

DEFENSE SYSTEMS AGAINST ROCKETS & MORTARS

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Purpose

- Show that the selection of “Iron-Dome” as a **sole solution** is a **strategic mistake**, severely threatening the nation security and economy
- Show that “Skyguard” is a much more cost-effective solution
- Show that there is a place to evaluate an **integrated Skyguard/Iron-Dome solution**, that will enable **destruction of essentially all threats in minimal cost**
- Convince to take the immediate actions needed for the implementation of the Integrated Solution

Presentation content

- Consequences of the “Nagel’s committee” decision
- Skyguard – pros & cons
- Solid State Laser (SSL) – still a “science fiction”
- Skyguard's “Operational Philosophy”
- Skyguard – deployment & availability
- **Recommended – integrated solution**
- “Apple to apple” economical analysis & comparison
- Response to MAFAT's negative remarks regarding Skyguard

Consequences of the “Iron-Dome only” resolution

- Iron-Dome cannot provide protection against short range missiles (Shot from 4 – 6 Km) and mortars
- Thus not able to protect all “Gaza Strip” population from its main threats
- Same for all population in the North, close to the Lebanese border
- Iron-Dome is a “price-wise” prohibitive solution:
 - A “kill cost” (2 missiles) is around 160,000\$ - 240,000\$
 - We will never have enough missiles – leads to partial defense only
 - Significant portion of the damage WILL NOT BE PREVENTED
- **Prevents protection that could have already been implemented:**
 - **Nautilus / THEL could have been deployed on July 2007**
 - **Skyguard's deployment could have started on JULY 2008**

Consequences of the “Iron-Dome only” resolution (cont.)

- “Preferential Defense” will never be accepted by the population
- A proven Laser technology and an immediate low-risk, very effective solution (Nautilus, Skyguard) were simply “thrown away”
- The “Will be ready in 2 years” promise (**not** commitment) for “Iron-Dome” deployment continues to slide...

CHEMICAL LASERS

- A matured and proven technology
- Energy results directly from burning fuels
- No need for large power supplies
- No need for large heat exchangers
- Modular scale-up to Megawatt class power
- Eye-safe
- Effective range of a Ground-based lasers (Like the 1 Megawatt SkyGuard - SG) – 10km
- SG on C-130 (ARIEL) – 150km
- Airborne-lasers (ABL) – 500km
- Space-based lasers (SBL) – 10,000km

GASES & FUELS

- Nitrogen Fluoride (NF₃), diluted to 24%
- Hydrogen (H₂) / Deuterium (D₂), diluted to 9%
- Ethylene (C₂H₄), diluted to 7%
- Helium (He), 90% of the flow, heat absorbent
- JP8 & Oxygen (O₂), for the ejector

- All:
 - **Commercially available**
 - **Inert, non-toxic**

EXHAUST GASES

- Fluoric Acid (HF/DF), 1-2% of the flow
- Carbon Fluoride (CF₄)
- Helium (He), 90% of the flow
- Steam
- Scrubber (Calcium Hydroxide)
 - → HF/DF only a few ppm
- Safety range: 100m (w/o scrubber),
 - 30m (w scrubber)
 - (Safety range for launching a Patriot missile is 300m)

(NAUTILUS (THEL

- Development: 1996 – 2000
- Goal: protection of Kiryat Shmonah
- Effective range: 3 – 5 km
- 46 successful tests (rockets, mortars, artillery)
- **Available to defend Sderot (In 6 months, \$50M)**

Nautilus Validated Performance

- 46 successful shoot downs***
- 28 Katyusha rockets***
(including salvos & surprise attack)
- 5 artillery projectiles***
- 3 large caliber rockets***
- 10 mortars (including salvo of 3***
 - 7 Medium, 2 Heavy, and 1 Light***
- >90% Kill Probability***

First Katyusha Rocket



June 2000

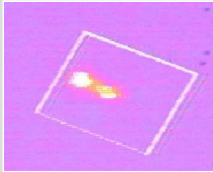
Multiple Katyusha Rockets

Incl. Surprise Attack



Sep. 2000

Mortars



Aug.-Nov.2004

Large Caliber Rockets

June 2004



Artillery



Nov. 2002



Skyguard סקייגארד



Skyguard

- A direct derivative of the Nautilus
- Mechanical design is done. Presented in a successful PDR conducted on August 2005
- Megawatt Class
- Power intensity on target > 4-5
- Four times size reduction
- Effective range: up to 10 km
- Intercept targets within 1-3 sec
- Switch to next target: 1-2 sec

SOLID STATE LASERS (SSL)

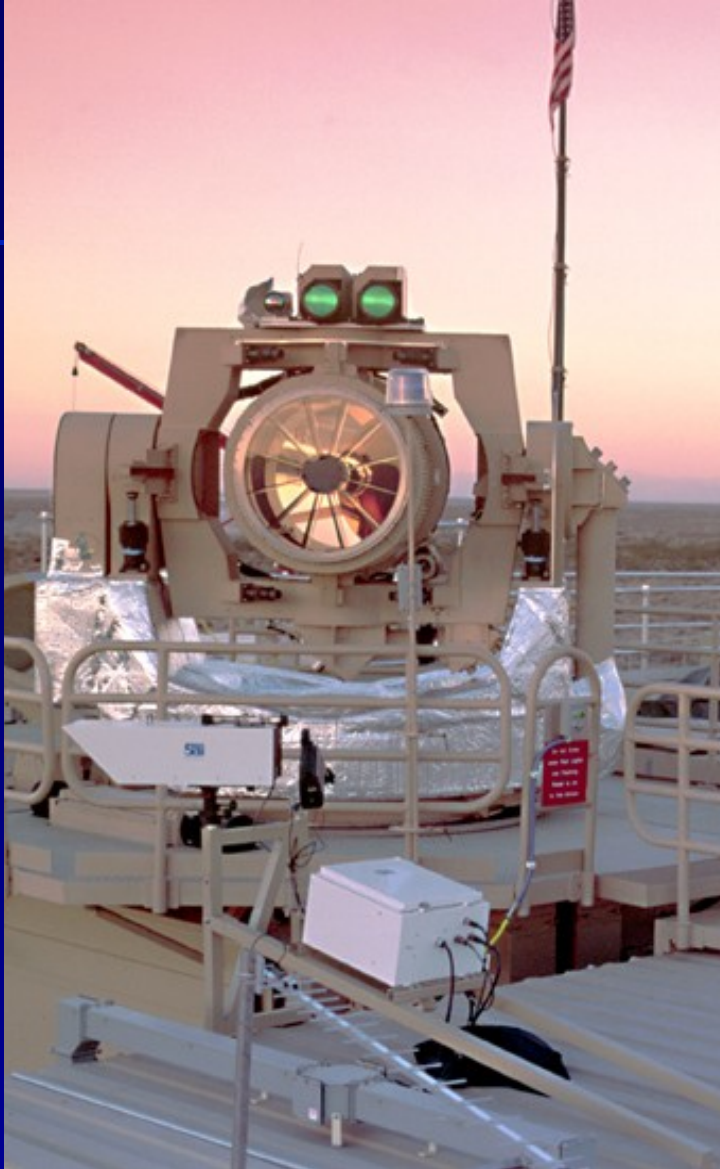
- Technologies: Slabs, Fibers
- **Military application: 7-10 years away**
- Power limit ~ 100 KW
- **→ Effective range: 1-3 km**
- Short wavelength (1/4 of the SG):
 - **Enhanced sensitivity to weather conditions**
 - **It is NOT eye-safe**
- May be used to defend:
 - Mobile units
 - Point targets
 - **NOT large populated areas**

OPERATIONAL CHARACTERISTICS

((Chemical Laser

- Speed of light weapon
- The target's speed & range - irrelevant
- Missing the target - impossible
- The energy burns / explode the target
- No additional mass
- Effective against BC warheads
- Cost per shot – \$1,000 – \$3,000
- Changing magazines: 1 – 2 min (fast switching between magazines)
- Ready to fire state: unlimited in time
- Weather sensitivity:
 - "Below cloud-base" operation
 - Only limitation: dense & low clouds (< 2 – 3 % around the year)

Ground Based Lasers' Applications



Rockets •

Mortars •

Artillery •

RPVs •

Cruise missiles •

SRBM •

Anti-Tank Missiles •

• Large Caliber
Rockets



A Damaged Mortar

Skyguard's "Operational Philosophy"

- It is a simple "philosophy": **KILL THEM ALL!**
- **2 systems will protect each town / strategic site**
- **26 systems** will protect the entire **northern area** – from Kiriat Shmona down to the Haifa / Afula / Beit-She'an line
- **8 such systems** will protect the entire **Gaza-strip area** – from Ashkelon to Kerem Shalom
- **Unlimited fluids supply** – short term purchase in the free market
- **We will always have enough fluids to destroy all enemy threats**
- Self protection capability against all ballistic threats & others
- Preferential engagement only if needed (dense salvo below clouds)

Price & Availability

■ Nautilus / THEL

- For the protection of Sderot & vicinity
- **Deployment in 6 months**
- At a price of \$50M (verbally mentioned)
- Effective against all relevant threats

■ Skyguard

- **First system in 18 months.** Additional units at 2 month intervals
- 310 M\$ for first 3 systems
- 30 M\$ for each production system
- **34 systems (to cover both Northern & Gaza areas) – \$1.24B**
- All under a **firm & fixed price contract**, calling also for delay penalties

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16 January 2007

BG (ret.) Shmuel Keren
Director of Israel Directorate of Defense Research & Development (MAFAT)
Ministry of Defense
Hakiryia
Tel Aviv, Israel

Dear BG Keren:

Thank you for the time you have taken last week to discuss Skyguard with me, for your insightful comments, and for clarifying the urgency with which your organization is looking for a timely and affordable solution to the constant threat of rocket attacks. And finally I want to thank you for your letter dated Dec. 3, 06, and for the opportunity you afforded us to meet with your technical experts and the rocket defense evaluation team headed by BG (ret.) Jacob Nagel.

I want to take this opportunity to assure you once more that our company is fully committed to providing Israel with a rocket defense system. In response to your request we are now prepared to offer performance, cost and schedule assurances for our Skyguard defense system.

I believe that BG (ret.) Jacob Nagel and his evaluation team are now essentially in agreement with us as to the projected performance of Skyguard, especially in terms of the protected area or coverage, and that in principle a single Skyguard unit can defend a town like Sderot or Ashkelon. Two units for each defended city may be preferable, to provide redundancy and enhance system availability and salvo performance in inclement weather. If a decision is made by Israel to order Skyguard, it will be subjected to mutually agreed acceptance criteria to validate its performance.

As for cost and schedule, single unit, for initial deployment, will be provided at a price of \$177M in 18 months. Our preference would be to provide three units at a price of \$310M within 24 months from date of order. All this at a firm fixed price subject to meeting agreed performance requirements. Additional units will cost \$40 to \$50M depending on how many are ordered and at what intervals. Northrop Grumman would be prepared to move forward at its own expense upon commitment by Israel to Skyguard in order to save time. We would be further prepared to accept schedule penalties (and incentives), should there be any deviations from these delivery schedules.

We remain convinced that Skyguard is the best answer for rocket defense. Skyguard is the only proven system available within 18 months that can accommodate new technologies such as solid state lasers or low cost missiles if they become available. We believe that the best answer is to deploy Skyguard, continue development of these alternative technologies and to insert them in the flexible Skyguard system architecture if they work. We hope very much to have the opportunity to deploy this system in Israel.

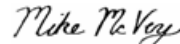
To meet Israel's requirement for rapid operational deployment **we plan to team with IAI** to ensure timely integration and compatibility with the IDF sensor and C3I infrastructure. The best of Israeli sensor and C3I technology from other Israeli firms, including Rafael, will be incorporated, as and if desired by the ~~MoD~~.

Our recommendation is to move immediately now to the operational deployment phase with laser firing units incorporating tested technologies that are inserted within a proven acquisition and tracking sensor network, with firing solutions and command/control infrastructure that can be used not just for lasers but also for projectiles and guns, if such systems are developed and proven to be cost-effective. Northrop Grumman has done such integration of kinetic energy weapons in Iraq. Similarly, in addition to projectile/gun systems, if a new type of laser is developed and proven advantageous, it can be integrated in Skyguard with most of the existing weapon remaining intact. Given this open, adaptable approach, the Skyguard integrated defense system accommodates future evolution by providing ready, critical and mandatory infrastructure. It provides open system development options, thereby fully mitigating technical risks.

Thank you again for the opportunity to present our Skyguard proposal to you.

Please let us know if we can provide further information to you.

Warmest regards,



Mike McVey
Vice President, Directed Energy Systems

Recommended solution

Integrated Skyguard / Iron-Dome System

- Will use:
 - Same Elta's Radar
 - Same C³I
 - 2 types of launchers within a battery – Skyguard and Iron-Dome
- Whenever possible – Skyguard will be used (price & kill probability considerations, expected for more than 90% of all operational events)
- Iron-Dome missiles will be used only in very bad weather conditions / very dense salvos (expected in less than 10% of all events)
- Such integrated system will call for **only a few thousand Iron-Dome missiles to be produced**
- The integration approach will allow:
 - **Shooting down all threats**
 - **During all weather conditions**
 - **At the lowest, affordable price**
 - **Highest kill probability**
 - **Fluent operation. No "ammunition" supply issues**

What has to be done

- Short-term
 - Immediate deployment of the THEL / Nautilus system at Sderot
 - Sign for the first 8 Skyguard systems to allow full protection of all "Gaza Strip" population – Ashkelon to Kerem Shalom
 - Bring Iron-Dome to the scene ASAP, for integrated system evaluation
- "Longer" term
 - Prepare for purchasing additional 26 Skyguard systems for the protection of the Northern area
 - Evaluate the optimal balance between Skyguard and Iron-Dome in terms of "whole country" protection approach
 - Start planning of the fluids supply system for Skyguard

Nautilus / SkyGuard (N/SG) – Iron-Dome (ID) - Cost Analysis principles:

- **Compare solutions not systems (1 system may not provide full solution)**
- **Full solution approach - to all threats (current, improved and future)**
- **Superior solution principle - maintain “superiority gap” over all threats!**
 - #When first time introduced into the battlefield!
 - # Over time (Break through technology edge for superiority gap)
 - # for all current, improved and future threats!
- **Comparison methodology** - compare solution level (not systems – as one system may not offer comprehensive solution)
 - Compare “Apples to apples”
- **LCC (life cycle cost)** – Total cost of all ingredients over relevant period!
 - direct and indirect cost over time.
- **Add relevant cost** - to relevant system for defined solution level!

This is what we will do (highlights) in this presentation

N/SG Comprehensive vs. ID Partial solution - Cost Derivatives....-

- **Skyguard is a comprehensive solution addressing all threats over time:**
 - Superior solution rule – superiority gap is kept over time
- **Iron-Dome is a partial solution with big “holes” in the following areas::**
 - **Range** - ineffective against short range threats, fired below 4–6 Km. Population in these areas - not protected!
 - **Mortars** (one of the main threats) – Can’t cope with them at all
 - **Hit probability** - much less than 100%! 2-3 Iron-Dome missiles per 1 threat would be needed to destroy a target!
 - **Missile cost** - \$80,000 – \$120,000\$. Result: only some 3,500 missiles (per MAFAT) will be produced. Enemy has many more threats (40,000 Hizbulla's, Mortar shells, Cannon projectiles... additional improved threats...) – **a big “hole”!**
 - **Prioritization** - IDF will have to choose/prioritize – what threat to engage? What about the rest? - substantial damage derivatives. Chances prioritization approach will not work/be accepted (While Skyguard can shoot them all down!)
 - **ID missiles** missing the threat will cause additional damage
 - **Over the head explosions** - damage (of 2 missiles)
 - **Other damage - over time - TBD**

ID – Complementary cost - to add:

- Ineffective range of 4-6 km - **Fortification** - an open loop – first round, second round retrofit to meet threats improvements and new threats:
 - Speed – a longer ineffective range...
 - Accuracy - more ID rockets needed
 - Warhead – fortification retrofit.. open loop
- We will be running after the threat. Huge cost and not effective - initiative is in the hands of the enemy!
- LCC of ID - additional element to close gap vs. SkyGuard full solution:
- Mortars – LCC (dev', production, operation, maintenance etc.)
 - Cannon projectiles - LCC
 - SSL – LCC, aimed at same threats
 - Damage cost by all missiles hitting un-protected areas
- Potential damage caused by all threats that will not be intercepted due to the limited amount of ID missiles produced (Price limitation)
- Total exposure when limited amount is exhausted in a confrontation!
- Over the head explosions damage - of 2 missiles (Quassam+ID)
- ID missiles falling in our territory
- ID manufacturing facility - build, cost when idle?
- Availability gap - Nautilus and SG - damage caused in interim period

Total shooting cost of 40k missiles

- Direct shot cost only

Scenario - Shooting down all 40,000 Hizbulla's rockets

Skyguard:

\$**1.24** billion (not \$2B as presented by MAFAT) for all 34 systems (Gaza & North)

\$80 million for 40,000 "shots" (\$2000 average cost per shot)

\$80 million for replenishment

Total: 1.4 B\$

Iron-Dome: for same number of shots:

\$X million for producing 9-18 units

\$300 million (250+ 30% deviation) for development

\$**6.4** billion-\$9.6 billion for producing 80,000-120,000 missiles (2-3 per shot at \$80k)

\$**6.4** billion-\$9.6 billion for replenishment of used 80,000-120,000 missiles

\$**1** billion for building shelters for population in un-protected areas

Total: About \$14.1B-\$20.5 + X = prohibitive!

Note: If ID's missile cost is \$100,000 each – Total cost is significantly higher

Total shooting cost of 10,000 missiles and salvo of 10 missiles

10,000 rockets will be shot. Iron-Dome will intercept only 25%
(Skyguard will still shoot them all)

Skyguard:

- \$ 1.24 billion for the deployment of the 34 systems
- \$20 million for 10,000 shots
- \$20 million for replenishment

Total: \$1.28 billion (all threats will be shot-down)

Iron-Dome:

- \$X million for 9-18 units
- \$300 million for development & production
- \$400 million-\$600 million for 5,000 missiles (2-3 per target)
- \$400 million-\$600 million for missiles replenishment
- \$1 billion for the 4.5 Km zone fortification (both north and south)
- \$4 billion in damage, done by not-intercepting threats (similar to Lebanon war II)

Total: \$6.1 billion +X = Still prohibitive (Actually no protection. All areas will be paralyzed)

"Killing" a Salvo of 10 rockets (shots only - no deployment cost)

Skyguard: \$20,000

Iron-Dome: \$1,600,000-\$2,400,000 for use of 20 missiles

(Un-believable difference... More than 100 times Skyguard's cost!!!)

Cost analysis - conclusion

- **N/SG – is a cost/effective full solution we can afford!**
- ID – When all LCC ingredients are taken into account - comparing “apples to apples”:
 - **Solution is still partial.**
 - **Cost – is prohibitive – “we can not afford it”**

Additional N/SG potential - is huge:

- Other implementations (defense and offense)
- Strategic level
- Enhanced cooperation with US
- Smooth move to next generation

All in all a very cheap entrance fee to:

- A dominant technology we must have
- Enable us protect our population, and
- Free the IDF forces to move the battlefield to enemy's territory!
- Instead of wrestling these threats

נגד קסאמים

ברק: "למאן עוד" אולמרט: "תביא כסף"

מאת **איתמר אייכנר**, כתב "ידיעות אחרונות"
מחלוקת חדשה בין ראש הממשלה אהוד אולמרט לבין
שר הביטחון אהוד ברק, והפעם סביב המשך מיגון שר-

רות ויישובי עוטף עזה.

ראש הממשלה ומנכ"ל משרדו, רענן דינוה, חתו בימים
האחרונים הצעת החלטה שגובשה על ידי שר הביטחון אהוד
ברק וסגן שר הביטחון מתן וילנאי לעבור לשלב השני של
מיגון שדרות ויישובי עוטף עזה. ההצעה: למגן עוד 4,750
יחידות דיור בעלות של 500 מיליון שקל.

האוצר התנגד במרצות להצעה וטען שאין לה מקורות
תקציב. אולם ברק ווילנאי מתעקשים שאי אפשר להתמח-

מה, ושיש להתחיל כבר עתה בכל האישורים כדי שניתן
יהיה להתחיל בעבודות בתוך כשנה.

ברק דרש להביא את תוכנית המיגון לאישור הממשלה
כבר בשיבתה ביום ראשון הקרוב ולאשר לה תקציב מיוחד.

אולמרט דחה את הבקשה, והנושא לא יידון ביום ראשון הק'-
רוב.

בלשכת ראש הממשלה הבהירו אתמול שלאולמרט אין
התנגדות לתוכנית המיגון, אלא שהוא סבור שמשרד הבי-

טחון צריך להצביע על מקורות מימון. "מאיפה יביאו את
הכסף? בבקשה שיוציאו את זה מתוך תקציב משרד הביטחון.
אי אפשר לבוא פתאום כאמצע שנת תקציב ולהציע הצעה
כזו", אמרו גורמים בלשכת ראש הממשלה. 500 מיליון שקל
זה תקציב אידי, וצריכים למצוא מקורות מימון ולא סתם
להעלות הצעות מפוליטיות".

הממשלה אישרה בפברואר האחרון את ביצוע השלב
הראשון של המיגון, שכולל 3,800 יחידות דיור בהיקף של
327 מיליון שקל. העבודות עתידות להתחיל בשבועות הק'-
רובים על ידי משרד השיכון ומשרד הביטחון. השלב הראשון
כלל מיגון בתים עד לטווח של 4.5 ק"מ מהרצועה, אך עם
עדיפות לגגות הכים וליישובים שקרובים יותר לגדה השלב
השני כולל גם הוא מיגון בתים עד לטווח של 4.5 ק"מ, אך
ביישובים רחוקים יותר וכאלה עם גגות כבדים יותר.

MAFAT's negative remarks regarding Skyguard **and responses**

1. Skyguard has also a minimum launch range of 4 Km, due to 17 Sec reaction time.

Not true. SG's reaction time sums the following: 1 sec. Radar alert, 1-2 sec for start tracking, 1 sec (in short range) for Tgt. Destruction. Total 4-5 sec. - yields Min. range of a few hundreds meters only.

2. Nautilus requires a Cement base to "microns" accuracy.

True, but never being defined as a problem. Was easily implemented.

3. With the Nautilus – only 46 successes out of 150 shots.

Not true. Success rate was closed to 100%. After over-coming "childhood problems" – Every time the beam was turned-on it was a successful shoot-down.

4. All shots during Nautilus tests were from distances greater than 7 Km – indication for Min. launch range problem.

Min. range was never considered as an issue during the tests. Never defined as a problem (see item 1).

MAFAT's negative remarks regarding Skyguard **and responses** (cont.)

1. Having just 1 magazine – Nautilus will provide partial protection only
Additional 5-6 magazines can be built during the 6 months deployment time
1. Nautilus had reliability problems
As tests continued (2001-2004) reliability reached over 80%
1. 92% of all rockets shot to Israel (during last 20 years, north and south) were launched from ranges greater than 4 Km
Most shots in the South are from 3-4 Km range. Iron-Dome can't cope with it.
Will not provide protection to the Gaza-Strip area
1. Skyguard is not effective against salvos
Each SG unit can shoot-down 10 rockets launched simultaneously. A City is protected by 2 SG units. "Over protection" to worst MAFAT's scenarios
1. Skyguard is not effective against Quassam and Fager rockets
SG was effective against any threat (ATM, Cruise Missiles, Rockets, Artillery Shells & Mortars). Never tested against Quassam, Fager

MAFAT's negative remarks regarding Skyguard **and responses** (cont.)

10. "Lasing" cost might reach 7,000\$
1 Sec. "lasing" costs about 1,000\$. Engaging a Tgt. Takes 1- 3 Sec. Thus a "Kill price" is 1,000\$ - 3,000\$

1. Northrop-Grumman (NG) did not meet any price / time goal
In 4 years (instead of 3) and \$220M (instead of 168) NG brought to successful tests one of the most technology-challenged systems. NG should be decorated for that

1. Price of 30 Skyguard systems will not be less than 2 B\$
In its Jan. 16, 2007 letter, NG had committed for a unit fixed price of 30M\$ (No Radar). Price of the total required amount of 34 Systems is \$1.24B

1. Skyguard deployment time is 3 years
In same letter NG had committed for an 18 Mo. Start of deployment time

MAFAT's negative remarks regarding Skyguard **and responses** (cont.)

1. Nautilus will be placed by the Gaza Strip border. It will be impossible to protect it
The System can be placed behind a hill, preventing, thus, any hit by a "line of sight" weapon
15. Economical balance should be calculated according to potential damage that was eliminated
Iron-Dome is economical-prohibited (see our "apple to apple" comparison)
1. Skyguard will be cost-effective only when intercepting more than 160,000 threats
Same as 15
1. 50 US technicians will be required to maintain the Nautilus system. They will run away once Qassam rockets will be launched
No need for any US crews during operation
18. The Skyguard is very big. Difficult to protect
Skyguard's battery is smaller in size in comparison to a Patriot battery

MAFAT's negative remarks regarding Skyguard **and responses** (cont.)

1. Skyguard will "poison" the environment
Skyguard's safety zone is 100m, compares to Patriot's 300m
1. Chemical Laser will never be implemented, anywhere
Right now the ABL (Chemical Laser) starts its flight tests. Same with the ATL (Chemical Laser), built by Boeing
1. SSL is the future solution
SSL is a "bird on the tree" that most probably will never be implemented to protect population (see chart 13)
1. The US Army stopped the Nautilus project, not Israel
Not true. It was stopped by Israel on 2001 (stepping out of Lebanon, budget)
1. MAFAT is not considering the 16/1/2007 Northrop-Grumman's letter as a valid one
Just an un-believable position. NG's letter can be used for starting negotiation

MAFAT's negative remarks regarding Skyguard **and responses** (cont.)

1. MAFAT will not believe in any argument presented by Northrop-Grumman
"Shame" for people presenting such attitude
1. The US Authorities have refused to provide the IMOD with the necessary details needed for Skyguard negotiation
170 charts, fully detailed presentation was given to MAFAT on early January, 2007
1. Iron-Dome was found by the Nagel's Committee to be more effective than the Skyguard in 15 parameters
The only dvantage of Iron-Dome in comparison to Skyguard is in operation during very severe weather conditions (less that 5% of the time, around the year). Skyguard is superior in all other parameters
1. Skyguard will not be effective in cloudy weather conditions
See above. During "regular" clouds conditions (5/8 and above), Skyguard will operate against threats below cloud-base