SEVENTH EUROPEAN ROTORCRAFT AND POWERED LIFT AIRCRAFT FORUM

Paper No. 28

ARMY LYNX
PRODUCT DEVELOPMENT MATCHED TO MILITARY COMBAT DEVELOPMENT

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September 8 - 11, 1981

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ABSTRACT

This paper presents a review of the Lynx programme to date and planned product development related to the evolution of military combat thinking; especially the anti-armour role. The background for this product development is the impact of technology in the areas of materials, sensors, armaments and systems, both in the context of the helicopter as a total weapon system and the development of air defence systems that pose a threat to the helicopter in the battlefield scenario.

1. RESUMÉ OF THE LYNX PROGRAMME TO DATE

The LYNX helicopter programme has provided reliable and effective weapon systems for NATO and other free-world forces since 1976. The operational performance of these helicopters has met, and in many respects exceeded, the original design objectives.

The first LYNX development phase was launched as a result of the Anglo/French helicopter agreement and established the production programme for ARMY LYNX I for the British Army and SEA LYNX I for the Royal Navy and French Navy. This programme developed the LYNX hingeless rotor technology, the conformal gear technology for the main transmission and the Rolls Royce GEM-2 engine.

Phase II, the second stage of development, was a Company funded programme to uprate the LYNX dynamic systems and establish the production programme for SEA LYNX II, Figure 1, and ARMY LYNX II. As a result of this uprating programme the maximum take-off weight of SEA LYNX was increased form 9,760 lb.to 10,750 lb, and of ARMY LYNX from 9,600 lb to 10,000 lb. In support of this programme Rolls Royce developed the GEM-41 series engines increasing the maximum take-off power from 900 shp to 1050 shp. Both the Royal Navy and the French Navy have subsequently ordered SEA LYNX II to further extend their operational capability. To date some 170 SEA LYNX are in world wide operational service with, or in production for, nine Navies, and have established an unmatched small-ship operational capability at sea. This programme has developed an impressive weapon system capability for SEA LYNX which encompasses the integration of the Sea Spray radar, Sea Skua anti-surface vessel missile system, Alcatel and Bendix AQS-18 sonar systems, Decca ESM, torpedo and depth charge armaments; together with comprehensive navigation, communication and flight control system facilities.

The current ARMY LYNX production programme is some 126 helicopters primarily for the British Army which will deploy 100 TOW equipped anti-tank LYNX in Germany, Figure 2. The British ARMY LYNX with its hingeless rotor, shallow profile, oil loss tolerant transmission, highly responsive engines, TOW roofsight and missile load of 8TOW; together with provisions for the carriage of re-arming missiles and other combat stores, is the most effective operational anti-tank helicopter in NATO service.

In parallel with the UK (MOD) LYNX TOW missile system integration, Westland Helicopters have conducted firing trials with HOT missile system and an extensive range of rockets, cannon and machine gun armaments.

The third aircraft in TEAM LYNX is TRANSPORT LYNX (WG30, Figure 3) which meets the bulk transport requirements of the light tactical transport helicopter by providing the capacity to transport 14 fully equipped NATO troops whilst retaining extensive component commonality with other LYNX variants. The rationale of this TEAM LYNX concept is illustrated by Figure 4.

Before we consider the future development of LYNX it is necessary to consider the environment in which the helicopter must operate, together with the way technology may change that environment and the capability of the helicopter. For the remainder of this paper only the battlefield scenario and product development of ARMY LYNX III, Figure 5 will be considered, although many aspects of this product development are again applicable to all TEAM LYNX helicopters.

2. THE BATTLEFIELD SCENARIO

The massive armoured force capability of the Warsaw Pact countries is well documented together with the relative strength of NATO armoured forces. Within the Warsaw Pact tank and motorised rifle divisions there is a prolification of low altitude air defence systems. These air defence systems are being improved both doctrinally and through the use of advanced technology. The air defence system threats are primarily the ZSU-23-4 cannon system, and SA-8 and SA-9 missiles. Additionally, however, the combat helicopter can expect that every weapon on the battlefield that can be brought to bear will be; for example artillery, tank guns and anti-tank missiles.

The Warsaw Pact are also rapidly expanding their airmobile and attack helicopter fleets, and engagements with both these attack helicopters and fixed wing aircraft can be anticipated. It must also be recognised that helicopters on the ground are vulnerable targets and may be destroyed before their first combat flight unless appropriate deployment tactics are used.

Finally, the forward area considered by NATO commanders to be the location for the anti-tank helicopter ambush fire positions, may well be the area penetrated by fast moving, lightly armoured enemy reconnaissance units. The combat helicopter can therefore also expect machine gun and small calibre cannon fire from these units.

In order to survive in this environment the combat helicopter must:

i. use stealth and tactics to minimise the probability of detection

ii. stay outside the effective range and/or target acquisition and lock-on performance envelope of air defence systems

iii. select air defence systems as high value targets and destroy them to increase survival probability and hence the overall effectiveness of the combat helicopter

iv. incorporate a level of damage tolerance that does not compromise cost and hence numbers; or performance and hence effectiveness

v. incorporate a self-defence system against other helicopters and airborne threats

vi. have sufficient agility to gain cover when warned of exposure to a threat.

3. HELICOPTER, SENSOR AND WEAPON TECHNOLOGY

The first point that must be realised when the application of advanced technology is considered, is that it is almost certainly available to increase the combat effectiveness and lethality of the enemy systems that pose the threat to the helicopter.

For example these systems already use radar for search, acquisition and tracking of airborne targets using conical scan with compensated tracking techniques, and a moving target indicator to permit target tracking in ground clutter; together with techniques that reduce signals from wind blown chaff.

The application of advance technology is expensive however, and there is a limit to what can be fielded both in terms of capability and quantity on both sides. The question is "How can advanced technology enhance the combat effectiveness of the helicopter without detracting from its cost effectiveness?" It is also only appropriate in the context of immediate development plans to consider technology areas that are likely to reach operational maturity during the next decade.

In order to take a rational view of the contribution technology is able to make in this context it can be assessed against the six aspects necessary for survivability listed in Section 2.

3.1. Stealth and Tactics

Stealth is a combination of the skill instilled into the combat helicopter crew by rigorous training under simulated combat conditions and signature suppression of the helicopter. The skill of the crew, and handling characteristics of the modern helicopter incorporating hingeless rotor systems and highly responsive engines, already confer a true "nap-of-the-earth" (NOE) flight capability.

This NOE capability can be extended into progressively worse weather conditions and darkness by the application of FLIR technology as demonstrated by the Martin-Marietta Pilot Night Vision System (PNVS).

Visual, infra-red, radar and acoustic signature suppression cannot make the combat helicopter undetectable by the most advanced sensors. However a reasonable level of signature suppression can make it necessary to field relatively advanced and expensive technology, expensive for the enemy forces both in terms of procurement and support, if a high probability of detection is to be achieved.

Visual signature obviously depends on size, glint, rotor flicker and camouflage, and has been a major influence during the design of a number of combat helicopters including ARMY LYNX. Advanced camouflage schemes are also becoming available for the infra-red as well as visual bands and promise to also merge the helicopter with its infra-red background.

Infra-red signature suppressing of engines to levels that give survivability against the currently deployed heat seeking missiles is operational. Further suppression of the radiated energy, together with plume cooling can be achieved but at the expense of further weight and power loss penalties - penalties which the combat helicopter will be forced to accept over the next decade as the technology of missiling homing heads is enhanced.

The radar signature can be attenuated by attention to detail design and techniques such as the application of a thin metallic coating to rotor blades, access panels, etc. The use of radar by enemy air defence systems can also be turned to the advantage of the combat helicopter as discussed below in paragraph 3.3.

The acoustic signature of helicopters is now well understood and many techniques may be employed to reduce the detectability to a reasonable level considering the overall battlefield environment.

The final stealth contribution that technology is able to make to the combat helicopter is associated with the location of the target acquisition sensor. The traditional nose and roof sight locations are being challenged by the introduction of mast mounted sensor packages above the rotor. It is important however to achieve the necessary target acquisition range performance from such packages since any concealment advantage gained by mast mounting can be rapidly negated if the combat helicopter is forced into closer proximity with the air defence system.

3.2. Stand-Off Capability

The greatest contribution that technology is able to make to the effectiveness of the combat helicopter is perhaps the increase in stand-off engagement capability. Today T.V. and FLIR target acquisition sensors are able to out perform current direct view optical systems over a wide range of ambient conditions, whilst conferring the additional advantage of automatic target tracking, and for FLIR sensors operation in low light level conditions and darkness.

This coupled with laser target designation and weapons such as HELLFIRE, will confer a major improvement in combat capability by the mid 80's. In the longer term laser beam riding weapons, RF/IR/Millimetric Radar homing heads, improved war heads, and higher speeds will increase the effective fire power and lethality of these helciopter borne anti-armour weapons.

It must be recognised however that both the target acquisition sensors, and the next generation anti-armour weapons will demand greater payload from the combat helicopter.

3.3. Detection of Air Defence Systems

Probably the greatest threat to the combat helicopter is the ZSU-23-4 cannon system which employs both radar and optical target acquisition and tracking. Stealth tactics will make it difficult to visually detect the combat helicopter but a modern radar will be able to detect and track the helicopter, even through modest foliage cover that affords good visual concealment. The use of radar will however immediately warn the combat helicopter of the presence of such threats, and the use of passive RF interferometer techniques may be employed to indicate the direction of the threat. The integration of such threat detection with the combat helicopter weapon system that contains an appropriate threat file, will give the combat helicopter the capability to unambiguously acquire enemy radar emissions, and to slave the helicopters passive target acquisition sensor onto the threat whilst remaining well outside the lethal range of such weapon systems. The combat helicopter thus equipped with suitable target acquisition sensors and weapons would be able to detect, engage and destroy such systems before its own presence was detected. The utilisation of radar by the enemy forces will also confer the further advantage to the combat helicopter of signalling the location of enemy armour; thus minimising the exposure time necessary to make initial detection of enemy armour units.

To detect air defence missile systems that use passive target detection techniques, the combat helicopter must rely on the performance of its own target acquisition sensors, the advantage of freedom from the restriction of terrain, and greater agility than any land based system.

3.4. Damage Tolerance

It is not possible to design a combat helicopter that is able to survive all threats that may be encountered on the battlefield. Therefore a judgement must be made with regard to the level of damage tolerance that should be built into the helicopter, remembering that it may be better to invest in stand-off capability, signature suppression, warning systems and armaments rather than extensive application of armour and mechanically 'hard' components, which would increase overall size and costs, and reduce agility.

The advent of composite materials has been heralded as a major contribution to survivability, especially with regard to the damage tolerance of main rotor baldes. The application of composite materials for primary fuselage structure also holds out much promise for enhanced damage tolerance whilst reducing structural weight. Much remains to be learnt in this area however before such technology is fully developed, and it is probably necessary to wait until the next generation requirements before we see the "all composite" combat rotorcraft enter service.

3.5. Air-Air Self Defence Weapon Systems

To date there are no air-air self defence weapon systems effective against all airborne threats. Cannon, rockets and missiles have been considered and developed to provide a degree of self-defence capability - but this remains an area where the imaginative application of technology could yield a significant improvement in the effectiveness of the combat helicopter.

A reasonably promising development is the General Dynamics development of STINGER for this application - the Multipurpose - Lightweight - Missile System (MLMS) - which has been used in current LYNX design studies. However the potential of rocket armaments with special flechette or chemical warheads should not be ignored as they may prove a most cost effective means of disabling enemy helicopters.

3.6. Agility

The absolute necessity for the combat helicopter to use NOE stealth tactics means that high speed and the ability to pull high 'g' levels at high speed are of marginal benefit. It is far more important that the combat helicopter should be able to accelerate and decelerate rapidly in all axes in the low speed regime, with high rates of turn and precision of yaw control. Manoeuvres that demand precise attitude control throughout all thrust states-conferred by the characteristics of the hingeless rotor-and rapid engine response with good power margins. Flight characteristics which are already exemplified by the two hingeless rotor helicopters in operational service the BO.105 and LYNX.

It is possible, however, to enhance these flight characteristics, and Westland Helicopters are considering in particular the benefits that may be conferred by twin tail rotors. With suitable control systems these may be used to absorb the kinetic energy of the helicopter at low speed, by working against each other extracting power from the main rotor during flare type manoeuvres, thus reducing deceleration distances by some 30-40%. Such a twin tail rotor configuration would also give an enhanced level of survivability since adequate yaw control would be retained in the event of loss of one tail rotor.

4. ARMY LYNX III

From this brief summary of the contributions that technology - which will reach operational maturity during the next decade - is able to make to the effectiveness of the combat helicopter, it is apparent that most contributions are in the field of sensor systems and weapons. Consequently, the main development thrust of ARMY LYNX III, planned for operational service from the mid 80's, is in these areas; supported by an appropriate uprating programme to accommodate the increase in systems payload and additional features to enhance survivability.

4.1. Configuration

ARMY LYNX III at a nominal 11,750 lb all-up-weight retains the basic configuration, and utilises the rotor/transmission assembly of the current LYNX, Figure 6, with some modifications to cater for the increased power and aircraft weight. The most noticeable changes from the current LYNX is the introduction of a crashworthy tricycle undercarriage, that also gives enhanced ground mobility, and the larger rear avionics bay and tail cone structure.

This third phase of development also encompasses the introduction of advanced aerofoil composite main and tail rotor blades to expand the flight envelope at the increased all-up-weight to retain performance comparable to the current aircraft.

Power is provided by the development of the GEM 60 Series engines, and a second generation I.R. suppression system is incorporated for enhanced survivability.

The final configuration of Army LYNX III will also depend on the location of the target requisition sensor system. Figure 5 shows TADS/PNVS integrated into the nose of the aircraft since these systems will reach operational maturity by 1986. The potential of mast mounted sensors (MMS) is being carefully monitored, however, and engineering designs are prepared to integrate such sensors with the LYNX rotor/transmission assembly when these became available. Such a MMS installation would include the integrated RF interferometer discussed in Section 3.3.

4.2 Operational Concept

The operational concept of ARMY LYNX III is unique amongst the combat helicopters of NATO. It incorporates side-side seating for enhanced crew communication and co-ordination under the stress of battle conditions and a battle-hold that together with a transit overload capability, gives ARMY LYNX III an unrivalled operational flexibility.

When deployed forward from the Corps area ARMY LYNX III, utilising the battle hold and transit overload capability, is able to take forward re-arming missiles, support personnel and other stores vital to the combat operation. This, coupled with the high capacity fuel system of nominally 1000kg, gives ARMY LYNX III a true multi-mission capability with minimum transit and maximum engagement times, utilising a total mission profile similar to that shown by Figure 7. ARMY LYNX III is thus able to deliver fire power comparable to that of larger and more expensive combat helicopters; with the added advantage that valuable stores, personnel and casualties can be recovered from the forward area as an integral part of withdrawal of the combat squadron. If terrain or other factors prohibit the airborne attack of armour units, then ARMY LYNX III can still be used to deploy ground based missile teams thus increasing the overall combat effectiveness of this aircraft for the battlefield commander.

4.3. Systems

The primary systems developments for ARMY LYNX III are associated with night-operation and enhanced stand-off capability. The installation of systems such as TADS/PNVS on MMS/PNVS has already been mentioned. The target acquisition and fire control elements of such system are potentially compatibile with HELLFIRE, HOT, TOW and the planned third generation anti-tank missile.

As operations are extended into progressively more adverse conditions crew workload and fatigue become critical parameters, and to cope with these problems a fully integrated cockpit will be introduced utilising a dual redundant MIL Std-1553B data bus. This cockpit, shown by Figure 8, will introduce duplicated cockpit control units (CCU), to control all data bus functions, together with a multipurpose CRT. This CRT will be used during the deployment phase as a battlefield tactical plot giving a reference grid, key landmarks, fire positions, forward edge of own troops, known threat locations, target-area and assigned fire sectors, own position and mission way point plan, including re-arming points. Corridors, including the time dimension, through the NATO air defence systems will also be displayed. When in the fire position the CRT may be used as a monitor for day TV, or night FLIR video, to give the gunner a "head-out" mode for target selection and/or to provide the pilot with information concerning the gunner's engagement of targets.

The introduction of the integrated cockpit will also enable overhead panels in the current LYNX to be relocated in the inter-seat console, thus improving further crew external vision. The deletion of direct view optics from TADS, or the introduction of a MSS would enable the optical relay tube to be replaced by another CRT display and appropriate sensor control grips, potentially reducing cost and weight, whilst alleviating gunner fatigue.

The other system elements are similar to those already in operational service or flying on our demonstrator aircraft G-LYNX.

4.4. Survivability

LYNX, designed to meet stringent military specifications, already offers many features that increase the probability of survival in the hostile environment of the battlefield. In the development of ARMY LYNX III new systems and features will be introduced to enhance both the battle survivability of the aircraft, and crash survivability of the aircraft and crew.

It is not possible in a paper such as this to deal with the design features and the philosophy adopted in any detail. The main features exhibited by ARMY LYNX III for battle survivability are indicated on the cut-away illustration Figure 9 and for crash survivability by Figure 10. These measures address the following areas in a comprehensive manner:-

i)	Detectability	: Suppression of Visual, Radar, I.R. and Acoustic Signatures
ii)	Threat Warning	: Radar and Laser warning systems
iii)	Self Defence	: Air - Air Missiles, Chaff, I.R. Decoy Flares and possibly I.R. Jammer.
iv)	Damage Tolerance	: Extensive System Duplication, Composite Main/Tail Blades, Oil Loss Tolerant Main Gearbox, Damage Tolerant Structure, Fire Suppression/Self Sealing Fuel System, Armour Crew Seats, Selective Application of Armour to Critical Systems/Components
v)	Crash Survivability	: Long Stroke Trailing Main Undercarriage with Frangible Units, Long Stroke Nose Undercarriage with Frangible Units and Fuselage Well to accommodate Nose Wheels, Long Stroke Crash Survival Crew Seats, Fuel and Hydraulic Systems designed to Crash Survival Principles, Structure Design to avoid Ploughing incorporate Roll-over Protection and provide High Energy Absorption, High 'g' Retention of Rotor/Transmission/Engine Components, Electrical/Avionic Systems designed to Minimise Fire Risk, Fire Suppression/Self Sealing Fuel System, Cooling of Engine Exhaust/Plume, Jettisonable Doors.

5. CONCLUSION

Technology is able to contribute significantly to the overall combat effectiveness of the helicopter during the next decade. New sensors will confer a true night operational capability, crew workload will be contained in this environment by automatic target tracking, threat warning, tactical displays and integrated systems.

Weapon reliability and lethality will be improved and self-defence weapons efffective against enemy helicopters and other airborne threats must become available. Survival probability will be significantly enhanced and it will be necessary for enemy forces to field increasingly sophisticated and expensive technology to counter the combat helicopter. Indeed the point is rapidly approaching where the cost of the modern tank/air defence system able to survive in this environment is comparable to that of the combat helicopter (if comparable production rates are included in the argument) with the exchange ratio significantly in favour of the helicopter.

Most of the contributions that mature technology is able to make in the next decade are in the field of systems and weapons, and therefore can readily be incorporated into an existing suitable combat helicopter platform. This is the philospohy of the third phase of LYNX developments which will generate ARMY LYNX III for operational service with the combat forces of NATO by 1986.

ARMY LYNX III will provide a unique tactical flexibility in the European battlefield scenario with a comprehensive day and night anti-tank capability. Coming from an established European helicopter programme and utilising extensively the development already completed and in operational service from LYNX Phase I and II, ARMY LYNX III is able to meet the military, industrial and economic requirements associated with fulfilling the European anti-tank helicopter requirements from the mid 1980's.

FIG. 1 SEA LYNX II

FIG. 2 ARMY LYNX

FIG. 3 TRANSPORT LYNX

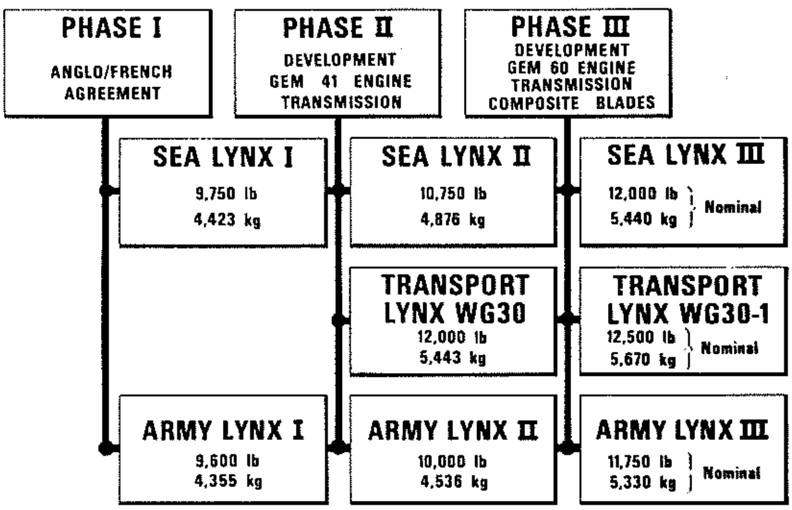

FIG. 4 TEAM LYNX RATIONALE

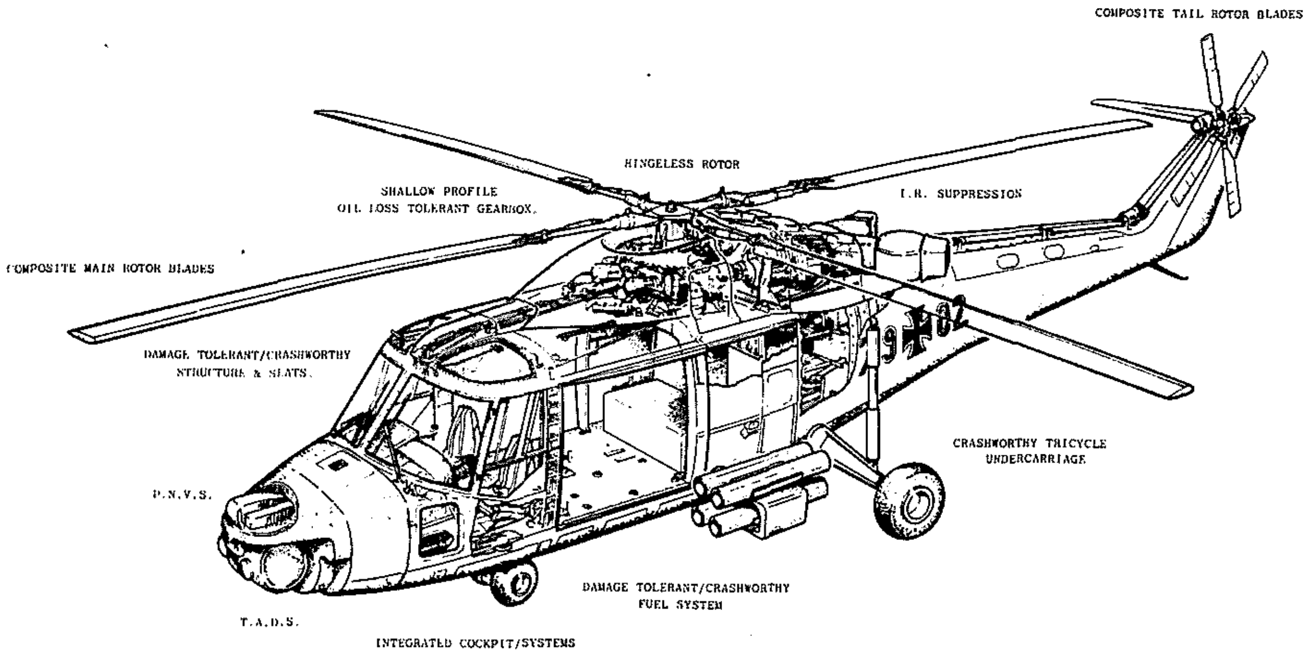

FIG.5 ARMY LYNX III

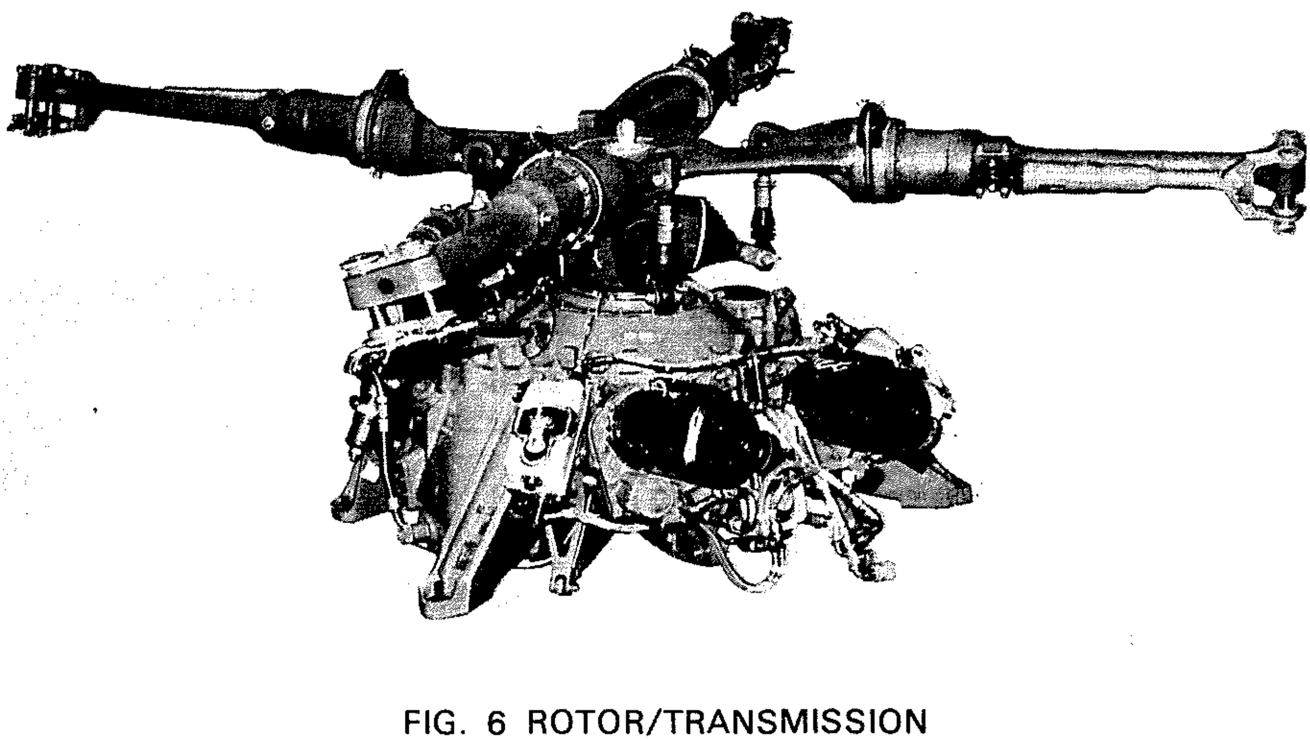

FIG. 6 ROTOR/TRANSMISSION

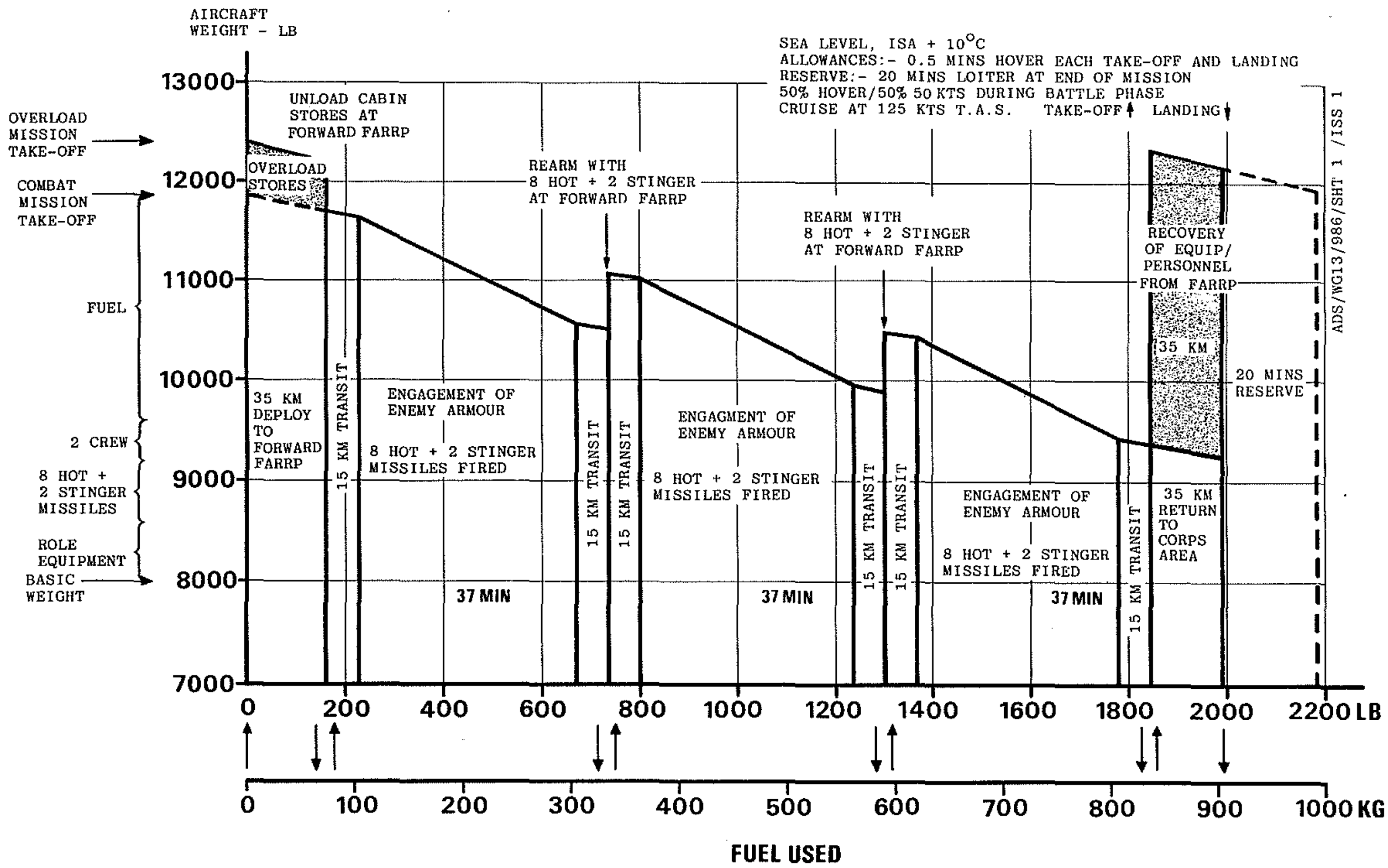

FIG. 7 ARMY LYNX III MISSION PROFILE

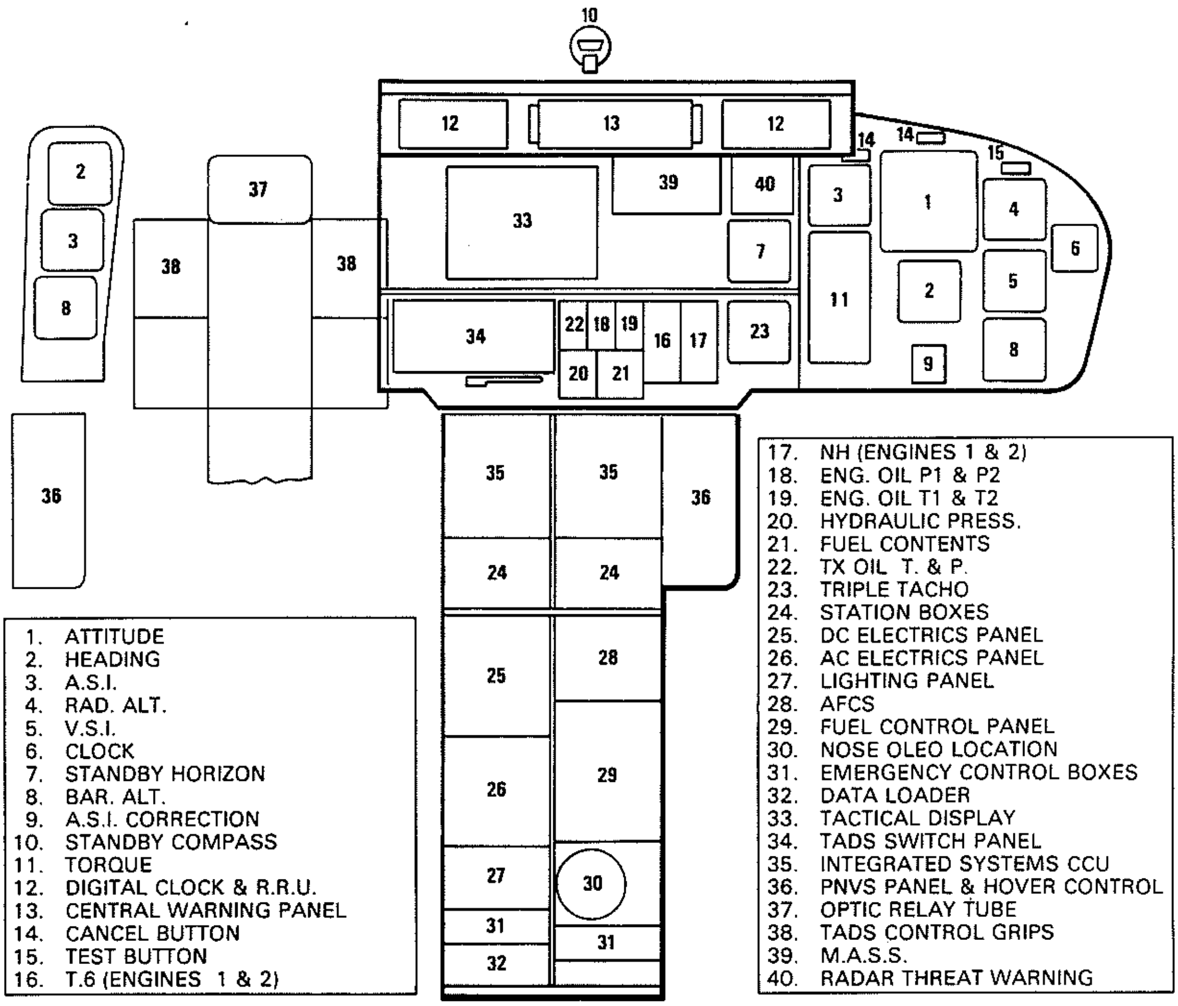

FIG. 8 COCKPIT LAYOUT.

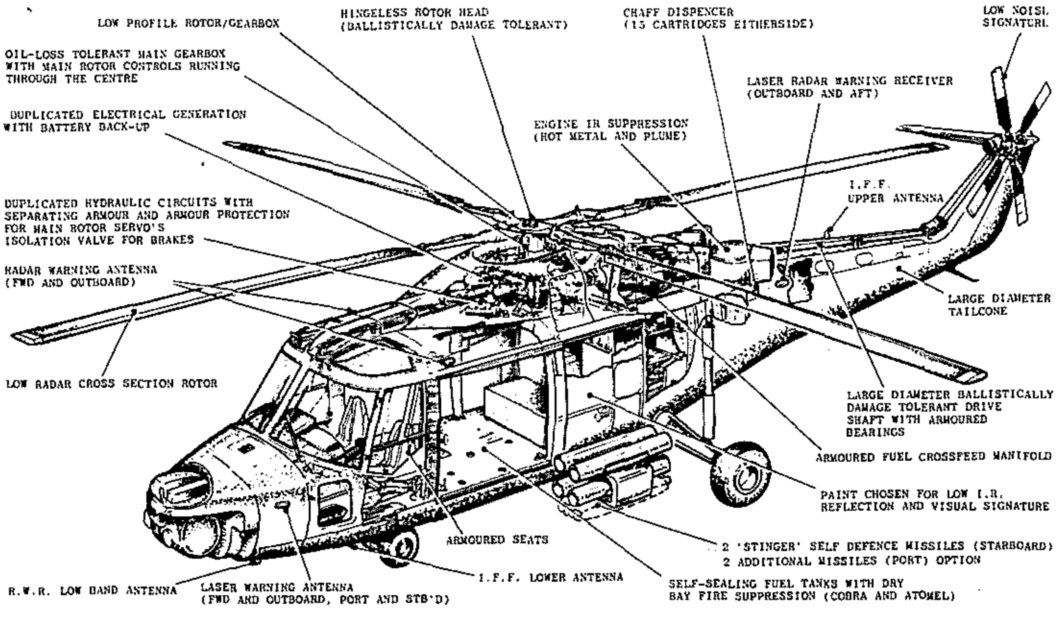

FIG. 9 BATTLE SURVIVABILITY FEATURES

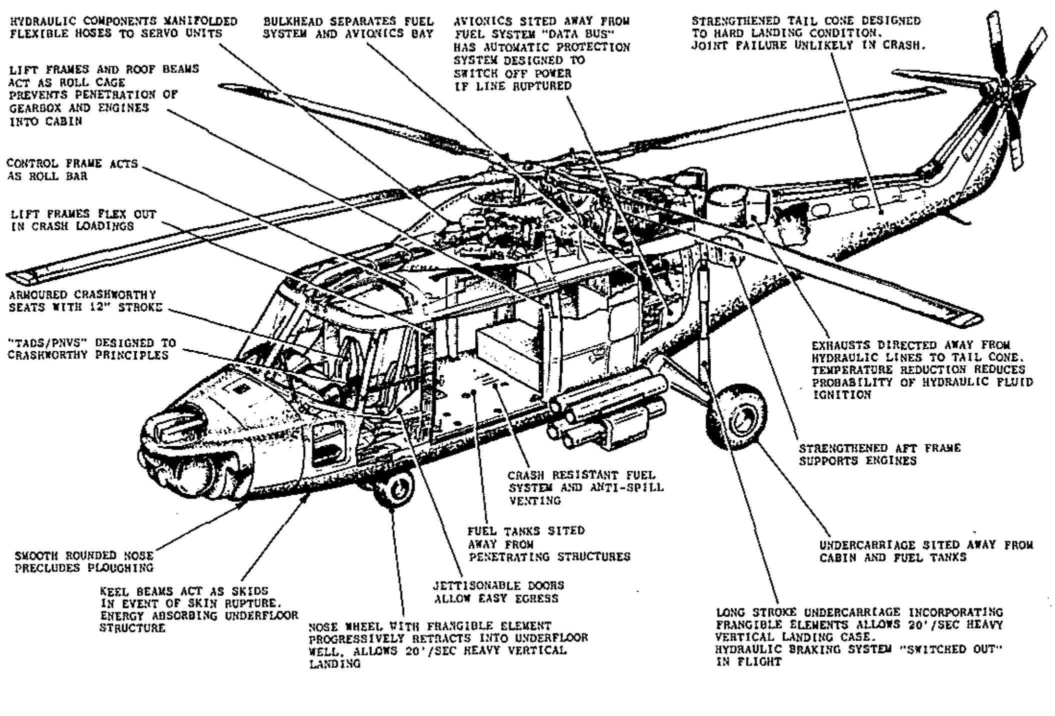

FIG. 10 CRASH SURVIVABILITY FEATURES