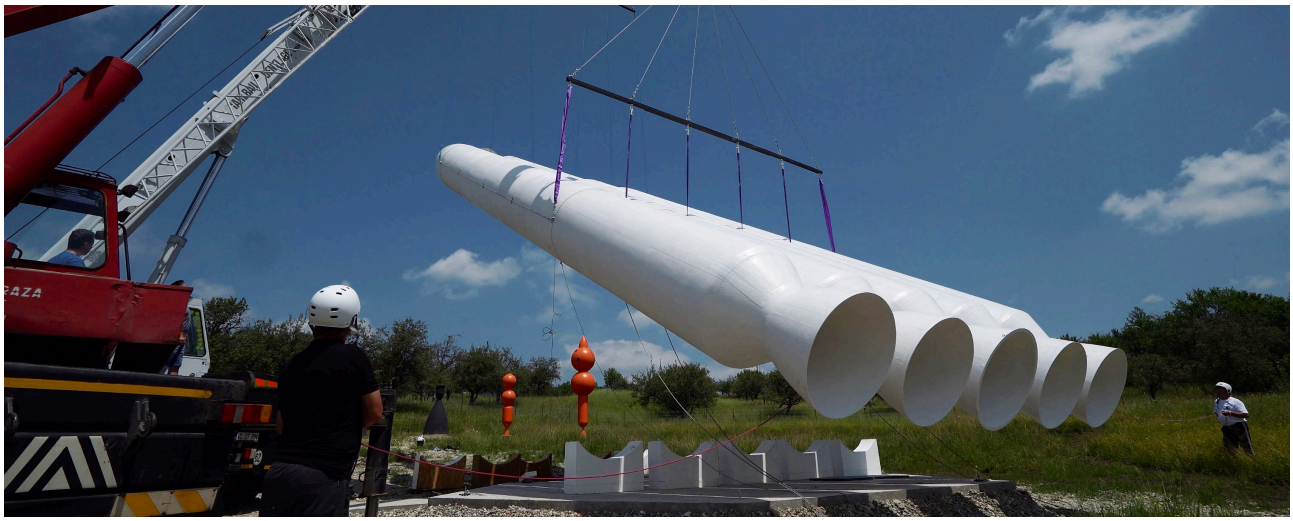
The A1B is a low-altitude, anti-ballistic, hypersonic and supersonic missiles interceptor, designed to protect small, high value assets, by deploying a dome consisting of 6 tons of pellets, at an altitude of up to 2,000m, in the path of the incoming targets. The targets are destroyed or diverted through kinetic impact, or by deceiving them with chaff and flare.
The A1B interceptor has the capability to engage incoming MIRV-ed ICBM, SLBM, IRBM, MRBM, RV-ed SRBM, and HM carrying carrying nuclear air burst warheads or conventional cluster munition.

2.4 IRST detection

The A1 system uses four IRST systems able to easily detect extremely hot temperatures generated by RVs, MIRVs or HMs during their terminal phase, when their structures become extremely hot. This enhances the IRST detection capability.
The four IRST units help compute the target’s altitude and speed, which are ultimately translated into time-to-target (TTT), to be relayed to the command station.



The A1A and A1B interceptors. The A1A, designed to counter ground detonation warheads, has a larger warhead than the A1B, which is designed to counter air burst warheads.



A1 interceptor airframes during fabrication phase.

3. A1 warheads

3.1 Overview

The core philosophy of the A1 is the capability to intercept incoming threats without a need for precise tracking. Thus, it is immune to countermeasures and any kind of avoidance manoeuvring the target could undertake.

This is possible due to the use of a passive warhead that is activated electromechanically at a pre-programmed altitude.

A1 interceptor warhead is probably the heaviest ever mounted on an anti-missile defence system.

Instead of explosives, or a single, large kinetic warhead, it contains a large amount of metallic pellets, chaff and flare, that are deployed mechanically.

Warhead	Warhead weight (kg)	No. of deployed pellets, million	Pellets deployment altitude (m)	Incoming target type	Engaged target type	Detonation height
A1A	10,000	2	100-200	RV, MIRV, SRBM, TBM, HM, SCM	Nuclear / conventional	Ground detonation
A1B	6,000	20	1,000-2,000	RV, MIRV, SRBM, TBM, HM	Nuclear / conventional (cluster munition)	Air burst / air deployment

Example of pellets options for the A1 warhead.

3.2 The A1A warhead

The A1A contains up to 2,000,000 pellets, chaff and flare. Their weight, composition and deployment pattern are confidential. The pellets act as kinetic projectiles, while the chaff and flare aim to distract the incoming missiles.

The estimated impact energy of one pellet deployed by the A1A is presented below:

Incoming threat	Terminal speed (m/s)	Impact energy (kJ)
ICBM-MIRV	~2,300	~25-130
ICBM-MIRV	~2,200	~24-120
SLBM-MIRV	~2,200	~24-120
IRBM-MIRV	~2,100	~22-110
MRBM-MIRV-RV	~1,400	~10-50
SRBM/TBM	~600-900	~2-21
Hypersonic	~1,500-2,000	~12-100
Supersonic	~600-900	~2-20

3.3 A1B warhead

The A1B contains up to 20,000,000 pellets. Their weight, composition and the deployment pattern are confidential.
Because the A1B needs to defend a larger area, and is deployed at a higher altitude where the target travels at higher speeds, the pellets are significantly smaller than those used with the A1A.

The estimated impact energy of one pellet deployed by the A1B is presented below:

Incoming threat	Terminal speed (m/s)	Impact energy (kJ)
ICBM-MIRV	~3,200	~1.5-5
ICBM-MIRV	~3,100	~1.4-4.8
SLBM-MIRV	~3,100	~1.4-4.8
IRBM-MIRV	~2,800	~1.2-3.9
MRBM-MIRV-RV	~1,700	~0.4-1.4
SRBM/TBM	~900-1200	~0.1-0.7
Hypersonic	~1,700-2,300	~0.4-2.6

4. Threats discussion

4.1 Reentry Vehicles (RVs)
RVs are transported to the target by ICBMs, IRBMs, or MRBMs. Each RV is equipped with a nuclear warhead, and rarely with a conventional warhead. Frequently, ballistic missiles are equipped with MIRVs. These vehicles contain multiple independent RVs that can be deployed at the same time or released from the missile bus at various times during the flight path.
The ICBM-carried RVs reenter the atmosphere at speeds of up to Mach 24 and start to slowly decelerate as they go through the atmosphere, starting at altitudes of around 40km.
Depending on the carrier rocket type, the impact velocity of modern nuclear warheads is in the Mach 4-7 range.

The table below is showing the typical flight profile of an RV released by heavy ICBM, ICBM/SLBM, IRBM and MRBM:

Altitude (km)	Heavy ICBM, RV speed (km/s)	ICBM / SLBM, RV speed (km/s)	IRBM, RV speed (km/s)	MRBM, RV speed (km/s)
100	7.2	6.6	5.2	3.7
40	7.2	6.6	5.3	3.8
30	7	6.5	5.3	3.8
20	6.8	6.3	5.2	3.7
15	6.5	6.1	4.9	3.6
10	5.7	5.4	4.4	3.1
5	4.3	4.1	3.6	2.3
2	3.2	3.1	2.8	1.7
0	2.3	2.2	2.1	1.4

The modern French, Russian and US RVs are equipped with nuclear warheads of up to 500 kiloton (and sometimes 1 megaton).
However, there are a few exceptions like the Chinese and Indian ICBMs, equipped with warheads of up to 3 megaton.
Depending on the nature of their target, nuclear warheads detonate above the target (air burst) and some detonate at impact or below ground.

Warhead	Optimum detonation altitude (m)
100kt	1,000
500kt	1,600
1MT	2,000
3MT	2,800

Impact detonations are preferred in the case of hardened, underground targets.

In the case of impact, the detonation probability increases as it avoids the use of electro-mechanical detonation devices susceptible to radiation, other countermeasures or just battlefield difficult conditions generated for instance by a previous nuclear strike (fratricide).

The MIRV-ed Yars ICBM, and the Mark 12 RV equipped with the W78, fitted on the Minuteman III ICBM.

In regard to nuclear warheads only, the A1A interceptor is designed to defend against ground detonations, while the A1B interceptor is designed to defend against air burst warheads with yields up to 500 kiloton.

4.2 Short Range Ballistic Missiles (SRBMs)

SRBMs can use both conventional and nuclear warheads.

Except for cluster munition warheads when deployment can occur at altitudes of around 1,500m, the warhead remains with the SRBM from launch to delivery, and no separation occurs like in the case of larger ballistic missiles.

Therefore, the SRBM and its warhead crash into the target at the same time.

Iskander SRBM, ATACMS TBM.

While the SRBM nuclear warhead could detonate at higher altitude, the conventional warhead (except for the cluster munition one), always detonates at impact or in the very close proximity of the target (10-20m).

The impact speed of SRBMs is usually below Mach 3.

While a kinetic kill or a catastrophic failure of an SRBM going through the defensive cloud is probable, the cloud may also deceive its fuse to detonate at a significantly higher distance from the target.

4.3 Hypersonic Missiles (HMs)

While an RV usually flies to the target at hypersonic speeds, up to the warhead detonation, on a ballistic trajectory, an HM is defined by its capability to manoeuvre to avoid detection and interception.

HMs may carry both conventional and nuclear warheads, and those may separate from the missile or stay with the it until detonation, depending on the missile type.

The Kh-47M2 Kinzhal operational hypersonic missile underneath a MiG-31K fighter jet.

This rocket technology has been developed in the past decades mostly in China, India and Russia, but the US has recently made efforts to catch up. The impact speed of HM is usually up to Mach 6.

4.4 Supersonic Cruise Missiles (SCMs)

The Cruise Missiles (CM) are well developed weapons and saw massive deployment in conflicts from the past decades.

Their warheads may be conventional or nuclear. Conventional warheads are designed to detonate on impact or in the very close proximity of the target, with the exception of cluster munition delivery. Nuclear warheads may also detonate on impact, in close proximity to the ground, or (rarely) at higher altitudes.

Due to its low flight speed, a CM is vulnerable to air defences and therefore avoids flying at high altitudes to prevent detection as much as possible. Therefore, CMs are less suited to cluster munition dispersion or nuclear air burst from significantly high altitudes.

Brahmos,
supersonic cruise missile.

However, in the past decade we saw an increase in CM capability through the development of Supersonic Cruise Missiles (SCM). These fly at low altitude but supersonic speeds, which significantly increases their survivability.

In the case of SCMs however, the A1 interceptor remains highly efficient, as it uses the high speed of the incoming target to its advantage.

4.5 Cruise Missiles (CMs)

Although CMs fly very low, their speed is usually around Mach 0.8, which makes them easier to intercept, especially due to the latest advancements in the radar technology.

The efficiency of cruise missiles has been lately debated because of their modest performance in the Ukrainian conflict, where reportedly, around 90% of Russian-launched CMs have been intercepted by Ukrainian air defences (accordingly to the Ukrainian military reports, which should be taken cautiously).

Also, there have been historical doubts about treating cruise missiles as strategic weapons because, among other things, the US and UK military doctrines regard them as sub-strategic weapons.

Although A1's ability to destroy a CM is questionable at speeds below Mach 1, the latter may well be damaged or confused and deviated from its course when it reaches the chaff and flare cloud released at a significantly longer distance from the target.

Most CMs detonate at impact or use a proximity fuse and detonate at very low height above the target (around 10-20m). Thus, they cannot avoid going through the pellets, chaff and flare cloud that our interceptor releases.

Even if A1's has been designed as a strategic interceptor for strategic threats, it can also provide some degree of protection against CMs when used as a last resort defensive device. That is why we are not going to analyse the A1 as a CM defence solution, but rather list it as a potential defensive option.

4.6 Circular error probable discussion

Current US and Russian ICBMs use inertial guidance systems that allow them to deliver RVs and MIRVs to their targets with a Circular Error Probable (CEP) in the range of 150-350m. Chinese ICBMs have a much higher CEP, in the range of 800m.

This is something to consider when deploying A1 interceptors, as the RVs and MIRVs are not always delivered precisely on target.

While the A1B has a fairly generous cloud surface to allow the US and Russian RVs and MIRVs to strike it even in the case of a major error, in the case of the A1A interceptor special attention must be paid to the deployment design.

The hypersonic and supersonic cruise missiles tend to be more precise as they rely on multiple, redundant guidance systems.

5. How the A1 interceptor works

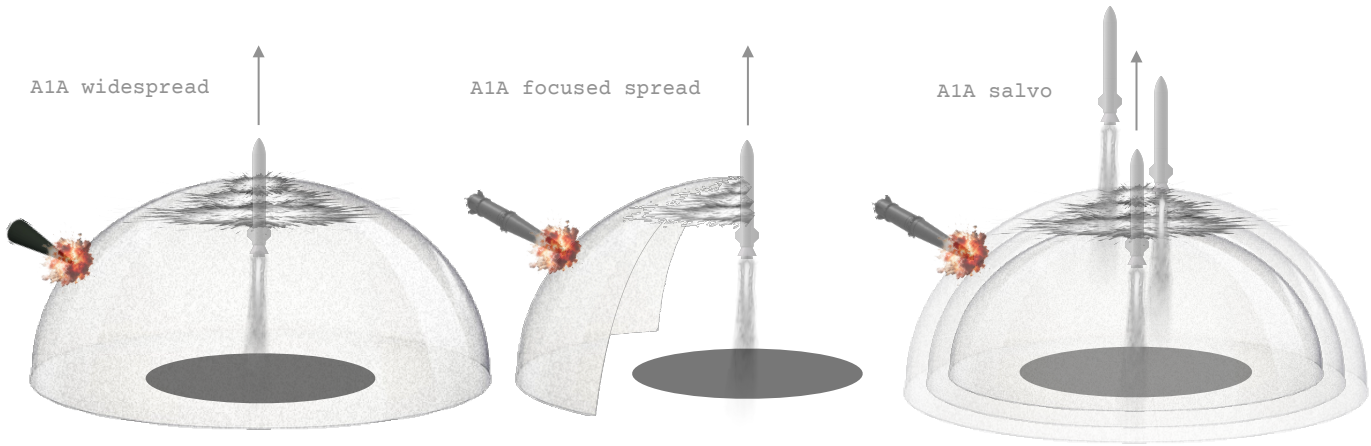
The A1A defends against RV-ed and MIRV-ed ballistic missiles, SRBMs/TBMs as well as HMs and SCMs that deliver conventional and nuclear warheads designed for underground, ground or near-ground detonations.
The A1B defend against RV-ed and MIRV-ed ballistic missiles, SRBMs/TBMs as well as HMs that deliver air burst nuclear warheads and cluster munitions.
The ballistic and hypersonic missiles's strong suit is the extremely high terminal speed that makes them difficult to hit with interceptors. But the A1 interceptor takes a completely different approach by using the attacking vehicles's high speed to its advantage.
While a conventional antiballistic systems philosophy is to hit the incoming RVs, MIRVs, SRBMs/TBMs, HMs and SCMs at high altitudes, either through kinetic impact or the detonation of a nuclear warhead, the A1 interceptor deploys a dome, or a high density directional sector of a dome, of millions of pellets, chaff and flare released at low altitudes, above the areas it defends, intersecting the attacking vehicle's path.
The A1 interceptors are equipped with extremely heavy warheads: 10 tons for the A1A and 6 tons for the A1B.
The A1A warhead contains up to 2,000,000 pellets of various calibres, chaff and flare that are deployed at altitudes between 100-200m.
The A1B warhead contains up to 20,000,000 pellets of various calibres, chaff and flare that are deployed at altitudes between 1,000-2,000m.
Intercepting an RV or a hypersonic missile with a guided missile is inherently difficult, because of the challenges raised by placing the interceptor in the right position and acquiring and firing at a fast-flying target, exhibiting sometimes a complex trajectory.
The A1 is able to create a large cloud of dense pellets, chaff and flare, in the path of the incoming target, hence making the need for a track-to-kill system redundant.
Removing the interceptor's need for a guidance system also dramatically decreases cost.
The attacking vehicle will hit the pellets at high supersonic or hypersonic speeds. That will either compromise the airframe, penetrate through the outer structure and hit the warhead and guidance system, with a substantial probability of disabling or destroying the vehicle.
In the scenario of a disabled vehicle, the vehicle might hit the target's surroundings, or even the target itself, but it will inflict significantly less damage compared with a nuclear blast or a conventional explosion coming from a correctly detonating warhead.
By using EcoRocket propulsion, the A1 interceptor exhibits a relatively high acceleration during flight, but also lifts extremely heavy warheads at unprecedented low cost.
The A1 interception method is not new. During the 1970's and the 1980's it was proposed as an option to defend the LGM-118 Peacekeeper ICBM silos as part of the "Star Wars" initiative. The system was however deemed to unbalance the MAD doctrine, and was therefore canceled.

6. Deployment

The optimum deployment option for the A1 as a strategic interceptor is to form multiple 12-unit squadrons that are stored in underground silos, as close as possible to the centre of the Defended Area (DA).
However, if such an option is not locally feasible, the interceptors may be deployed in an open environment inside their canisters.
The deployment is made alongside the IRST units and the command station.
Although possible, a tactical, battlefield deployment of A1 interceptors is a rather limited option.

6.1 A1A

In the case of A1A, a typical DA has a diameter of 200m (31,416 sqm), while the ground diameter of the pellets, chaff and flare dome is 400m. Therefore, a circular buffer area with a diameter of 400m is established. The distance between the edge of the buffer area and the defended area is 100m.
The defenders do not need to precisely know the target's incoming direction, as the dome provides 360-degree protection.
Multiple arrangements may be fielded, taking into account the specific needs of each DA.
Below, we have provided a visual representation of a 200m diameter DA in the middle (light grey) and a 400m diameter buffer zone around the defended area. Smaller areas may be defended by a single A1A interceptor.
The A1A warhead may be programmed up to 1 second prior to launch to deliver the pellets, chaff and flare with a wide or focused spread, based on the type and direction of the incoming threat.
A1 interceptors may also be fired in salvos to increase interception probability by keeping the protective dome airborne for a longer time, by increasing the pellet density, or by creating multiple layers of defence.



The A1A interceptor deploys a dome of pellets (left), or a high density sector of a dome (centre) in the path of an incoming aggressor with ground detonation warheads.
Multiple domes created above a single DA resulting from the A1A salvo firing (right).

Multiple DAs that are overlapping or close to each other are viable options for defence with A1 interceptors. The closer the areas, the higher the kill probability, as a target will need to pass through multiple layers of pellets, chaff and flare.

Obviously, A1 interceptors can defend non-circular, irregularly-shaped areas, as illustrated below.

A1 interceptors launched above multiple clustered DAs create overlapping defensive domes (left). Irregular, clustered DA shapes also generate overlapping defensive domes (right).

Artist’s impression of A1A interceptors defending hardened ground assets attacked with MIRVs.

6.2 A1B

In the case of A1B, the typical DA has a diameter of 400m (125,664 sqm), while the diameter of the pellet cloud is 800m (502,656 sqm).

The target's exact direction is not relevant, since the cloud provides 360-degree protection.

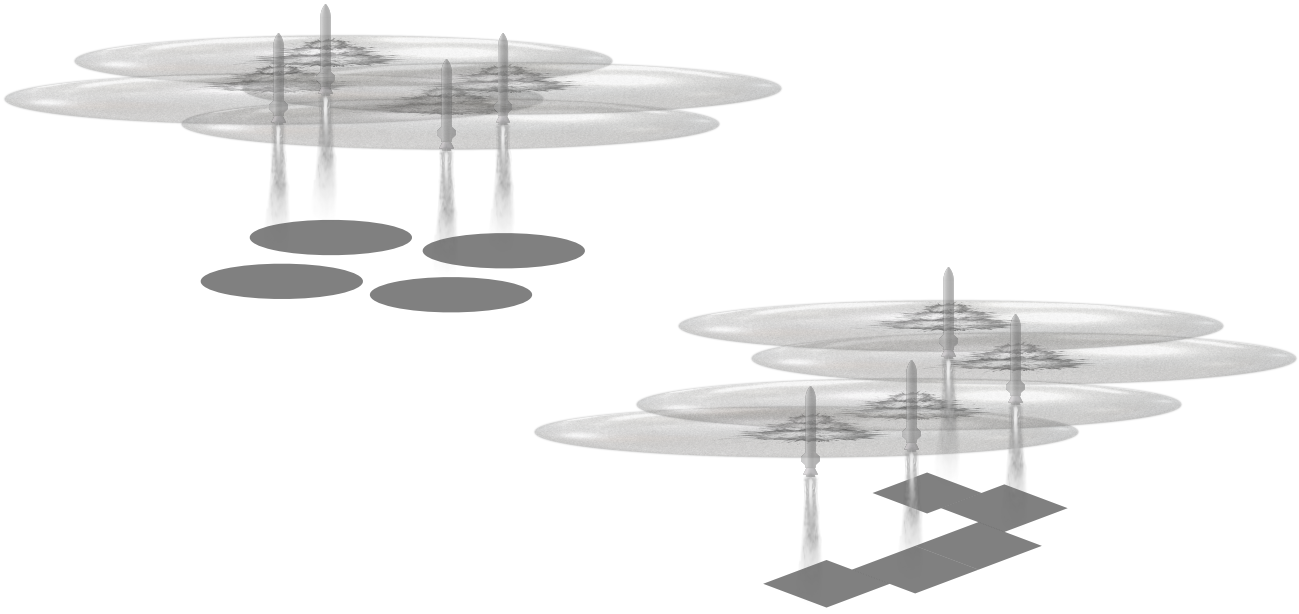
Again, similarly to the A1A case, multiple arrangements can be fielded, taking into account the specific needs of each DA.

A visual representation of a 400m diameter defended area in the middle (light grey) and a 800m diameter cloud above the defended area is shown below.

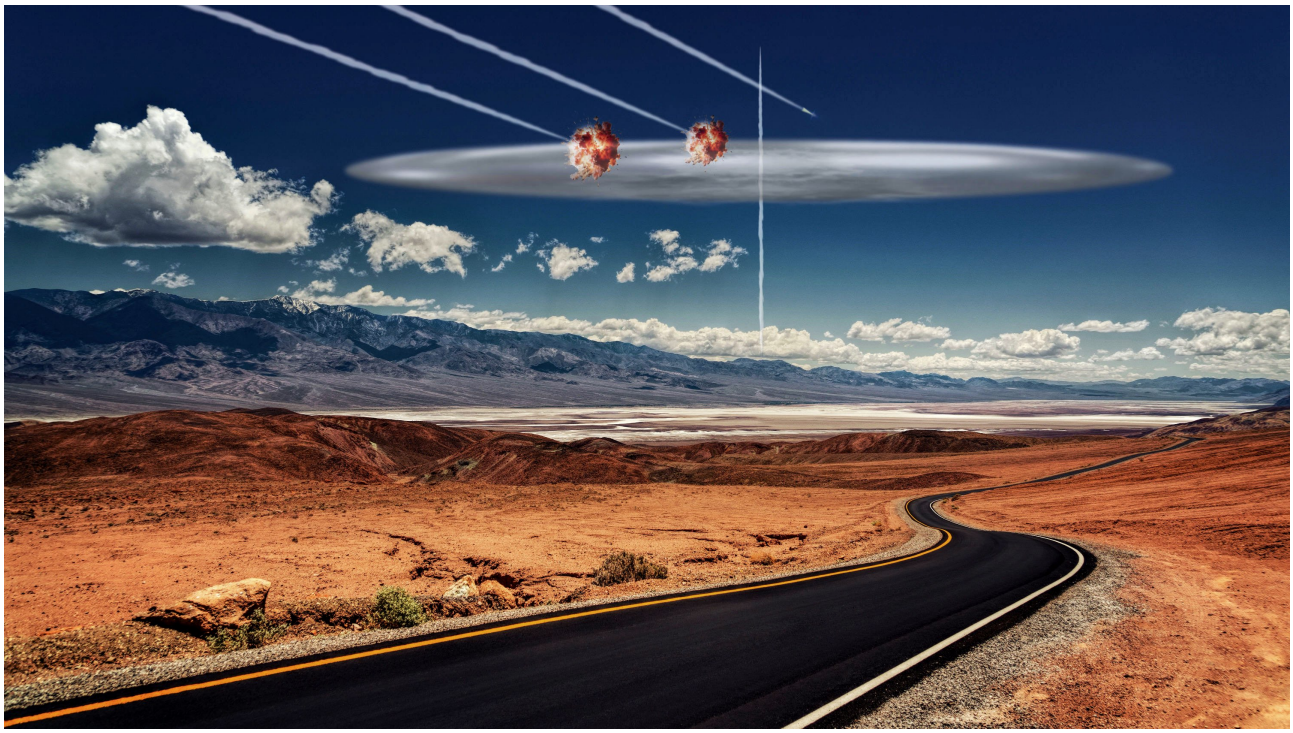
A1B interceptor deploys defensive clouds above the DA (left) and a salvo of A1B deploys multiple defensive clouds above the DA (right).

Multiple close or overlapping areas are viable options for defence by A1B. The closer the areas, the higher the kill probability for the incoming missile and RV, as the target needs to go through multiple layers of pellets.

Non-circular, irregularly-shaped DA's can easily be covered by multiple A1B defensive clouds.



A1B interceptors launched above multiple clustered DAs create overlapping defensive clouds (left). Irregularly-shaped DAs also create such defensive clouds (right).



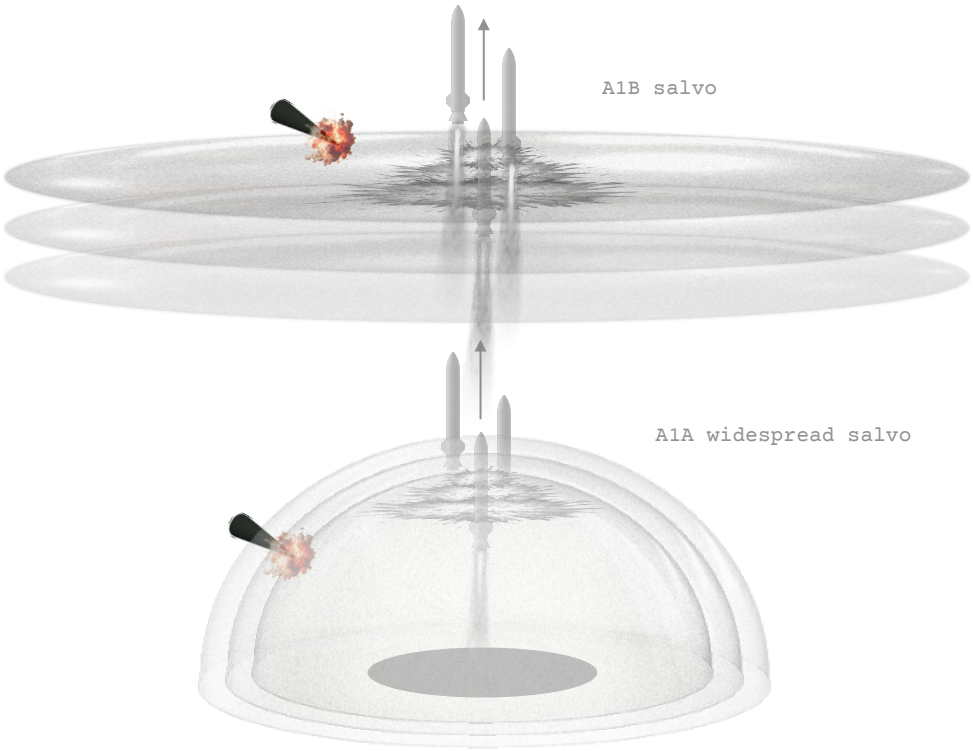
Artist's impression of A1B interceptors defending against an air burst MIRV attack.

6.3 A1A and A1B combined

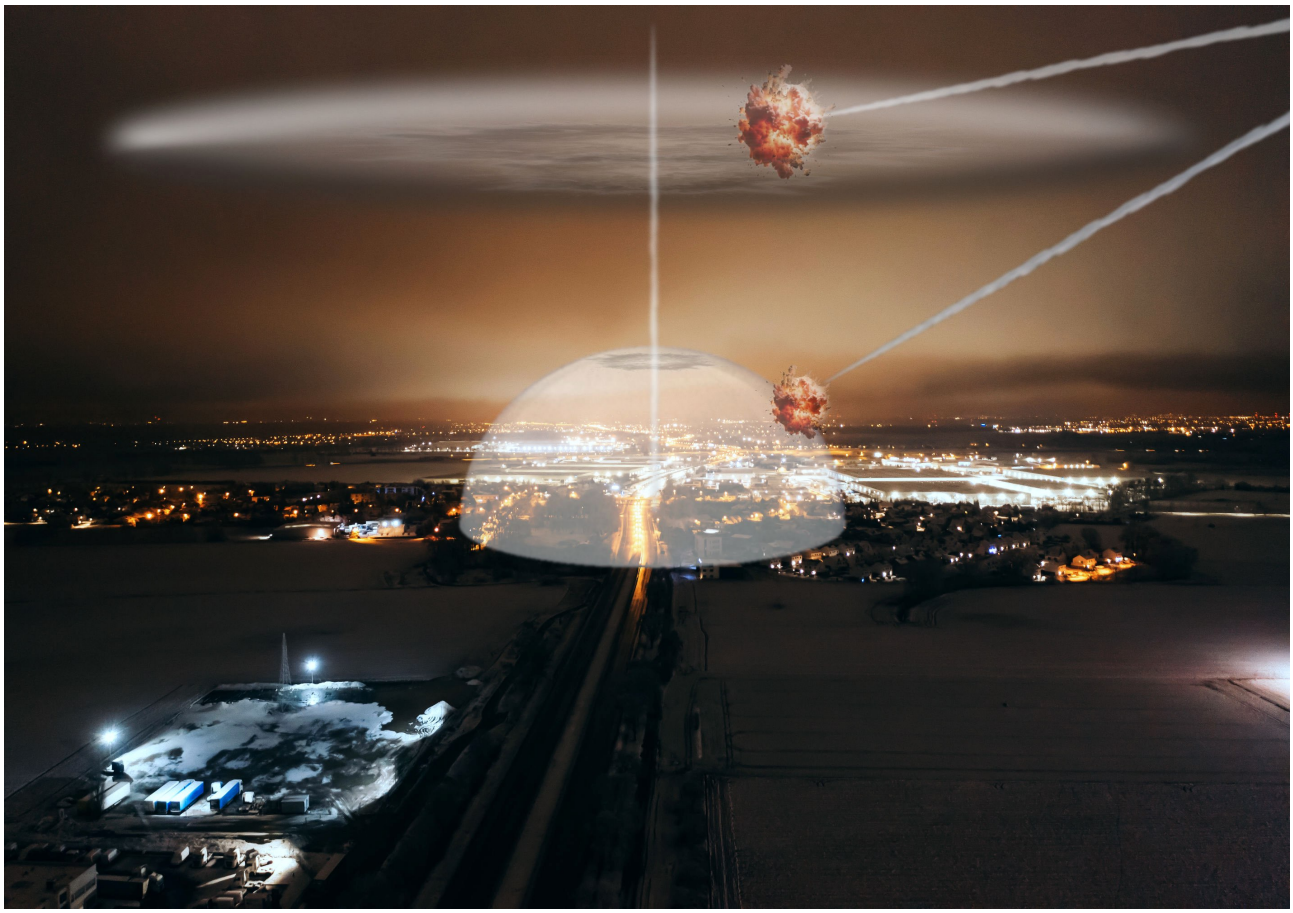
When a DA contains both hardened and non-hardened assets, it can be subject to combined attacks featuring ground detonations and/or air bursts.

In this uncertain scenario, a combination of A1A and A1B interceptors can provide a suitable defence option.

The A1A and the A1B combined can provide a good defence option when the aggressor may strike with ground detonation, air burst, or both types of warhead.



A multilayered defence using A1A and A1B salvos can be employed for high value DAs.



Artist's impression of the A1A and A1B interceptors firing simultaneously against ground detonation and air burst attacks.

6.5 Choosing the correct A1 version for deployment

Based on the Defendable Areas (DA) type, A1 operator may chose between A1A, A1B, or a combination of the two, using the below table as reference:

	Conventional warhead	Nuclear warhead
A1A ground or underground detonation	Hardened or underground military facilities: • Command centres; • Logistical hubs; • Naval bases; • Air bases; • Ground forces bases. Hardened or underground civilian facilities: • Industrial facilities; • Energy production facilities like nuclear power plants;	Hardened or underground military facilities: • Ballistic missile silos; • Command centres; • Logistical hubs; • Naval bases; • Air bases; • Ground forces bases. Hardened or underground civilian facilities: • Industrial facilities; • Energy production facilities like nuclear power plants;
A1B air burst	Surface, non-hardened military facilities: • Command centres; • Logistical hubs; • Naval bases; • Air bases; • Ground forces bases. Surface, non-hardened civilian facilities: • Industrial facilities; • Energy production facilities like hydro, thermal, nuclear power plants; • Civil engineering assets like dams, bridges, etc; • Small urban areas.	Surface, non-hardened military facilities: • Command centres; • Logistical hubs; • Naval bases; • Air bases; • Ground forces bases. Surface, non-hardened civilian facilities: • Industrial facilities; • Energy production facilities like hydro, thermal, nuclear power plants; • Civil engineering assets like dams, bridges, etc; • Small urban areas.

As part of the A1 delivery process, General Astronautics will provide options for optimum deployment in the desired defensive areas.

7. Firing solutions (FSs)

7.1 Target detection

An important aspect of target detection is related to the general environment in which the A1 interceptor operates. Surprise attacks are rare. Most of the times they occur after political tensions have risen for a while.

The A1 launch-to-intercept relies on detecting the target and computing its TTT as early as possible.

All firing solutions require an initial target detection, preferably 20 seconds or more before impact.

The TTT difference between an airburst and a ground detonation is about 0.6 seconds.

The altitude difference between a ground detonation and an air burst for warheads below 500 kiloton is around 1,600m. A precise determination of a trajectory, at least in the initial moments after target identification, is difficult to achieve.

Therefore, to make interception easier, we are going to treat the ground detonation and the air burst in a similar fashion, and not regard them as different events with different interception procedures.

Target detection will be performed using four Infrared Search and Track (IRST) systems with a 70 km range. These can continuously provide altitude and TTT estimates to the air defence commander.

7.2 The A1A firing solution

The A1A interceptor defends against underground, ground and just above ground warhead detonations.

Its firing solution relies on the incoming aggressor’s time-to-target (TTT) provided by IRST units.

The optimum launch time for A1A is at a TTT of 12 seconds, regardless of the incoming aggressor type and speed (hypersonic or supersonic).

A salvo of multiple interceptors is recommended to increase the kill probability of incoming threats, with an ideal scenario of three interceptors fired at 3 second intervals.

Target type	A1A launch sequence start interval (s)	A1A rocket flight interval (s)	Pellet deployment interval (s)	Time until intercept * (s)
RV / MIRV / HM / SRBM	12-9	9-5	7-5	5

* At this time the pellets are fully deployed and the incoming warhead will reach the defensive cloud in about 5 seconds.

7.3 The A1B firing solution

The A1B interceptor defends against air burst explosions.

Its firing solution relies on the incoming aggressor’s time-to-target (TTT) provided by IRST units.

The optimum launch time for A1B is at a TTT of 17 seconds, regardless of the incoming aggressor type and speed (hypersonic or supersonic).

A salvo of multiple interceptors is recommended to increase the kill probability of incoming threats, with an ideal scenario of three interceptors fired at 2 second intervals.

Target type	A1B launch sequence start interval (s)	A1B rocket flight interval (s)	Pellet deployment interval (s)	Time until intercept * (s)
RV / MIRV / HM / SRBM	17-14	14-5	7-5	5

* At this time the pellets are fully deployed and the incoming warhead will reach the defensive cloud in about 5 seconds.

7.4 A1 interception example

As previously stated, the A1 will be deployed as close as possible to the centre of the defended area.

A1 interceptors operations are simple and involve pressing only two switches, “ARM” and “LAUNCH”.

Assuming that the IRST system detects the incoming aggressor at a 70km range, from that point the time to impact or airburst is roughly 25 seconds in the case of RVs, MIRVs and HMs.

Immediately after detection, the A1 squadron commander presses the “ARM” switch. That unlocks the A1 launch sequence for all A1 interceptors in the squadron. They then have 10 seconds to confirm the aggressor’s legitimacy in the case of the A1A, and 8 seconds in the case of the A1B.

The commander also needs to decide if the A1A is going to deploy its warhead in widespread or focused mode in one of the four available 90° sectors, based on the data received from the IRST units.

After these initial 10 (8) seconds, the commander starts the A1A interceptor launch procedure by pressing either the “LAUNCH” switch or one of the sector switches, “LAUNCH N”, “LAUNCH E”, LAUNCH S”, LAUNCH W”. For the A1B interceptor, the commander only has a “LAUNCH” switch available.

If the aggressor is detected between 50 and 70 km for A1B, or 40 and 70 km for A1A, interception is still possible.

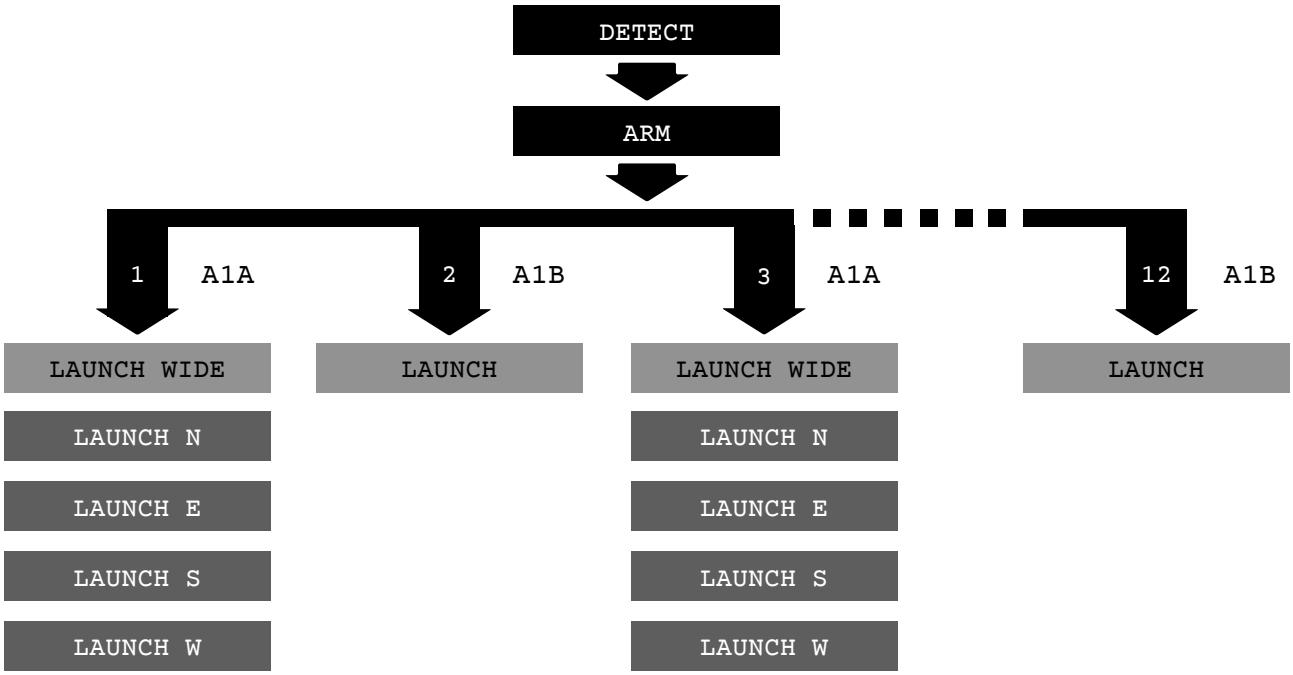
NOTE: Each A1 interceptor in a squadron has its own “LAUNCH” switch, but there is only one “ARM” switch for the whole squadron.

After the “LAUNCH” switch is pressed, the A1 interceptor pressurises its tank and is airborne in 3 seconds.

In the case of the A1A, the interceptor automatically deploys its warhead 3-6 seconds after lift-off. For the A1B, that interval is 7-10 seconds.

After warhead deployment and propellant tank depletion, the interceptors will reach their apogees at 480m for the A1A and 4,100m for the A1B respectively.

At apogee, each interceptor deploys its recovery parachute. By that time, the aggressor should already have hit the pellets, chaff and flare domes.



Example of an A1 squadron commander panel, featuring 6 x A1A and 6 x A1B interceptors.

NOTE: In the case of Short Range Ballistic Missiles (SRBM) which usually travel at supersonic speeds in the terminal phase, the TTT remains the same, even if the time from detection to A1 interceptor launch is roughly double. However, in the case of Supersonic Cruise Missiles (SCM), which fly at lower speeds when compared to other examples, the time from detection to A1 launch remains almost similar, because the ideal detection distance is twice as short.

8. Prerequisites

The A1 interceptor requires the following items to make it ready for combat duty:

- 1 crane to lift the canister with the vehicle in the vertical position;
- propellant, 2,300kg and 4,800kg for each A1A and A1B interceptor, respectively - 1-year rocket-storable hydrogen peroxide 50%. The rocket is fuelled after erected into vertical position and it is either placed in a silo, or its canister is secured above ground;
- 12 V, 5 A electrical power source;
- underground silo (preferably but not mandatory);
- maintenance team - 4 people per squadron;
- launch team - 6 people per squadron, of which 2 on permanent duty.

9. Maintenance

Beside regular interceptor maintenance, such as checking the vehicle's integrity and other minor operations, A1 interceptors require an annual maintenance service to replace seals and hydrogen peroxide. This services shall be performed on site by the manufacturer. While serviced, the interceptor is non-operational for up to two days.

10. Pellets, chaff and flare fallout

Each A1 interceptor warhead is equipped with a large number of pellets: up to 2,000,000 pieces for the A1A and up to 20,000,000 for the A1B, alongside chaff and flare. After deployment, the pellets fall to the ground at a speed of around 50 m/s.
A1A pellets are heavier than A1B pellets, and although most A1A pellets fall outside of the defended area, they might injure people and animals on the ground. Therefore, when the air alarm sounds, both should seek cover. Usually this happens anyway in case of a missile attack.
Although not advisable in any scenario, key personnel may remain outside if they wear adequate, military-grade protective equipment.
The pellets and chaff pose negligible threats to building roofs.
The A1 interceptor itself is equipped with a reactive parachute that brings it down at a descent rate of 4 m/s. The parachute deploys at apogee, that is 480m for A1A and 4,100m for A1B.

11. Targets compatible with the A1 interceptor

The A1 interceptor can be deployed against the whole range of intercontinental, intermediate, medium, and short range ballistic missiles, as well as hypersonic and supersonic missiles with warheads aimed to detonate underground, at ground surface, or at higher altitude for nuclear warheads of up to 500 kiloton.
Below is a non-comprehensive list of missiles that the A1 interceptor can defend against.

11.1 ICBM - Intercontinental Ballistic Missiles

Missile	Country	Range (km)	Warhead type
DF-4	China	5,500	3.3Mt RV
DF-5	China	16,000	5-20Mt RV / 12x1Mt MIRV
DF-31	China	8,000	1x1Mt RV / 5 x 90-40kt MIRV
DF-41	China	15,000	8x250kt / 10x150kt MIRV
Surya	India	16,000	3-10x750kt MIRV / 1x4-5Mt RV
Agni-V	India	12,000	10-11 MIRV
Agni-VI	India	8,000	10-12 MIRV
Jericho-III	Israel	11,500	Unknown
Hwasong-13	North Korea	12,000	Unknown
Hwasong-14	North Korea	10,000	Unknown
Hwasong-15	North Korea	13,000	Unknown
Hwasong-17	North Korea	15,000	Unknown
Hwasong-18	North Korea	15,000	Unknown
R-36M2 Voevoda	Russia	16,000	10×550-750kt MIRV
UR-100N	Russia	10,600	1x1Mt RV / 6x400kt MIRV
RT-2PM Topol	Russia	12,500	1x800kt RV / 1x1Mt RV
RT-2PM2 Topol-M	Russia	11,000	1x1Mt RV
RS-24 Yars	Russia	11,000	3-6x300-500kt / 6-10x150kt
RS-28 Sarmat	Russia	18,000	10, MIRV
Minuteman III	US	14,000	3xMk-12 x 170kt

11.2 IRBM - Intermediate Range Ballistic Missiles

Missile	Country	Range (km)	Warhead type
DF-26	China	5,000	Unknown
Agni-III	India	5,000	Nuclear/conventional

Missile	Country	Range (km)	Warhead type
Agni-IV	India	4,000	Nuclear/conventional
Shahab-5	Iran	4,300	Unknown
Hwasong-10	North Korea	4,000	Conventional/possibly nuclear
Hwasong-12	North Korea	6,000	Conventional/possibly nuclear

11.3 MRBM - Medium Range Ballistic Missiles

Missile	Country	Range (km)	Warhead type
DF-2	China	1,250	Unknown
DF-16	China	1,600	Unknown
DF-21	China	1,700	Conventional/200-300-500kt RV
Agni-I	India	1,200	Conventional/nuclear
Agni-II	India	3,500	Conventional/nuclear
Agni-P	India	2,000	1xMARV / 2xMIRV, conventional, nuclear
Ashoura	Iran	2,500	Conventional/nuclear
Emad	Iran	1,700	Conventional/nuclear
Fattah	Iran	1,400	Unknown
Ghadr-110	Iran	3,000	Unknown
Khorramshahr	Iran	2,000	Conventional/nuclear
Sejjil	Iran	4,500	Unknown
Shahab-3	Iran	2,000	Conventional/nuclear
Jericho-II	Israel	1,300	Conventional/1x1Mt RV
Hwasong-7	North Korea	1,500	Conventional/possibly nuclear
Hwasong-9	North Korea	1,000	Conventional/nuclear
Hwasong-10	North Korea	4,000	Conventional/nuclear
Ababeel	Pakistan	2,200	3-8 RVs, conventional/nuclear
Ghauri-I	Pakistan	1,500	Conventional/nuclear
Ghauri-II	Pakistan	2,000	Conventional
Shaheen-II	Pakistan	2,500	Conventional
Shaheen-III	Pakistan	2,750	Conventional/50kt RV
J-600T	Turkey	2,500	Conventional

11.4 SRBM - Short Range Ballistic Missiles

Missile	Country	Range (km)	Warhead type
B-611	China	280	Conventional
BP-12A	China	300	Conventional
DF-11	China	350	Conventional/2-20kt
DF-12	China	400	Conventional/nuclear
DF-15	China	600	Conventional/50-350kt
Prhar	India	150	Conventional
Pragati	India	170	Conventional
Pralay	India	500	Conventional
Pranash	India	200	Conventional
Prithvi-I	India	150	Conventional/nuclear
Prithvi-II	India	350	Conventional/nuclear
Prithvi-III	India	750	Conventional/nuclear
Fateh-110	Iran	300	Conventional
Fateh-313	Iran	500	Conventional
Fateh Mobin	Iran	300	Conventional
Quiam 1	Iran	800	Conventional/possibly nuclear
Raad-500	Iran	500	Conventional
Samen	Iran	700	Unknown
Shahab-2	Iran	750	Conventional
Tondar-69	Iran	150	Conventional
Zelzal-1	Iran	150	Conventional
Zelzal-2	Iran	210	Conventional
Zelzal-3	Iran	250	Conventional
Zolfaghar	Iran	700	Conventional
LORA	Israel	300	Conventional
Predator Hawk	Israel	300	Conventional
Hwasong-5	North Korea	320	Conventional/chemical
Hwasong-6	North Korea	500	Conventional/chemical
Hwasong-7	North Korea	995	Conventional/possibly nuclear

Missile	Country	Range (km)	Warhead type
Hwasong-11	North Korea	220	Conventional/nuclear/chemical
KN-23	North Korea	700	Conventional/nuclear
Abdali-I	Pakistan	200	Conventional
Ghaznavi	Pakistan	320	12/20kt nuclear
Hatf-IB	Pakistan	100	Conventional
Nasr	Pakistan	90	Conventional/0.5-5kt
Shaheen-1A	Pakistan	1,000	Conventional/nuclear
9K720 Iskander	Russia	500	Conventional/nuclear
OTR-21 Tochka-U	Russia	180	Conventional/nuclear/chemical
J-600T	Turkey	900	Conventional
Hrim-2	Ukraine	500	Conventional
ATACMS	US	300	Conventional/nuclear
PrSM	US	500	Conventional/nuclear
Burkan-1	Yemen	800	Conventional
Burkan-2	Yemen	1,000	Conventional
Qaher-1	Yemen	250	Conventional

11.5 SLBM - Submarine Launched Ballistic Missiles

Missile	Country	Range (km)	Warhead type
M51	France	10,000	6-10x110-300kt MIRV
JL-2	China	8,000	1Mt RV/ 1-3x20/90/150kt MIRV
JL-3	China	12,000	3 MIRV
K-4	India	4,000	Nuclear
K-15	India	1,500	Nuclear/conventional
Pukguksong-1	North Korea	2,500	Nuclear/conventional
R-29RMU2	Russia	12,000	4x500kt/12x100kt MIRV
RSM-56 Bulava	Russia	9,300	6-10x1—150kt
Trident II	US	12,000	1-12 Mk-5 475 kt / 1-14 Mk-4 100 kt/90 kt/5-7 kt

11.6 HM - Hypersonic Missiles

Missile	Country	Range (km)	Warhead type
DF-17	China	2,500	Conventional/nuclear
BrahMos-II	India	1,500	Conventional/probably nuclear
Shaurya	India	1,900	Conventional/nuclear
Kinzhal	Russia	2,000*	Conventional/5-50kt nuclear
3M22 Zircon	Russia	1,000	Conventional/200kt nuclear
Avangard	Russia	**	800kt-2Mt nuclear

*Including the range of MiG-31K carrier aircraft
**Launched by Topol M, Yars, R-36, RS-28, Bulava.

11.7 SCM - Supersonic Cruise Missiles

Missile	Country	Range (km)	Warhead type
BrahMos	India	500	Conventional/nuclear
P800 Oniks	Russia	800	Conventional/nuclear

12. A1 system cost

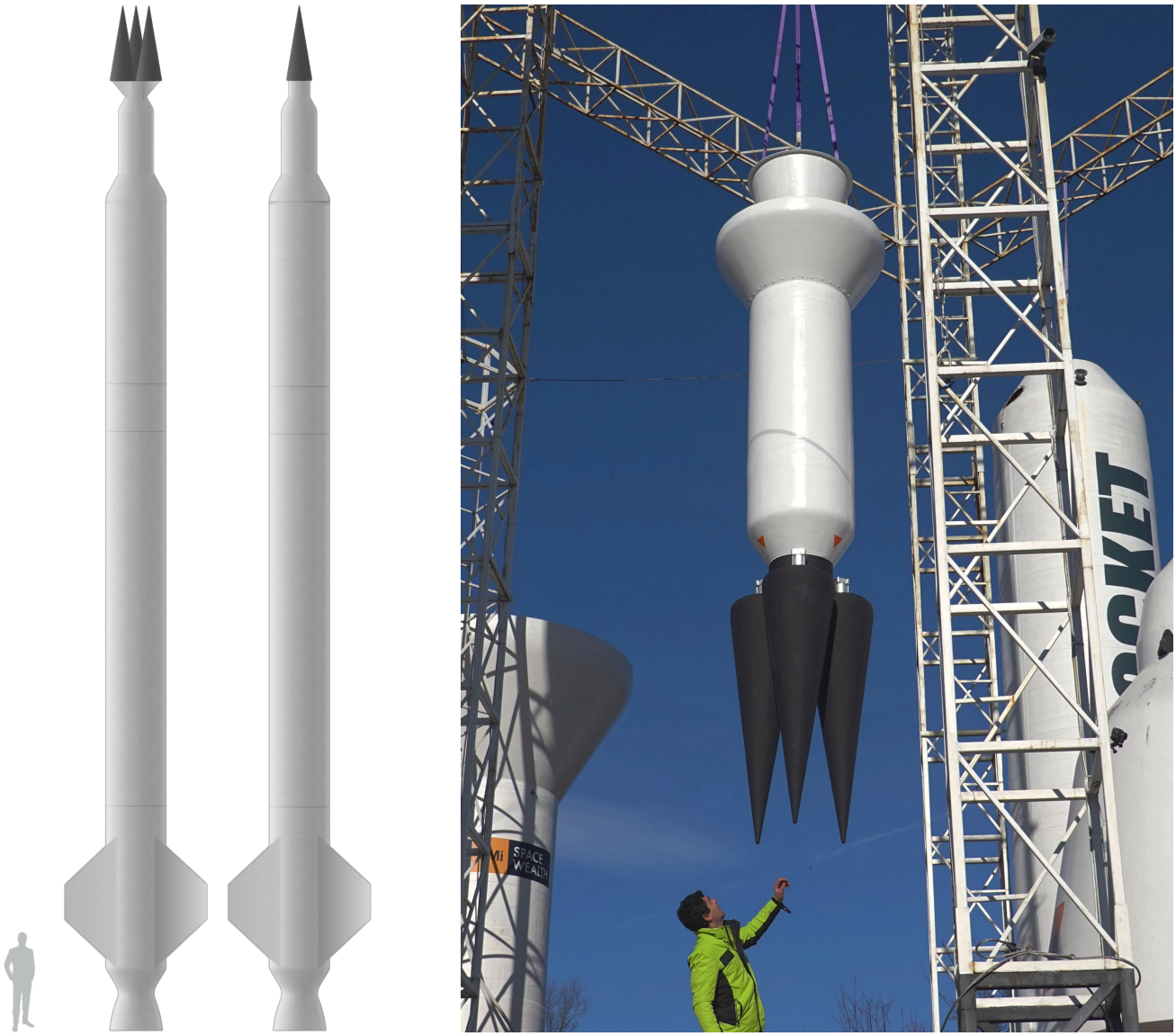
The cost of A1 interceptors is low because they carry no guidance systems and use benigne propellant. Thus, they are probably the most affordable anti-missile defence devices in the world at the time of this document (January 2024).
The table below shows the prices, VAT excluded, for the A1 interceptor, canister, command station and accessories:

	Price [€]	Price [€] in AMiE*
A1 interceptor**	699,900	629,900
Launch canister	69,900	62,900
Command station	29,900	26,900
4 IRST detection units	Not defined yet	
Accessories	29,900	26,900

* If the A1 system components are purchased using ARCA's crypto token, AMiE, a 10% discount is applied.
** The prices for A1A and A1B interceptors are the same. For orders of a squadron of A1 or more, custom discounts apply.

13. Operationalisation, testing and operator training

ARCA will fully support all customers in their efforts to operationalise A1 interceptors, and will make optimum deployment suggestions, based on the operator's needs in relation to protected assets, geography, incoming threats, and so on.
ARCA also manufactures Hypersonic Reentry Target Vehicles (RTVs), supersonic MIRTVs (Multiple Independent Reentry Target Vehicles) and STMs (Supersonic Target Missiles). Thus, customer may choose to purchase target systems for A1 training, along with their desired assortment of interceptors.
More details are available at ecorocket.space



The Mach 4.4 MIRTV and Mach 6.6 RTV vehicles that can be used for A1 training

14. Who this product is for

The A1 is a strategic, low-altitude interceptor that targets ballistic, hypersonic and supersonic missiles employed in nuclear and conventional strategic, sub-strategic, and tactical strikes.

14.1 Nuclear and non-nuclear countries

Nuclear countries can use A1 interceptors to defend military and civilian assets against nuclear and non-nuclear attacks. A good example is Israel, a nuclear country that has been attacked with conventional ballistic missiles several times in the past decades.

However, non-nuclear countries are the most vulnerable to nuclear strikes as they have no capability to respond in kind. This scenario unfolds presently in Ukraine, where the risk of a nuclear strike against the country was intensely discussed and even promoted by its neighbour in the first months of the war.

Also, non-nuclear countries can be subject to conventional strikes using ballistic, hypersonic and supersonic missiles. We have seen this on numerous occasions over the past decades, but never at such a large scale as, again, in Ukraine.

As Russia unleashed ballistic, hypersonic, supersonic and subsonic missile attacks at a level that the world has never before seen, Ukraine has been able to efficiently counter cruise missile attacks. Intercepting ballistic, hypersonic and supersonic missiles was significantly more difficult.

The past years have shown that the world is more likely than not heading towards a difficult period, pushed by changing economic circumstances, creation of new alliances, and an ever more ruthless search for all kinds of resources.

Nuclear countries, which also have significant conventional forces, may choose to project their military strength through ballistic, hypersonic and supersonic missiles. Here, the A1 interceptor is designed to respond against all such attacks, nuclear or not.

14.2 Conclusions

The A1 strategic interceptor is a one-of-a-kind weapon, offering interception capabilities at an altitude where no other anti ballistic system can operate. As of January 2024, no similar product is available anywhere else in the world.

The A1 is suitable for both nuclear and non-nuclear countries, to defend against both nuclear and conventional strikes delivered by ballistic, hypersonic and supersonic cruise missiles.

15. Partnership program

The A1 Partnership Program is designed to enable military customers to participate in the development phase of the A1 interceptor, to localise part fabrication, and to benefit from discounts for future purchases.

Tier 1 - EUR 4,000,000
Tier 2 - EUR 3,000,000
Tier 3 - EUR 2,000,000
Tier 4 - EUR 1,000,000

	Tier 4	Tier 3	Tier 2	Tier 1
Participation in technical development				X
Participation in deployment architecture			X	X
Participation in testing phase		X	X	X
Participation in interception testing	X	X	X	X
Parts fabrication, up to 10%	X			
Parts fabrication, up to 20%		X		
Parts fabrication, up to 30%			X	
Parts fabrication, up to 40%				X
First ten squadrons purchase discount, 5%	X			
First ten squadrons purchase discount, 10%		X		
First ten squadrons purchase discount, 15%			X	
First ten squadrons purchase discount, 20%				X

16. Orders

The A1 can be ordered from December 2024. However, reservations can be made immediately for a 10% advance payment. Deliveries will be made based on a first come, first served basis. Partnership Program participants will have priority over any other orders.

17. Purchase eligibility

Due to A1’s minimal features and characteristics, such as the lack of a guidance system, the low flight range, and the engine performance (3-4 times less than that of a typical military rocket), it is unrealistic to use this product as an offensive weapon. Nonetheless, we reserve the right to refuse sales to any prospective buyer, based on our own internal criteria. For instance, if the purchaser’s country of origin is currently at war, then the sale might be denied.
As sales are determined on a case-by-case basis, please contact us for any inquiries, and we will promptly inform you if we can go forward with your purchase request.
The same criteria apply to the A1 Partnership Program.

18. FAQ

18.1 Operations

How difficult is it to prepare the A1 interceptor for launch?
The A1 interceptor is very easy to operate and prepare for launch. Follow the instructions from the User Guide and Operation Manual that are provided with the product. The process should be straightforward.

How difficult is it to place the A1 interceptor in the canister?
The A1 rocket has dedicated lift elements to which lifting devices can be attached. The rocket is placed in the canister in vertical position through the top of the canister.

What propellant does the A1 rocket use?
The A1 rocket uses a mixture of 50-50 water and hydrogen peroxide, commercially available as hydrogen peroxide 50%.

How much does the hydrogen peroxide 50% cost?
Depending on the region, prices for hydrogen peroxide 50% are between €0.5 and €1 per kg.

How difficult is it to procure hydrogen peroxide 50%?
The hydrogen peroxide 50% is commercially available and easy to procure in almost any part of the world. 50% hydrogen peroxide is even available in regular DYI stores.

How dangerous is hydrogen peroxide 50%?
You must avoid ingesting hydrogen peroxide 50% or getting it in contact with your eyes and skin, by wearing goggles and gloves during manipulation. In case of contact with your eyes and skin, always have fresh water available and apply it in abundance on the the contact region. The skin may turn white in the contact region, but it will regain the normal colour in about two hours. Please carefully read the Safety Data Sheet provided with the product.

18.2 Features

Is the A1 interceptor reusable?
The A1 interceptor is not reusable after flight. However, the launch canisters, command station, and the accessories are all reusable.

Is it possible to use the A1 rocket as a weapon?
The lack of a guidance system and on-board avionics, as well as its extremely low range make the A1 rocket completely unsuitable for offensive purposes.

18.3 Reservations and orders

How can we order the A1 interceptor?
The A1 interceptor will be available for purchase in December 2024. However, if you want to make a reservation, you can do so by emailing contact@arcaspace.com. A 10% down payment is required for a reservation. Deliveries will be made on a first-come, first-served basis.

How long is the lead time for our order?
Lead times depend on order size. Usually, for a complete A1 interceptor, shipment takes place 90 days after payment is received. After the first unit is delivered, the following ones should arrive at 60-day intervals.
For larger orders, including a 12-unit squadron, the shipment date will be communicated before payment.
These lead times are valid as of January 2024, and may change as our manufacturing facilities develop.

Can we get a refund after having placed an order for A1?
Once you have placed an order and paid for A1 products, we start preparing and executing the manufacturing process. From that moment, refund is no longer possible.

Will we a get a discount for A1 products if paid in AMiE tokens?
Yes, you will get a 10% discount if you pay in AMiE crypto tokens.

What is the delivery cost for an A1 interceptor?
The product(s) will be shipped from Romania and the cost depend on the destination. For instance, the delivery of an A1 interceptor to North America is around €19,000. For deliveries in Europe, the cost is significantly lower.

18.4 Partnership program

How useful will be for a country's military to join the Partnership Program?
The main advantage of joining the Partnership Program is the possibility to provide input in the development phase. That input will reflect in cost and operational characteristics when the A1 enters service.
There will also be a financial advantage (price discounts), as well as the opportunity to manufacture A1 components in the customer's home country.

19. Legal considerations, risks disclaimer

PLEASE READ THE ENTIRETY OF THIS "Legal Considerations, Risks and Disclaimer" SECTION CAREFULLY.

The issuer is solely responsible for the content of this User Guide. This User Guide has not been reviewed or approved by any competent authority in any member state of the European Union. To the best knowledge of the issuer, the information presented in this User Guide is correct and complete without any significant omission.

The information shared in this User Guide is not all-encompassing or comprehensive and does not in any way intend to create a direct or indirect contractual relationship. The primary purpose of this User Guide is to provide potential product buyers with pertinent information so as to help them thoroughly analyse the A1 products and program, and make an informed decision.

IF YOU ARE UNCERTAIN AS TO ANYTHING IN THIS USER GUIDE, WE STRONGLY URGE YOU NOT TO PURCHASE THE A1 OR JOIN THE PARTNERSHIP PROGRAM.

20. Contact

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