Acoustic Stealth

(Now & Future)

CC Paulson
(13110)

Abstract

To the general pubic, stealth is a relatively new thing and to most totally revolves around radar and hiding from it. Although that part is true, it is only one aspect of stealth. Stealth is hiding from all types of sensors. That includes: Electromagnetic; Infra-red; Visual, acoustic and any other sensor not already named. Since an air sonar type system does not yet exist, to most military personel “Acoustic Stealth” is probably the least important item in the above list. However to MUFON it is very important. In many of our cases, the factor separating the UFO from a known vehicle is its silence. Therefore, this paper has been written to acquaint MUFON members with what Acoustic Stealth means today and what may be in our future.

Contents

Acoustic Stealth

It is the author's recollection that the first stealth flying craft he heard of was a "Bird of Prey" flown by Klingon warriors. Fortunately for the Federation it wasn't perfect. When cloaked, the system left an "energy surge" that could be picked up on close-range sensor scans; the ship had to uncloak to use its shields and weapons systems; and it was determined there was a couple second delay between activating / deactivating the cloaking system and deactivating / activating the ships shields.

Since the "United Federation of Planets" is yet to be incorporated and we haven't yet met a Klingon starship what has this opening got to do with MUFON's sightings? It is a statement that no weapon or defense system is ever perfect. For any offensive or defensive technology, there is a corresponding technology to defeat it. Stealth is therefore an ever-changing science providing ever-changing glimpses to its witnesses. That is not to say everything we see is a result of Earthly science but we should be aware of what is being done here in order to recognize those few grains of non-Earthly wheat.

Stealth is not a single thing. We all know it includes Radar stealth; but its not so well known that, it should also include Electromagnetic Stealth, Visual Stealth, Heat (IR) Stealth, Acoustic Stealth, and for viewers of "Under Siege 2" Turbulence Stealth. This paper is attempting to describe what can presently be done and what may be possible to do in the near future in the milieu of the acoustic facet of stealth science.

1.0 The Present

Acoustic stealth is well known in submarines. In the air, however, sound is considered by many as the least important element of stealth. However, for any design to be truly stealthy some thought has to be given to reducing the ability of acoustic sensors to locate the craft. Present examples are the B-2[1] Spirit bomber and the Special Operations stealth modified MH 60 Black-Hawk helicopters.

1.1 The B-2 Spirit bomber

In today's known aircraft, Acoustic Stealth is probably epitomized in the design of the Northrop-Grumman B-2 Spirit bomber. Anyone who has seen and heard a B-2 Spirit take off or fly by is astonished by how quiet it is. Various writers have described it as incredible, shocking, eerie, and many other terms. The following figure is a picture of a B-2 on take off at the 2005 Edwards Air Force Base air-show.

Figure 1: B-2 Spirit of New York taking off; Edwards AFB 2005

One source[2] has stated that a B-2 “is so quiet that it will fly over your head at 500 feet and you would not hear a thing”. Another source, a Northrop Grumman document[3], describes football fans watching a B-2 flyover. It mentions how after seeing jets going over with their afterburners roaring, the B-2 was found “disappointingly quiet”. Many other similar statements can be found on the net. Since data on the B-2 is obviously scarce, the rigor of these statements is unknown. They do however make one consider this airplane in a new light.

Statements such as those above all lead to one unmistakable conclusion; silence should no longer be used as the one factor that distinguishes an Alien UFO from Earth built one. The B-2 is already flying with this characteristic. Granted there are presently only 21 B-2s in existence, but they do exist. It is believed that presently most of the B-2s are stationed at Whitman AFB in Missouri and 1 at Edwards AFB in California. It would seem prudent to consider them a possible source if a MUFON “silent triangle” sighting occurs in the vicinity of those bases.

1.2 Mechanization of the B-2

As stated above, the B-2 is a very silent aircraft. This section is a description of some of the reasons for that silence. Although the design of a B-2 is obviously secret, there are clues that can be discerned just by looking at the plane. Two of them are related to what makes an airplane inherently noisy. They are the slipstream (turbulence of the air flowing past the airplane) and the engine.

That last statement indicates, acoustic stealth is a complete design problem, not just an engine choice. It requires a systems approach to remove the tail, flaps, spoilers, ailerons, jagged nozzles, doors, nacelle parts, etc. To fly the plane, the effects of those parts are still required but different ways to accomplish then were needed.

Its obvious the plane is very smooth but how are the other requirements met. The tail and ailerons (flaps on the tail to provide lateral motion) function is provided by independent control of the four engines. Multiple small flaps have been built into the wings in such a manner as to maintain smooth airflow while optimizing the camber of the wings for the speed desired. The four engines are buried in the wings with exhaust directed upward rather than directly to the rear. It is assumed the engines are non-afterburner high-bypass-ratio turbofans. Those engines are very efficient in that they ingest a large amount of air and move it just a little bit. A reduction in the exhaust temperature is obtained by mixing it with external air before releasing it.

In addition to lowering slipstream noise from turbulence, making the plane as smooth as possible has a secondary advantage. It reduces drag. Effectively that means the air offers less resistance to the planes movement. It is the author's opinion that these noise abatement features may be the most interesting aspect of this airplane.

Before leaving this section it should be noted that despite the efficiency and noise reduction advantages of the B-2 engines, they are not the engine of choice for most combat aircraft. Combat aircraft normally use low-bypass-ratio engines since they provide more thrust, acceleration, velocity and maneuverability.

1.3 MH 60 Stealth Helicopters

The helicopters used in the Bin Laden raid show had a very low sound signature. The two attached figures are from "Good Morning America" (ABC). Both are for modified Sikorsky Blackhawk MH 60 helicopters. It was stated on the newscast that when flying low, a witness would not hear the new version until it was directly over him. Additionally even then, he would probably think the helicopter was going away rather than hovering directly over. In these figures the peaks looked to have decreased by about a factor of 2 or 3. Since power is proportional to the square of the waveform and sound intensity is proportional to that power, the above reduction reduces the sound intensity by factors of 4 to 9. The sound unit normally quoted is the decibel. The equation comparing two noise signals of powers P_1 and P_2 is given by:

: $$\text{Noise Reduction (db)} = 10 \log_{10}(P_2 / P_1) .$$

Figure 2 Standard Sikorski MH 60

Figure 3 Stealth Sikorski MH 60

This indicates a noise reduction in the above figures of 6 to 9.5 db. According to a NASA publication, the 6 db reduction is "Substantially Quieter" and the 9.5 db reductions is approximately "Half as Loud". Additionally since Intensity of a point source drops off as the square of the distance from the object, it indicated that the witness will hear what would have been heard if the original helicopter was 2 or 3 times farther away.

It should also be noted that the above is from what has been released. It is safe to assume the real numbers will be better. The following section provides a discussion of the modifications used to make the MH 60 helicopter stealthy.

1.4 MH 60 Stealth Helicopter Mechanization

The assumed modifications discussed below to the Sikorsky MH 60 helicopter to reduce its noise signature mainly come from past helicopter projects and pictures of the crashed copter used in the Bin Laden raid. In term of radar stealth, the helicopter' is known to be similar to an F-117 Stealth Fighter with hard sharp edges and a special radar absorbent windshield coating.

There are two fundamental systems that contribute to both near-field and far-field noise on a helicopter. They are the main rotor and tail rotor. Typically, engine noise is of secondary importance. One of the problems the came about due to the wreckage left in Pakistan is that the explosives used to destroy the remains did not destroy the tail rotor section. Photographs of it seemed to jump onto the internet immediately after the raid creating a great deal of speculation about almost intact section. The military attempted to gloss over the plate covering the tail rotor by referring to it as a "hubcap". Actually the hub or cowling or whatever it is called is most likely a noise baffle.

Figure 4: Tail Section of Crashed MH 60 Stealth Helicopter

A helicopter's main rotor mainly generates low frequency noise and some high amplitude low-to-mid-frequency noise modulated at the blade rotational frequency. During descent it also generates Blade Vortex Interaction noise. Finally there is also a High Speed Impulsive noise generated during high speed operation. It is unknown exactly how these sources

were handled but all can be minimized by rotor design. This includes more blades arranged non-equally spaced and modifying the airfoil shape

Increasing the number of blades reduces the speed of any single blade tip thus reducing the noise. The blade number also alters the frequency distribution of the sound generated. Modulating the blade spacing and using airfoil control (X-Force* control) to even the force, breaks up the acoustic spectrum of the blade passage. The acoustic effect of uneven blade spacing is to generate several blade-passage frequencies, one for each unique angle between blades. Each blade passage frequency, in turn, generates its own set of harmonics. The total acoustic energy is thereby spread over a broader range of frequencies, rather than being concentrated at one blade-passage frequency and a single set of harmonics. It should be noted this design method would probably be utilized on the tail rotor also.

The most direct method of controlling Blade Vortex Interaction noise is by reducing or diffusing the tip vortex. Tip shapes such as the sub-wing, swept ogee, or others have been shown to cause measurable reductions in this noise by modifying the vortex structure.

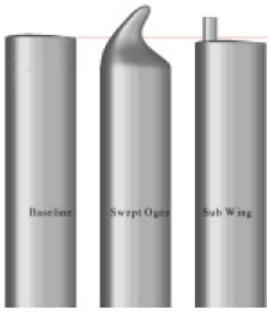

Figure 5[4]: Rotor Blade Tips

In Figure 5 the blade tip to the left is a standard blade tip; the one to the right is sub-wing tip; and the center one is a swept ogee tip.

2.0 Atmospheric Effects

It may be noted that Northrop–Grumman document referenced in Section 1.1 only said “quiet” and not silent. “Ambient Noise, Wind, Temperature, and Atmospheric layering all combine to make sound a rather unreliable”[5] factor in describing how quiet or silent an object actually is. This section will provide an overview of how the atmosphere can affect sound that is heard.

- **Ambient Noise**: The effect of background noise is relatively easy to understand. We have all had to strain to have a conversation with someone next to us in a crowded room. By asking a hearing disabled person what that situation is like to them we would learn speaking louder almost doesn’t matter. The total sound seems to mask everything into an undistinguishable roar.

Wind[6]: Wind is also not difficult to understand. As we know, sound consists of a series of compression and rarefaction waves in air. Normally due to surface friction, wind velocity increases with height (positive wind gradient). If there is only this positive gradient and no temperature gradient, due to changes in the speed of sound, sound waves downwind will be refracted (bent) downward and upwind will be refracted upward. The upwind refraction produces a shadowed area where sound does not penetrate; it is almost as if the wind is blowing away the sound. This effect is illustrated in Figure 6. In this figure the wind is going left to right and the shaded area represents the shadowed area.

* See Appendix A

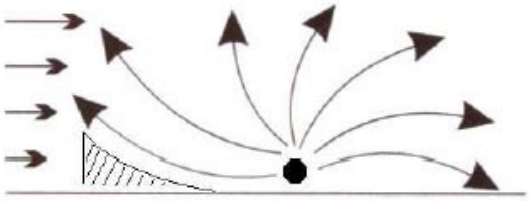

Figure 6: Effect of Positive Wind Gradient on Sound

- **Temperature[7]:** The effect of a temperature is similar to that of wind except it is not direction dependent. A positive temperature gradient means the temperature rises with altitude. That is normal in the daytime. If there is a positive temperature gradient but no wind gradient sound waves on both sides of the source will be bent downward. Although in general, temperature does rise with increasing altitude, it actually decreases slightly for the initial 10-20 km. Coupling that negative gradient with a null wind gradient will bend the sound waves upwards and produce a shadowed area ringing the source. If there is also a wind gradient, the effect in the upwind direction is magnified.

- **Atmospheric layering:** Atmospheric layering refers to any of a number of strata or layers of the earth's atmosphere. The criteria denoting the layer and its most common cause, is temperature. Since we are considering airships, a thermal profile in which warmer air is near the surface (normal profile) will create less dense air at the surface and sound will refract upwards, resulting in a reduced sound intensity reported by an observer.

Figure 7 is an empirical graph of the Earth's atmosphere. The item of interest in it is the maximum at about 50 km. Any noise produced between the two minimums on either side of that

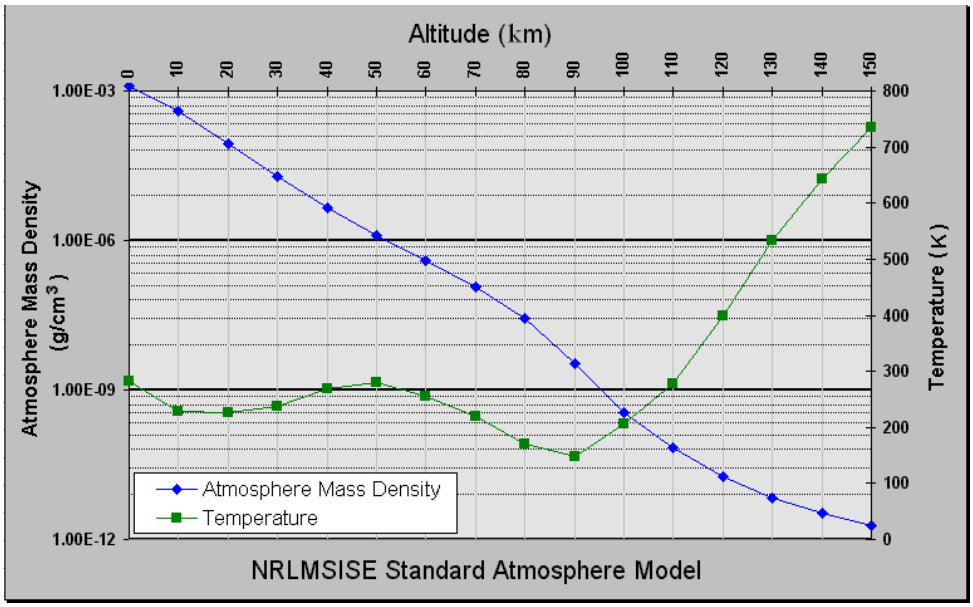

Figure 7[8,9]: Naval Research Laboratory: Empirical, Model of the Earth's Atmosphere

Location, will see an increasing temperature pointing toward the maximum. It will therefore refract in that direction until it is at the 50 km point. From that point on, regardless of which direction the wave tries to move, it will be bent back to the maximum. In essence, in this model, that location is a pipe that exists totally around the world. This interests the author because essentially the same thing exists in the ocean. That is the SOFAR[10] (Sound Fixing and Ranging) channel. Whales go there to "talk" and submarines go to listen for other submarines. Anyone who has seen "The Hunt for Red October" has seen this channel in action. In that movie, the operator had to eliminate ambient noise and search in the silent ranges for sounds specifically related to the Red October. Since the B-2 is provided to the air-shows such as the

2005 Edwards AFB show, it is the authors opinion that many militaries have already recorded B-2 flights to obtain the sounds needed. This possibility of a passive "sonar" type of determination and location has been raised because it is exactly what should be expected of militaries. It would be nice if MUFON could emulate them to separate UFOs, but assuredly it would be much too expensive.

3.0 The Future

Although the title of this section refers to a possible future of the US military, it actually may already be the past. That is difficult to determine with the obvious secrecy involved. Although it is not provable, it is the author's opinion that some of the sightings we are presently receiving are military prototypes or military vehicles already in service.

Consider the "silent triangle" sightings that seem to have become so prevalent. Initially those sightings seemed to be almost all at night with "daylight" sightings seemingly occurring mainly during twilight hours. Recently, however, daylight sighting have increased dramatically. There should always have been a question of why were they initially so "timid". What were they afraid of? It seems the only reasonable answer would be they were afraid of what people may see; and that implies an Earthly origin.

Aside from sighting times what are the characteristics of these crafts? They are large; they are silent; they can hover; and (at least high in the sky) they can move rather rapidly. At this moment we are mainly concerned about the silence when close to the ground. In this case the word is "silent" not "quiet". These craft are also capable of hovering, which the B-2 cannot do. That actually eliminates planes as we know them. Silence can be obtained by having engines that are basically silent and possible deflecting any remnant sound upwards. As stated in a previous document we need engines as silent as possible. That rules out internal combustion of any kind and even small nuclear plants. In terms of today's science it can be assumed the engines would be electric motors powered by batteries. The most silent engine to use for recharging the batteries would be a Stirling engine (engines noted for their silent operation). This is a well known system presently being used in small submarines.

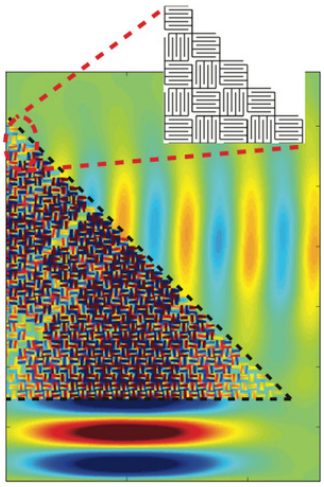

Figure 8: Meta-material Acoustic Blanket

Since the craft will still probably be noisy, it is also assumed the remnant noise will be shunted upwards. This is not as difficult as it seems. In March of 2012 Zixian Liang and Jensen Li published an article in Physics Review Letters[11] concerning a 2 dimensional meta-material blanket that can completely deflect sound around corners. Figure 8 shows sound entering their design from the bottom and being totally refracted to the right. Although a great deal of design and experimentation is still required, it seems likely a thin coating of this material would supply the needed acoustic blanket.

4.0 Conclusion

Pretty much everything discussed above is from publically available information. Additionally it has been shown aircraft presently being flown can be mistaken for UFOs. What really makes being a MUFON Field Investigator difficult though, is knowing that for everything we see from the military there is something we can't see that may be 20 years ahead. Going back to the silent triangles, what is their purpose? The author is aware that most people that think they may be of Earthly origin consider them to basically be large cargo transports. The problem with that thought is then why would they be secret?

The author would like to propose another possibility; that they are the prototypes for the aircraft carriers of the future. To make the thought even wilder, the author is not even sure the term **air**craft is correct. Flying craft may be the better term. There is no reason to believe that the military believes air is a limiting factor. In fact, if one looks at recent history, it is just the opposite (at least in terms of the Army and Navy). A not well known fact is that SDI was lead by the Army, not the Air Force. The Army was in charge of and evaluated all projects and they were very good at it. They are much more future-oriented than they are normally given credit for.

The interesting thing in the statements made above is that this author is normally not one who believes in huge conspiracies. The statement that the military is planning years ahead is not seen as a conspiracy. We all plan for possible things in our future. For obvious reasons the military's plans are just little bigger than the plans most of us have.

What not too long ago would be considered Science Fiction could be normal today and even history tomorrow.

5.0 References and Comments

1. The author has to admit that he did not know how quiet the B-2 was until researching this paper.
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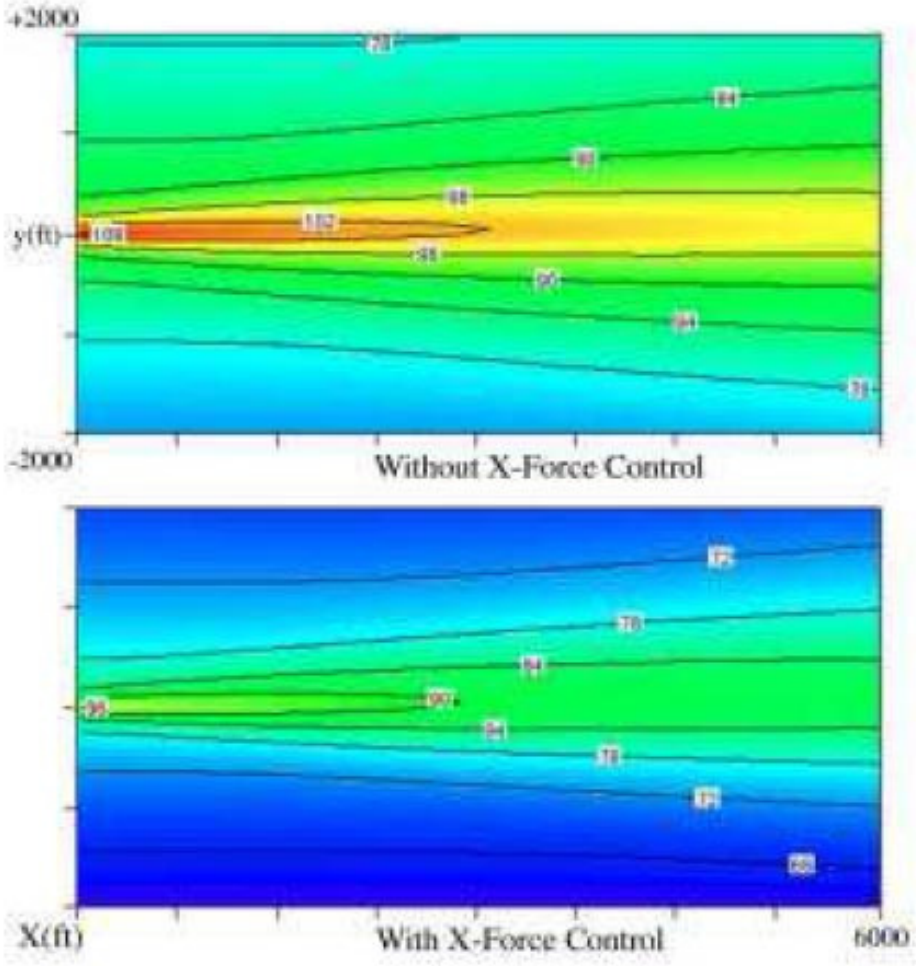
4. Edwards, B., Cox, C.; "Revolutionary Concepts for Helicopter Noise Reduction", NASA/CE-2002-2011650; pg 3-9
5. Kohout, J. J.; "Stealth in Context; The B-2 Bomber: Air Power for the 21st Century"; NYU Press; 1995; page 143
6. Drahos, M., Drahos, R.,; "Influence of Meteorological Conditions on Propagation of Sound"; pg 2
7. ibid; pg 2
8. Wikipedia; http://en.wikipedia.org/wiki/NRLMSISE-00
9. Hansen, D. B.; "Examination of Three Empirical Atmospheric Models"; Space Weather Center Technical Report; 2010; NRL MISE Model Pg 31; National Research Council Model, Pg 4; IRI Model does not show the altitudes interested in, The first pip on the scale is 160 km; The HWM does not plot temperature
10. Wikipedia; http://en.wikipedia.org/wiki/SOFAR_channel
11. Liang, Z., Li, J.; "Extreme Acoustic Metamaterial by Coiling Up Space", PRL **108**. 114301, 2012

12 ibid ref 4; Pg 3-2

Appendix A

X-Force

Wake vortices are constantly shed from the rotor tips of an operating helicopter. In a plane centered on the rotor huh and moving with the helicopter, these vortices are shed backwards from the 90 and 270 degree locations due to the forward velocity of the helicopter. Blade Vortex Interaction (BVI) is noise that is generated when a blade following the one that shed the vortex, passes through the vortex. When that occurs, the resulting pressure gradients produce a series of acoustic impulses at the blade passage frequency. X-Force control remedies this situation by tilting the rotor of the helicopter thus removing the trailing blades from the plane the vortices are in. In order to maintain normal flight the control system also modifies the camber of the airfoils (tilt of the rotor blades) to offset the effect of the tilted rotor.



Predicted Ground Noise without / with X-Force Control at 3° Approach Angle[12]