CONOPS of HALE UTA in an InfraRed Early Warning mission for Theater Missiles Defense

Hervé Gilibert
Defense Systems Preliminary Design Department
Extended Air Defense Systems design
Aérospatiale Espace & Défense
BP n° 3002 - 78133 Les Mureaux Cedex
France

Régis Thevenot
Defense Systems Preliminary Design Department
High Altitude Long Endurance UTA Systems design
Aérospatiale Espace & Défense
BP n° 3002 - 78133 Les Mureaux Cedex
France

LIST OF ACRONYMS

ATBM	Anti Tactical Ballistic Missiles
C2	Command and Control
C3I	Command, Control, Communications, Intelligence
COMINT	COMmunications INTelligence
CONOPS	CONcept of OPerationS
DSP	Defense Support Program
ELINT	ELectronic activity INTelligence
HALE	High Altitude Long Endurance
IR	InfraRed
IRST	InfraRed Search and Track
LEO	Low Earth Orbit
LWIR	Long Wave InfraRed
MTI	Moving Target Indicator
MWIR	Mid Wave InfraRed
NATO	North Atlantic Treaty Organization
OOA	Out Of Area
SBIRS	Space-Based InfraRed System
TBM	Tactical / Theater Ballistic Missile
UTA	Unmanned Tactical Aircraft
WMD	Weapons of Mass Destruction

1. SUMMARY

This paper presents the concept of High Altitude Long Endurance UTA equipped with InfraRed sensors for Tactical Ballistic Missiles (TBM) detection and tracking.

After a short presentation of the general context of operations in an Anti Tactical Ballistic Missile (ATBM) defense system, the IR HALE concept is depicted in its technical aspects as well as in its operational aspects :

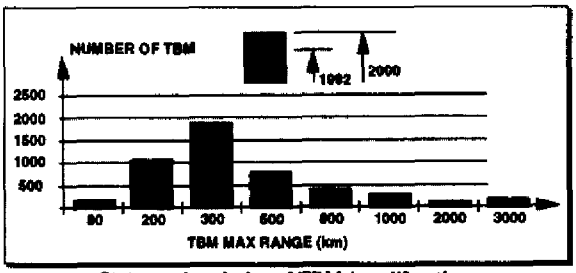
- analysis of potential "observable features" (signatures) of missiles, and crossing with general ATBM defense needs leading to introduce the IR HALE concept,
- analysis of its potential performance levels in two major observation functions (missiles detection and tracking), derivation of a preliminary design,
- exploration of major operational features (survivability, ...),
- synthesis of these elements :
  - analysis of defense capabilities in typical TBM "Out of Area" scenarii,
  - potential roles inside global ATBM defense systems, for Early Warning and Weapon Systems commitment,
- description of the command and control segment of such a system and its integration into air operations,
- brief overview of the other missions that can be envisioned for such a UTA.

Concluding remarks highlight the position of the IR HALE UTA concept among other Early Warning / Cueing systems, both in terms of technical performance and military concept of employment.

2. INTRODUCTION

As was demonstrated during the recent Gulf war, attacks of NATO nations troops by Theater Ballistic Missiles are now a highly probable risk in Out Of Area (OOA) operations.

Current proliferation monitoring indicates trends that will lead non NATO nations to be able to reach the southern and central part of Europe by using medium range TBM fired from their own territory : current indigenous developments in Middle East Area and South Mediterranean countries (sometimes supported by North Korean help) are preparing new TBM with ranges of 1000 to 1500 km, thus capable of crossing the Mediterranean sea.

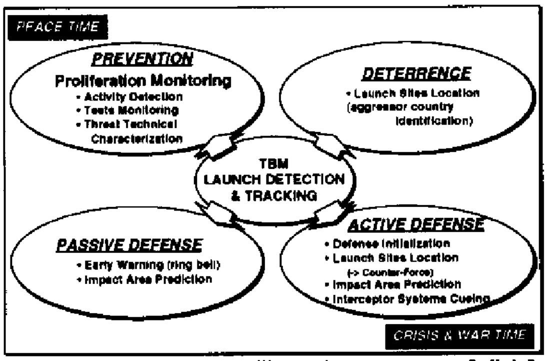


Status and evolution of TBMs' proliferation.

Several studies have been carried out in France in order to analyze possible postures of defense and needed defense systems against such a threat.

Paper presented at the AGARD MSP Symposium on "System Design Considerations for Unmanned Tactical Aircraft (UTA)", held in Athens, Greece, 7-9 October 1997, and published in CP-594.

At the end of these analyses, the ability to ensure ballistic activity monitoring in peace time, battlefield surveillance, TBM detection and tracking in crisis / war times appears to be the cornerstone of all defense policies, whether prevention, deterrence, passive defense or active defense.



TBM launches detection capability as the cornerstone of all defense postures.

Through its participation in these studies, AEROSPATIALE has highlighted a very promising new concept for performing this part of defense functions (usually called Early Warning and cueing of weapon systems) : an InfraRed sensors equipped High Altitude Long Endurance (HALE) Unmanned Aerial Vehicle (UTA) should have impressive operational performance, while being "easily" affordable.

The purpose of this paper is to present the overall IR HALE UTA concept, both in its technical and operational aspects.

At the intersection of these two aspects, the presentation will show how its needed technical features for achieving high level performance (especially flight altitude, ...), do converge with the operational use requirements and constraints (survivability, aircraft control, ...) for making it a particularly attractive concept.

3. ATBM Architectures

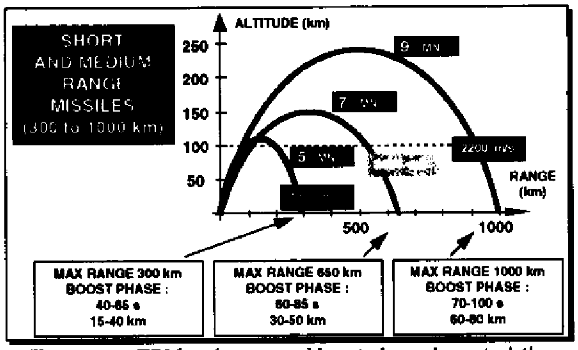
3.1 The threat

From a military point of view, Theater Ballistic Missiles have been shown to be a real threat during Gulf War. Their military efficiency was far smaller than their psychological effects, since they were equipped with conventional warheads, but the use of WMD warheads (Weapons of Mass Destruction) such as chemical ones, represents a high probability / high lethal risk in future comparable conflicts.

From a technical point of view, many countries now have the capability of deploying and using Theater Ballistic Missiles with ranges varying between 120 km and more than 2000 km.

Such missiles usually have a nominal apogee altitude which is about 25 % of the range, i.e. between 30 and 500 km of altitude.

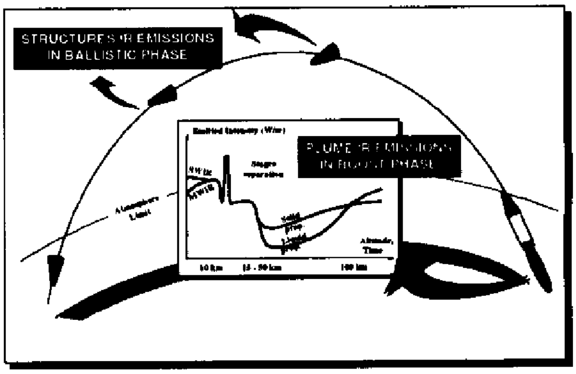
Initial boost phase may last between 20 to 120 s, and correlatively burnout may occur between 10 and 150 km altitude, depending on the missile range, the number of stages and the nature of the propellant (liquid or solid).



Short range TBM trajectory and boost phase characteristics

During this short boost phase (typically less than 15 % of the flight duration), the missile plume delivers very intense InfraRed emission, especially in Mid Wave InfraRed band (MWIR), providing a high signature that can be detected even by geosynchronous satellite systems such as US DSP (Defense Support Program) satellites that look at them over earth background.

The burnout event does not necessarily mean the disappearance of the missile InfraRed signature since some parts of it were heated during the ascent phase in the atmosphere : nose part structures, rear fins (if present), and, of course, the nozzle (if not masked by missile rear structures).



TBM plume and structures emissions in IR wavelengths.

Indeed the heating of the nose part leads to high level InfraRed signatures (mostly in M-LWIR : Mid to Long Wave InfraRed band), with high contrast when observed against a sky background. This signature remains quite constant during the ballistic phase, making it possible to track the missile throughout this phase. This drives for example the US concept SBIRS-LEO (Space-Based InfraRed Sensors - Low Earth Altitude satellite system : former Brilliant Eyes system).

As the missile flight in the ballistic phase is fully deterministic, very simple algorithms (typically based on Kalman principles) give high precision trajectory prediction, even with a rather small number of medium accuracy measurements ...

3.2 ATBM defense systems functions and architectures

Associated to the different possible defense policy in front of TBM attacks,

- passive defense, sending threatened people into shelters,
- active defense, committing interceptors against incoming missiles.

➥ or counterforce, sending attack weapons against TBM launch sites or aggressor's high value sites.

The required functions for ATBM defense systems are :

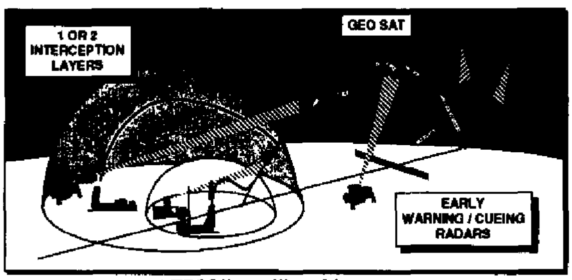
- TBM launch surveillance and [early] detection (Early Warning),
- TBM launch site location,
- Threatened sites / areas determination through ballistic trajectory prediction,
- TBM inflight destruction by interception systems.

If we consider not only the crisis / war phase of conflicts involving Tactical Ballistic Missiles, but also peace time, some other essential missions must be added for ATBM defense systems, related to Intelligence function :

- ballistic activity (flight tests ...) surveillance,
- TBM technical characterization (intelligence purpose ; defense readiness improvement, ...).

«Classical» ATBM architectures for meeting these needs are made of :

- Early Warning Satellite Systems (such as US DSP), in charge of wide area surveillance, TBM launch detection & location through IR plume signature ; their ability to predict the ballistic trajectory and estimate impact point location is generally rather limited.
- Medium-Long Range radars also capable of surveillance, and generally dedicated to the accurate tracking of TBM in order to provide precise estimate of impact point and precise cueing data for interceptors guidance. These radars are themselves often cued by the Satellite System.
- One to several families of interceptors : theater high altitude interceptors (see US Navy Theater Wide, US THAAD, ...), or low endo interceptor systems such as US Patriot / ERINT, Aster missile (Fr / It), where the interceptors are associated to smaller, dedicated "Fire Control Radars". Due to the small size of the defended area they provide, the latter are usually called "Point Defense Weapon Systems".
These interceptors families may be deployed simultaneously on a given theater, for enhancing defense efficiency through successive layers and shoot-look-shoot policy.



ATBM "usual" architectures

3.3 Introduction of InfraRed Airborne sensor systems in ATBM architectures

When we look at needed functions in an ATBM defense system and at the "observable features" of Tactical Ballistic Missiles that are described here above, we can rapidly imagine a conceptual observation system fulfilling a large number of needed observation functions.

Indeed, since TBM plumes can be detected from geosynchronous orbit, by sensors looking for them against earth background, they should be detected by comparable sensors placed on aerial platforms, and looking for them against [less emissive and less cluttered] limb / sky background : the penalty due to transmission losses on a rather horizontal line of sight will not lead, of course, to a 36000 km detection range (which is not needed in that case !), but transmission laws indicate that today achievable high flight altitudes lead to «high» transmission coefficients.

Moreover, the observation configuration of InfraRed sensors on airborne platforms is particularly favorable for targets tracking after their burnout, as we have already mentioned. The contrast against sky background is high, while transmission rate improves with line of sight elevation.

Thus appears the concept of «Early Warning / Early Tracking / Early Cueing» InfraRed High Altitude airplane.

Starting from these assessments about general principles, our technical analyses did confirm the high performance levels that it can achieve, and led us to go further into overall design and evaluation.

4. PERFORMANCE AND DESIGN OVERVIEW

4.1 Detection and tracking performance

The two major parameters which determine the detection range of an IR airborne sensor looking for TBM plumes against limb / sky background are :

- the sensor IR observation wavelength band,
- the platform altitude.

The choice of the first parameter is driven by the spectral characteristics of plume emission (depending on propellant nature : liquid / solid), the spectral characteristics of atmosphere absorption on the line of sight, and the spectral characteristics of background emission (mean level and clutter). In that area, the trade-off analysis leads to privilege the MWIR band.

The choice of the second parameter is driven by two factors, the [lowest] integrated transmission on the line of sight, and the [lowest] risk of presence of clouds on the line of sight. Of course, the first of these two factors has to be selected in relation with the IR band selection.

IR transmission rate variations as a function of the sensor altitude show that TBM plume detection ranges do increase when platform altitude varies from 15 to 18 km, and has less significant increase when taking higher altitudes.

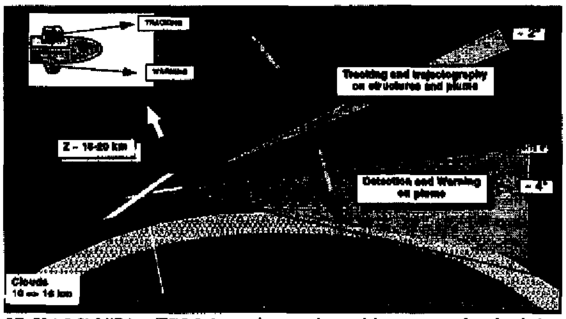
The non-interception of the line of sight by clouds means as well that the platform must fly over 15-16 km (especially in

So, the first essential conclusion is drawn : the IR sensor in charge of TBM plume detection has to be carried at rather high altitudes, typically 18 km and higher.

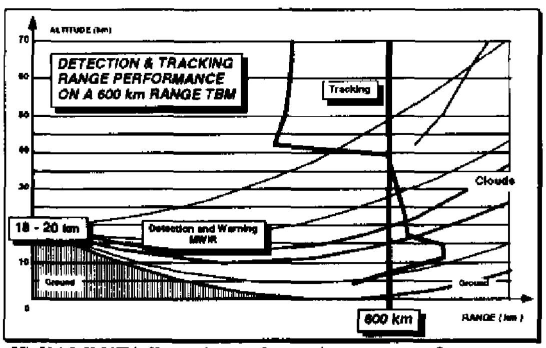
In these conditions, estimated performance is very impressive : TBM plume detection range is found between 600 and 8-900 km, depending on the TBM class (from SCUD B / Al Husayn class, having a range of around 300/600 km, to longer range missiles with ranges up to 2,000 km and more). The detection range is comparable with (sometimes higher than) the missile range ...

As far as the detection and tracking of TBM structures after booster burnout is concerned, the IR band trade-off analysis calls for slightly higher wavelengths, while tracking performance (impact point early and accurate prediction) makes it necessary to reach high observation elevations, typically 60° or more.

Tracking ranges are estimated to be quite equivalent to plume detection ranges on current proliferated missiles, so that a continuous detection and tracking process can be envisioned, on the first part of TBM flights (up to apogee area).



IR HALE UTA : TBM detection and tracking general principles



IR HALE UTA Detection and tracking range performance on a 600 km range TBM

In terms of trajectory prediction accuracy, the results obtained are impressive as well : impact point predictions with accuracy better than 5 km (diameter) are delivered before the TBM reaches its apogee, so that the remaining time for alerting populations or troops in the estimated area ranges from 3 to 6 minutes, depending on the TBM range (300 to 2000 km). This is also the time available for preparing the acquisition of the target by ATBM Point Defense Weapon Systems.

These results are obtained by simply using one passive InfraRed Search and Track sensor (IRST), i.e. without need for distance measurement (which could be provided by Laser rangefinder), and even without need for stereoscopic observation (which would require the association of two airborne systems for each surveyed area and thus multiply the number of loitering airplanes by a factor greater than two).

The gains assessed in presence of Laser rangefinder and / or stereoscopic observation are significant in terms of tracking duration, more than in terms of final accuracy.

	Single sensor observation	Stereo observation or laser telemetry
Flight duration	445 s	445 s
Apogee	163 km	163 km
Time for Apogee	250 s	250 s
Impact with 10 km error	213 s / 155 km	110 s / 80 km
Time before impact	232 s	335 s

Tracking accuracy sequence vs observation configuration

Single passive observer performance appears to be generally sufficient in that area of alert delay, so that the other two solutions do not really bring anything more. The single passive observer is then our basic assumption in the next paragraphs.

4.2 Design overview

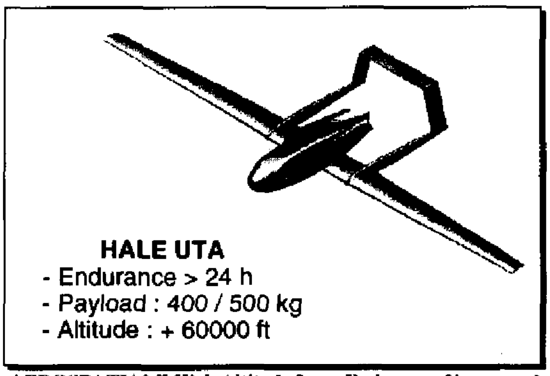
Previous elements define the primary requirements for the IR sensors and High Altitude airplane design.

Associated with a certain permanency needed in surveillance operations, the objective of overall operations cost reduction means searching for a small number of airplanes on the ground per airplane in flight, which leads to Long Endurance requirements. Cost analyses and confrontation with capabilities offered today by aeronautical technologies make it quite easy to design airplanes with 24 hours and more loitering duration.

Such flight duration and the interest of not having large pressurized volumes on such airplanes pull towards unmanned aircraft solutions.

Thus, the concept becomes naturally an IR High Altitude Long Endurance Unmanned Tactical Aircraft ***(IR HALE UTA).***

Preliminary design studies of 65000 ft IR HALE UTAs have been undertaken for ensuring the concept's feasibility, inventorying the technical difficulties, confirming system performance, and estimating costs and development / acquisition schedules.

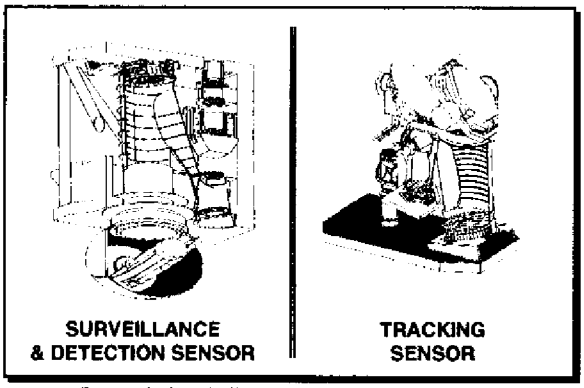


AEROSPATIALE High Altitude Long Endurance Unmanned Tactical Aircraft conceptual design.

These studies have led to 2 major design options, as far as sensor integration is concerned :

- a «double pod» design, with :
  - one pod mounted (partially included inside the airframe) under the aircraft, and in charge of 360° azimuth surveillance. This sensor is looking in horizontal directions and slightly downwards in a small elevation angular sector (a few degrees). Its role is TBM plume detection, and cueing preparation for rapid acquisition by the top mounted sensor.
  - one second pod mounted (partially included as well) on the top of the airframe. Its sensor is in charge of TBMs tracking at the end of their boost phase and during their ballistic phase. Its rather small Field Of View (a few degrees²), is mechanically moved in a large Field Of Regard (up to 60° and more in elevation ; 360° in azimuth).

  This «double pod» design provides for large surveillance and tracking sectors, only limited by rather small airframe masks. But its major drawback is the penalty on the aircraft drag, compared with following more integrated design.



Sensor designs in "double pod" integration option

- a «nose mounted» design, with two similar instrument solutions placed in front of the aircraft.

  This design gives smaller [azimuth] Fields Of Regard because of large rear mask due to the airframe, but this can be compensated by use of adapted loitering profiles (such as «8 shaped trajectories»), when surveillance is not needed in a 360° azimuth angle. One of its major advantages is the fact that the sensor is fully integrated inside the airframe, which gives better aerodynamical performance and offers opportunities for using the platform as a multimission one (design of removable payload).

5. IR HALE UTA OPERATIONAL FEATURES

5.1 A «natural» survivability ...

Defense systems design does not often bring such converging technical and operational features as the IR HALE UTA.

As a matter of fact, its needed technical characteristics lead naturally to a high survivability level :

- its high loitering altitude (65,000 ft) makes it unattainable by most of Air Defense Weapon systems in the world.

  The primary reason for this high survivability in a large number of [low to medium Air Defense threat level] scenarios is its low detectability : the needed cruise altitude is above current radars search ceiling, and robustness against possible (certain !...) improvements of these radars can be achieved by applying simple stealth design rules.

  Moreover, the observations through a fully passive sensor do not mark the presence of the aircraft : discretion is an other virtue of the concept ...

  Let's add that even in case of detection, the high flight altitude of the platform is also a protection against the majority of interceptors in the world, being above their flight domain.

  These features let us envision a safe use of the UTA very close to or even over hostile territories, in a great number of scenarios.

- in front of highly defended territories, a stand-off distance from hostile territory must be kept. But, even in the worst cases (for instance presence of SA-12 Air Defense systems), the subtraction of the needed stand-off distance from the sensors detection and tracking range still provides for a long observation depth inside the surveyed area : typically 400 to 6-700 km.

5.2 A useful flight altitude ...

The high flight altitude, provides an additional advantage (useful only when loitering is over allied territories) : it is higher than Controlled Airspace ceiling, so that operations can be achieved in a total free way between the climb and descent phases.

Nevertheless, this does not mean the absence of any control during the cruise phase : platform / payload integrity and mission controls remain of course necessary !

6. IR HALE UTA CONCEPT OF OPERATIONS

6.1 Deployment analysis

Short term scenarios will involve TBM with ranges lower than or just exceeding the IR HALE UTA detection range : from SCUD B missile to No-DONG missile. Except in the case of the latter one, shot against targets very close to the enemy area's border, the IR HALE UTA range will be sufficient for operating close to the border, with the adapted stand-off distance if necessary.

In most envisionable Out Of Area conflict scenarios, the border or coast length is not longer than 1,000 to 1,500 km, so that surveillance of TBM launches can be performed by up to three loitering HALE UTAs.

However, in the future or today in some particular cases, proliferating countries will be capable of in depth attacks from in depth (on their own territory) launch pads. In that case, additional (typically one or two) systems will be needed for in depth surveillance, either by flying over enemy territory or from rear allied territories.

Let's note here that the long endurance of the HALE UTA concept makes it possible to have one common base for all UTAs in such a configuration : indeed, the long loitering endurance can be partially traded-off for projection range. When surveyed countries are not too far from NATO nations (for instance South Mediterranean countries) this principle can even be applied by simply using homeland airbases ...

These estimates set the maximum number of needed systems for ensuring the surveillance of one among the largest countries :

- 8 to 10 airborne systems (3 to 4 loitering ones + ones needed for rotations ensuring long time permanency),
- 3 to 4 associated ground segments (operations plus support).

6.2 A central role in ATBM defense systems

IR HALE UTA systems are not only interesting thanks to the size of the coverage they provide for TBM launch surveillance, but we must underline here the tremendous set of services they can offer in an ATBM defense system :

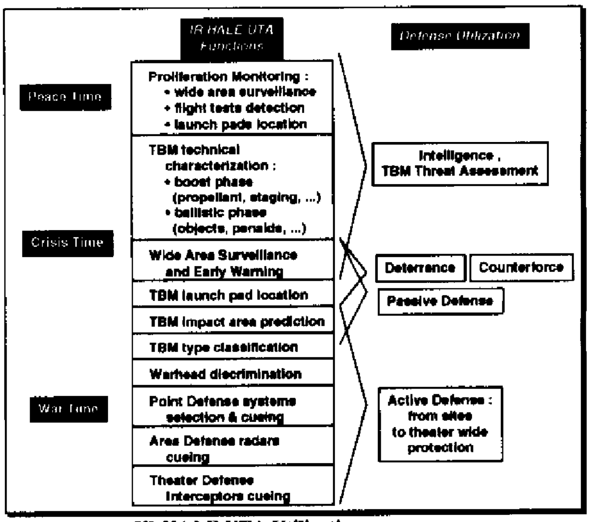
- In peace and crisis time :

1. Proliferation Monitoring through Wide Area Surveillance of ballistic activity (detection of flight tests in proliferating countries, launch pads location, ...),
2. Proliferating missiles technical characterization : range performance measurement, plume signature measurements, booster staging counting, warhead separation phase analysis, counting and signature measurements of objects present in the ballistic phase (warhead, last boost stage, shroud pieces, separation device pieces, ... that are potential penetration aids into defense system ; intentional penaids ...), ...
   All of this is dedicated both to the characterization of the attacking country's technological level and to improve defense systems readiness in case of conflict.

- In crisis / war time :

3. [Quite] Wide Area Surveillance and Early Warning (quite as early as Space-Based systems such as US DSP),
4. TBM launch pad location,
5. TBM type classification / identification (depending on peace time observation campaign measurements and on the dispersion of targets technical parameters),
6. TBM impact area [early & precise] estimate ; the performance level is similar to performances that achievable by radars ; the IR HALE UTA takes advantage of its forward deployment for providing accurate estimates very early,
7. Terminal Point Defense weapon systems [early & precise] selection and cueing,
8. Area Defense Weapon Systems radars [early & precise] selection and cueing, and, in some configurations, direct cueing of Area Defense Interceptors,
9. Theater Exoatmospheric Interceptors direct cueing ; we have to note here that the IR HALE UTA is one of the best solutions for allowing the earliest commitment of such interceptors (especially if they are themselves in forward positions), and thus allowing them to perform the interceptions early in TBM flight (in Ascent Phase, before the apogee) : in such conditions, they can protect tremendous areas.
10. Significant participation in warhead discrimination among all objects present on ballistic trajectories close to one another (see point 2 above) : the IR tracking sensor, maybe associated with additional sensors on the platform that would use other wavelengths, is a valuable means at least for separating heavy bodies from lighter, less emitting ones. This is very helpful for limiting the number of objects tracked and seen as potential warheads by terminal radars, and thus limiting the number of engaged interceptors.

So, while points 1, 2, 3, 4, and (partially) 6 make the IR HALE UTA concept competitive compared with geosynchronous satellite systems as far as technical capabilities are concerned, points 5 to 10 make it clearly competitive compared with radar systems or highly sophisticated Low-Earth Orbit optical systems.



IR HALE UTA Utilizations summary

When we add to this assessment the fact that the estimated acquisition costs seem to be 3 to 4 times lower than those for medium range radar systems or a geosynchronous Early Warning satellite, and at least one order of magnitude lower than LEO satellite systems, the concept becomes really attractive !

6.3 Utilization concept - Comparison with satellites and radars

In fact, this preliminary conclusion has to be balanced against the analysis of «ideal» utilization conditions of each alternative system.

Let's take as first example the comparison between a Space-Based (geosynchronous) IR Early Warning system and IR HALE UTA.

The satellite system's undeniable value comes from the following major features :

- its ability to ensure permanent surveillance over very long periods (years) without any "heavy" ground support,
- the [very large] size of the areas its Field Of View permits to survey,
- its total survivability versus proliferating countries' attack capabilities,
- its absolute stealthiness / discretion which allows its owner to survey any country without being detected.

Let's add as well the following obvious assessment : having its wide Field Of View, the satellite system is a true stand alone surveillance system, whereas the IR HALE UTA requires a preliminary «alert» for being committed on its operation theater : alert coming from intelligence sources, or even directly from activity detection by space-based assets.

All of this underlines in fact the usual special status of Early Warning satellite systems as sovereignty instruments.

Its major limitations lie in the fact that it can observe only TBM boost phase (which leads to poor Impact Point Prediction performance), and only if the burnout does not occur too early : too short range missiles cannot be detected by space-based Early Warning systems.

As far as the radar is concerned, the positioning distinction in terms of utilization concept is less clear, since both systems (radar and IR HALE UTA) may fulfill exactly the same functions in an ATBM defense system. Yet, let's mention the following slight differences :

- a better Early Warning capability for the UTA, due to its flight altitude and its «natural» forward deployment (threat is detected a little bit earlier in its boost phase),
- a more rapid deployment for the UTA (operationally available in a few hours after projection decision versus a few days for the radar),
- the discretion of UTA in its operations,
- the ability to detect very short range TBMs for the radar (their detection by IR HALE UTA is not certain, due to TBM low burnout altitude and the decrease of UTA detection capability when the targets are flying over earth background).
- probably better threat characterization capability for the radar,
- larger adaptation capabilities for the radar in the field of discrimination (thanks to possibilities like waveform adaptation, in real time or day after day in a conflict). In fact, detailed analysis of discrimination function in front of proliferating TBMs should lead us to consider that these two observation systems are more complementary than rival systems, for this function.

7. GROUND SEGMENT AND SYSTEM INTEGRATION

All elements are now gathered in this short briefing for dealing with the question of physical and operational integration into a global defense system.

HALE UTA is both a «classical» UTA in some aspects and a totally non classical one in some other aspects.

Indeed, it is a classical UTA in the sense that :

- it will fly within the atmosphere, the air traffic during climb and descent phases and in consistency with air operations during its whole flight. It is to be developed taking into account all the constraints coming from this environment,
- Its C2 system will have to be compatible with existing or future Air Defense C3I systems in order to be able to give as quickly as possible the right information to the right user.

As for all other concepts (Medium Altitude Endurance UTA, piloted observation aircraft, ...) these two main characteristics have to be taken into account from the early definition phase.

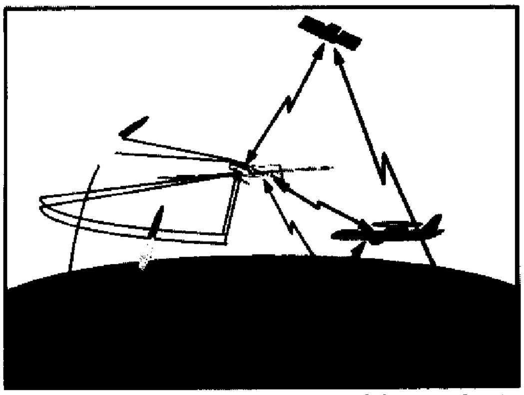
But besides this, two major features make it different from the majority of the other concepts :

- firstly its very long endurance allows patrols with a duration longer than Air Tasking Orders (and moreover all other subsequent, lower level tasking orders) renewal rate : thus the HALE UTA system must be able to respond to inflight retasking, which is not necessary for other surveillance or recce systems,

- secondly, its long projection range and its operation range once projected make it necessary to have several types of links for all ground-to-board or board-to-ground communications links. Data transmission and reception must be achievable :

  - through satellite datalink or airborne relay (other HALE UTA ...) during long distance projection operations, and in surveillance phases when the aircraft is deployed too far from its C2 base : for instance during proliferation monitoring operations such as flight tests detection in peace time, when one does not want to indicate the use of the system, and make it operate from a homeland base. Let's mention here that observation data do not systematically require high rate datalinks, and that the aircraft can be equipped with onboard recorders for peace time intelligence operations.
  - through direct insight datalink. This link is at least necessary in take-off and landing phases, and preferable in climb and descent phases when terrain topography permits it,
  - directly with airborne C3 systems (AWACS airplane, ...), when present, for allowing immediate integration of ballistic events in tactical situation and immediate appropriate reactions.

  Of course, due once more to the UTA long endurance, inflight reconfigurations of these connections must be possible.



Need for various possibilities of links (control & sensor data), depending on scenarios and their phases.

8. HALE UTA OTHER POSSIBLE MISSIONS

Before underlining the major conclusions that we draw from this brief overview of the IR HALE UTA concept (and from longer studies we have carried out ...), we have to highlight that if the TBM launch detection mission requires high operation altitudes, these altitudes are also of major interest in several other surveillance missions.

Indeed, besides the operational advantages (survivability, flight over controlled airspace) provided by these flight altitudes, some missions also take advantage of the wide area covered :

- Ground Surveillance missions :
  - Synthetic Aperture Radar images generation,
  - ground mobile target detection (MTI : Moving Target Indicator),
  - Adverse communications and radar monitoring (COMINT, ELINT),

  Let's note that high altitude often allows higher resolution or target location precision in areas between nadir and observation range than lower (and closer) flying systems, thanks to projection effects ...

- Ground to ground communications relay missions.

Analysis of payload volume, mass and required power supply in such missions shows that they are quite comparable with one another and with IR TBM detection & tracking payload, so that one can envision the possibility of a common generic airplane with removable payload : this would lead to a much higher number of airframes and overall aeronautical segment and thus to a significant reduction in their costs.

9. CONCLUSION

The InfraRed High Altitude Long Endurance Unmanned Tactical Aircraft (IR HALE UTA) appears clearly to be a very promising near term solution for fulfilling a large number of needed functions in Anti Tactical Ballistic Missile (ATBM) defense systems.

Placed somewhere between geosynchronous space-based Early Warning assets and TBM surveillance [ground based] radars, they cumulate capabilities offered by these two kinds of systems : early detection of missile plumes like the first ones, and target tracking during their ballistic phase, allowing accurate Impact Point Prediction and handover to terminal intercept Weapon Systems or directly to Theater Wide interceptors, like the latter ones.

Moreover, being easily and rapidly deployed at long ranges as well as being highly survivable they represent an essential surveillance means in peace time, for proliferation monitoring and technical TBM intelligence data gathering.

Being capable of long detection ranges (600 to 8-900 km) like huge ground based radars, they offer large instantaneous surveillance coverage. This coverage remains nonetheless rather limited when compared with geosynchronous satellite systems coverage.

Their technical capabilities are associated to operational virtues related to their high loitering altitude : high discretion and thus high survivability level, flight over controlled airspace, ...

From a technological point of view, all elementary technologies do exist, so that the major challenge lies in system integration.

Moreover, their acquisition and operating costs are significantly lower than those of alternative systems : IR HALE UTA does correspond today to a very attractive, cost-effective solution for dealing with Tactical Ballistic Missiles in Out Of Area operations.