LYNX - A 50 YEAR PRODUCT ?

J C BARKER - CHIEF ENGINEER (LYNX/W30)
WESTLAND HELICOPTERS LIMITED

1. This paper describes the development of the Lynx helicopter over the last twenty years to illustrate the costs and benefits of continued development and modification of existing helicopters rather than early replacement by new designs. Key features are identified, discussed, and where possible, quantified.

2. The Westland Lynx is a product of an agreement signed by the French and British Governments in 1967. Although not the subject of this paper, the agreement is worthy of study in that it involved development of three helicopters, jointly manufactured, but with Aerospatiale having sole technical responsibility for the Puma and Gazelle and Westland having the same for Lynx. Both nations bought and operate all three products and the joint manufacture continues to this day.

The Lynx was designed from the start to meet two differing rigorous military requirements. A Navy variant would fulfil the requirement for a frigate or destroyer based helicopter to replace the Wasp and Alouette, whilst similar Army or Utility machines would meet the needs of land based forces. The two Lynx have a high degree of commonality in their basic structures, dynamic components and the Rolls Royce Gem engine which was specially designed for Lynx. Their main differentiating features are:-

Navy Lynx	Army Lynx
Tricycle Long Stroke Undercarriage	Skid Undercarriage
Automatically Engaging Deck Lock (Harpoon)	
Folding or Fixed Tailcone	Fixed Tail
Nose Mounted Radar	
Torpedo/ASV Missile Carriers	NATO Flange Carriers
Sonar Provisions	
Triple Hydraulic System	Dual Hydraulic System

These features and the detailed fits of communications and navigation systems were the result of the specifications laid down by the launch customers (and funding sources) - the UK and French Forces.

The Lynx first flew in 1971 and entered service in 1976. The present worldwide fleet of 330 has accumulated almost 700,000 flying hours and the 180 Naval Lynx have made over 400,000 deck landings. Present operators are the British Army, the Royal Navy, five other European maritime forces (soon to be six) and three non European navies.

This is the background to the Lynx in service today. However, the main subject for discussion and analysis here is the continued development of the aircraft, the costs and benefits involved, and the wider implications for manufacturers and operators as the number of new projects becomes fewer and fewer worldwide.

3. It is convenient to divide the helicopter into four major systems:-

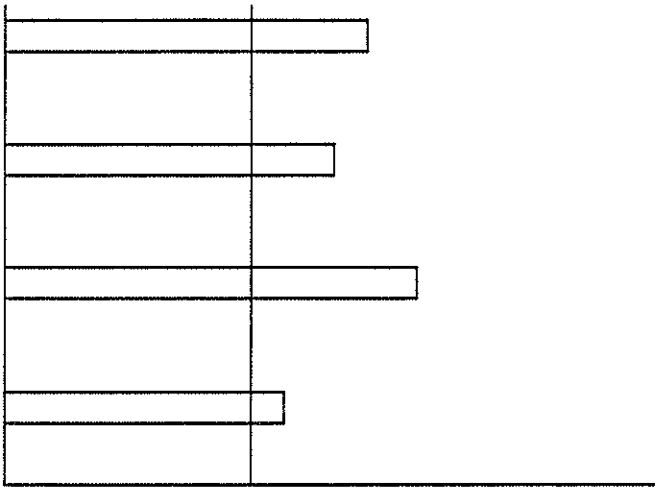
Structures
Dynamic Components
Engines
Avionics, Sensors, Weapons

Each of these contributes to and prescribes limits for the 'performance' of the machine. There are numerous measures of performance; a few examples are:-

Weight of fuel and payload
Range
Speed (max. endurance, best range, max. cruise, dash, dive)
Maximum altitude/temp. for hover (in and out of ground effect)
Climb rate
Wind envelopes for start up and for hover
Probability of locating/destroying submarines/tanks etc.
Probability of victory or escape in an air-air encounter
Tonne-miles of freight per hour
Cost per passenger-seat-mile
Total cost per hour
Survivability and detectability measures

Each of the four major systems contributes to these in varying degrees. It is impossible to define one single quality which relates to all aspects of performance, but I suggest that maximum operating weight is a useful measure because it directly affects most of the others we can devise. More weight will usually allow more fuel, more payload, more ammunition, more elaborate sensors or defensive measures. It usually goes with more power and thrust, which means that hover and speed performances are at least unimpaired.

When a new helicopter is designed the supplier and customer will define and agree a set of performance measures appropriate to the envisaged roles, which are presumably in some sort of balance, and presumably beyond the capabilities of older aircraft in several respects. In some instances the customer may require, or the supplier may wish to allow for, further future enhancement potential. For example, the specification for the US Army's T800 engine requires defined power increases at future dates, When the first prototypes are built, it is common that a few systems or components fail to meet their design requirements at the first attempt whilst others prove trouble free and immediately capable of more. This is real life. However, by entry to service it should be possible to summarise the design's performance in this overall form:-



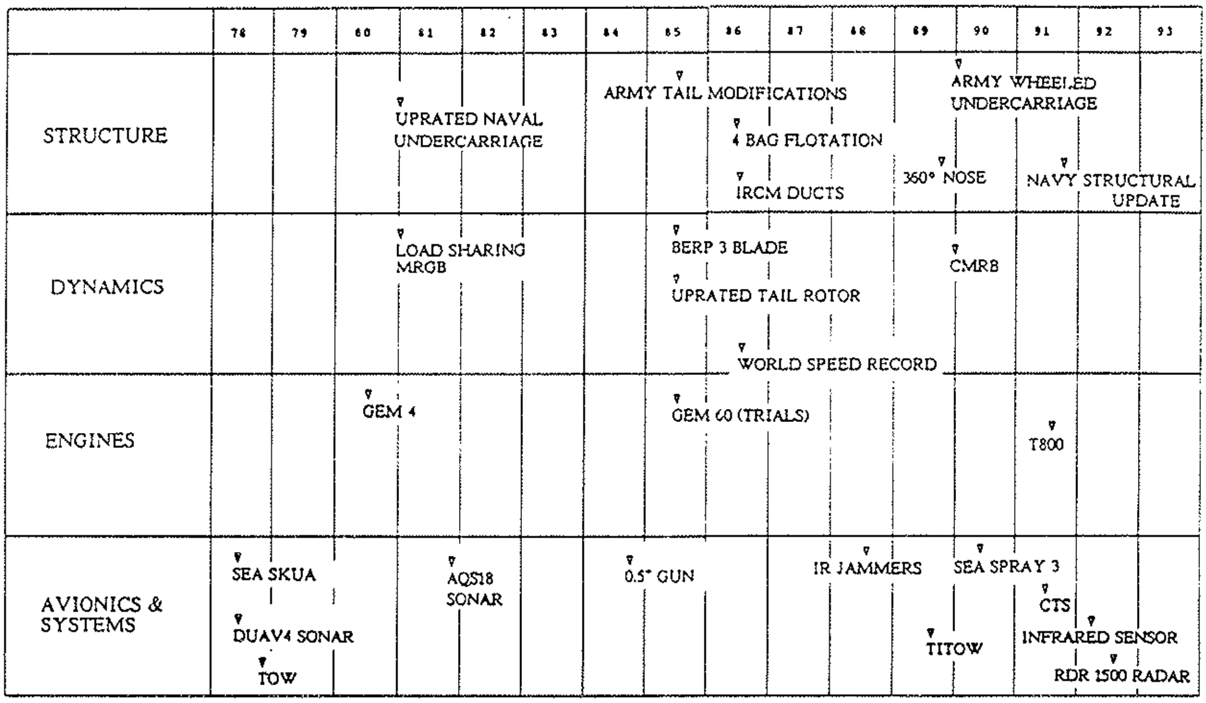
Each of these can be analysed in detail so, for example, the overall performance of dynamic components could be limited by blade stall, control loads, tail rotor authority, transmission power etc. Recent history seems to show that Avionic systems' performance is a function of time (i.e. developing technology) and money. This is less true of mechanical systems where the technology is closer to a plateau.

This all may seem fairly obvious and unarguable but a clearly thought out analytical approach of this kind is essential in order to evolve and to market a long term development strategy. Nevertheless, it only lays out what can be done and what is needed to do it. The vital ingredients are to match what can be done with present and potential customers needs <u>and</u> to generate an economic case for buying or modifying helicopters.

The purists would argue that the start point must always be the market needs, i.e. it is wrong to be product driven. However, reality intrudes in two ways. First, there is rarely enough money to satisfy anyone's desires completely, and secondly the needs, the perceived threats and the roles can change, and at present are changing extremely rapidly. The helicopter market presents us with many challenges, and there are opportunities for those who can identify them and act effectively.

4. I want to study and discuss the time issue in long term development, some cost/benefit measures and the key point where, for technical or economic reasons, further development becomes impractical. But first I want to cover the last 15 years development of the Lynx in accordance with the concepts discussed. A chronology of significant developments is as follows:-

LYNX: MAJOR DEVELOPMENTS



As far as the complete aircraft performance is concerned these changes can be summarised as two enhancement steps characterised by maximum weight increases from the original 4423kg to 4876kg and then to 5126kg.

	4.4t	4.9t	5.1t Max. weight
Structure		Army Tail Mods 4 Bag Flotation Naval u/c Mods	Navy Tail Mods Army Wheeled u/c
Dynamic Components		Load Sharing Transmission	Uprated Tail Rotor
Engines		GEM 4	
Avionics & Systems		AQS18 Sonar	Infrared Sensor Central Tactical System

Some of the detailed benefits of these two update stages have been as follows:-

	4.4t	4.9t	5.1t
Weight of fuel + payload (kg) (excluding 2 crew)	1240	1425*	1605
Vno, ISA 2000′ @ max weight (kts)	132	114	135
Vno, ISA 2000′ @ 4.4t (kts)	132	137	151
Max height for Hover OGE, ISA+10° at max weight (m)	1420	1560	1200
Max continuous power (twin) (kW)	1032	1194	1373

* Some of the benefit has been eroded by increased basic equipment.

For customers buying new Lynx, these benefits have become available for relatively little additional cost. Clearly, an emergency flotation system with 4 pop-out bags has a higher manufacturing cost than one with only 2 and the load sharing transmission contains some additional parts but its subsequent rating increases have been achieved by only minor treatment changes.

It has always been an important principle that Lynx updates have the maximum retrofit capability. Nevertheless, operators of the early Lynx had to make a careful evaluation of the benefits and costs. The cost of uprating an early Naval Lynx to 4.9t is approximately 8% of a whole new aircraft. This includes the mod kit, embodiment, man hours, spares provisioning and training, amortisation of development costs, but not the 'lost' usage of redundant parts.

The subsequent history of Lynx speaks for itself: of 216 early Lynx delivered 146 have been uprated and all but 9 of the remainder are programmed to be converted. In every case operators have carried out the uprating process in their own facilities.

It is the 4.9t variants which have played prominent roles in the Falklands and more recently the Gulf conflicts. In particular, Army Lynx Mk7 supported allied forces and used TOW missiles to destroy armoured and other targets, whilst at sea, Royal Navy Lynx Mk3 used their Sea Spray radar and Sea Skua missiles to perform spectacularly successful autonomous attacks on Iraqi Naval vessels.

The Lynx is the world's outstanding helicopter for operation from small ships in all weathers.

The second stage uprate is much more recent but is gaining wide acceptance. 19 new aircraft have been ordered and a further 55 are already committed to updating. The development cost of this uprating package and the new Royal Navy systems which its embodiment permits, has been only 5% of the original cost of development to entry to service (inflation effects removed). As a retro update to existing aircraft, the total cost is approximately 5% of the cost of a new helicopter, excluding any systems update which a customer may specify.

A vital ingredient for the Lynx' future is its revolutionary Composite Main Rotor Blade. The CMRB is a productionised version of the research 'BERP3' rotor blade which in 1986 enabled Lynx to become the world's fastest helicopter at 400 kph. Deliveries of the 1200 blades ordered to date are well underway, mostly for retrofit to 4.9t Lynx. Operators of these aircraft gain some improvement in flight envelope and the potential for uprating to 5.1t without further change to rotor head or blades. However the biggest attractions for these users are probably the virtual elimination of the maintenance and husbandry activity associated with steel blades, and a trebling of the fatigue life.

R & M effects play an important part in influencing operators to spend money. Nevertheless, although many profess to be keen to 'spend to save' the political reality is that short term thinking more often prevails. An economic case which shows excellent returns but a breakeven point five years hence is rarely accepted.

5. I have attempted to quantify, albeit in crude terms the costs and benefits of important Lynx developments. I believe it is worth studying the lessons which might be learnt and attempting to develop some analytical logic to understand what may happen in the future.

A study of the West's major new military helicopter projects of the last 15 years indicates that the total cost of design and development is typically $2bn at 1991 economic conditions. It is also evident that despite the introduction of CAD/CAM and very sophisticated analytical tools the cost is rising. As U.S. National projects are exhibiting the same trend we cannot blame inefficiencies of international collaboration!

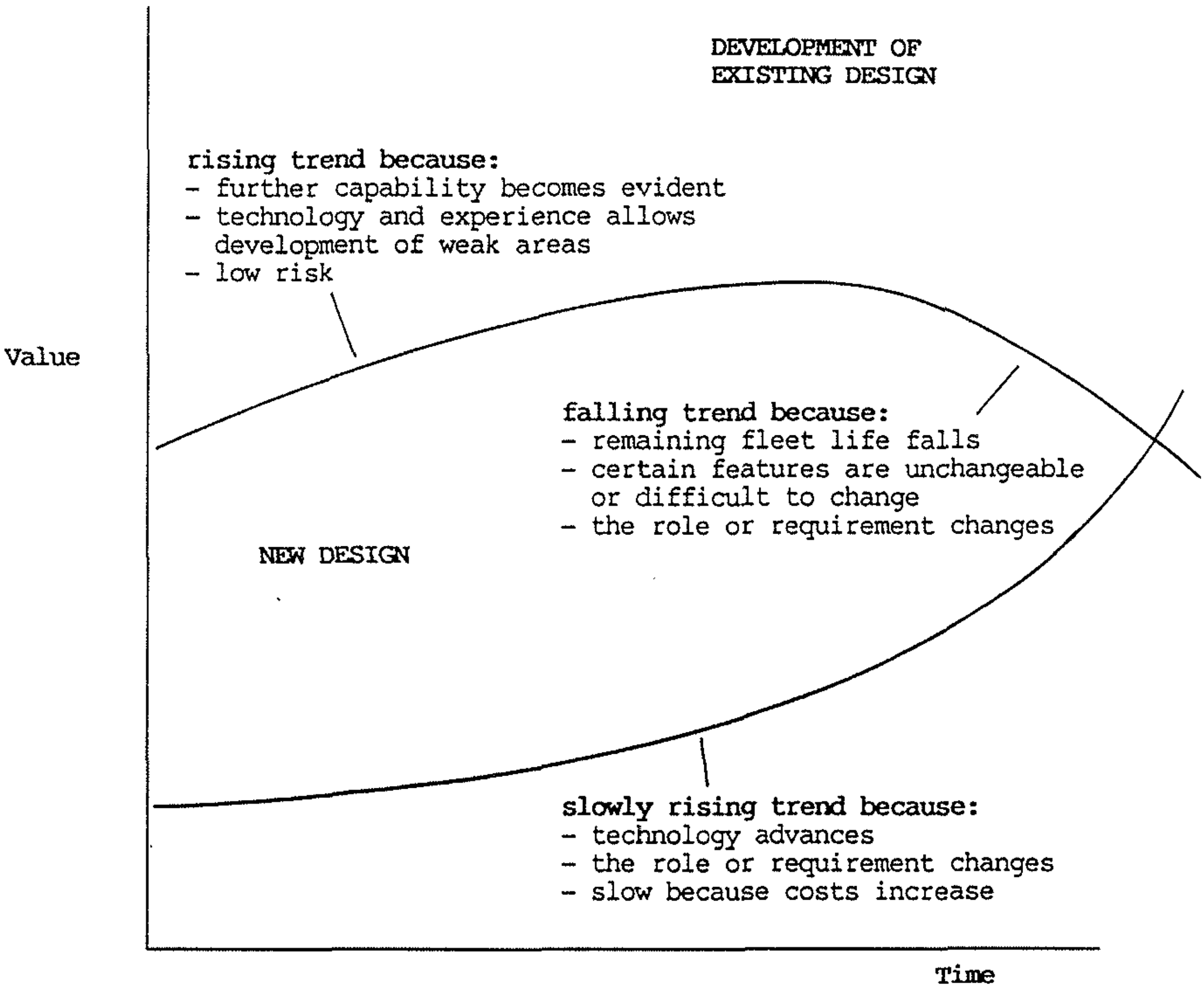
In my view, the three main factors are:-

- Enormous increases in the size and complexity of inbuilt avionics systems
- Increasing attention to demonstrated and guaranteed maintainability, supportability and life cycle cost issues
- A mature technology which is ever harder to improve

If a government or manufacturer chose to begin the design of a new helicopter on the day its predecessor entered service, it seems clear that the new design would only be slightly better at a cost similar to the bill just paid. The value (benefit/cost) would be very low indeed. As I have illustrated, much smaller sums spent on development of the older machine can give very good returns. Much later on it would be clearly unwise to spend money on the old machine, but this can be a long time in the future. Even now the proponents of the SLEP programme in the USA are advocating a major update of Bell UH1 helicopters which are 30 years old.

It seems to me that the successful factors which ensure funding of new helicopters are not technical obsolescence, but either the fact that the old aircraft are worn out (the main driver for the NH90 to be developed to replace Super Puma and S61?) or that the role changes (UH60, AH64 and EH101 have replaced, or will replace, very different machines). Regulatory requirements can hasten the demise of old helicopters and, no matter how vociferously they deny it, I am sure fashion influences most operators.

The following graph summarises these arguments:-



Promoters of existing designs can prolong their products' lives by:-

- ensuring that all features of the basic design have further potential
- making updates suitable for retro embodiment
- ensuring that updates maintain the balance of the design
- paying attention to extension of airframe and other fatigue lives
- exploiting technological developments
- development to meet new roles/requirements
- recognising and correcting features which cause operators to complain

6. It will be understood by now that this philosophy of long term continuous development has been totally embraced by Westland. It was applied to the S58 (Wessex), is still applied to the Sea King and will continue with Lynx. We certainly see a further growth step potential made possible by the appearance of two important new engines, one American and one European.

The LHTEC T800 developed for the AH66 Comanche is further along its development programme and the Westland owned Lynx which holds the speed record has now been adapted to take a near-production T800 installation. The Lynx transmission is already rated at 1960 HP via the civil W30 which makes it the only current T800 installation able to use its rated power. The MRT 390 is equally suitable for a 2000 HP Lynx. Other changes necessary to maintain the balance of an ultimate Lynx at 5.6t as a Naval machine or 5.4t as an Army aircraft are summarised below in the usual four categories:-

Structure	Main load path/lift frame modifications
Dynamic Components	Developed two piece semi rigid rotor head in 10-2-3 titanium
Engines	T800 or MTR 390
Systems (as required by customers)	Cockpit with multi function or helmet displays Low Frequency Sonar Air-air missiles Heavy ASV missile Mast Mounted Sight Active Control of Structural Response 12.7mm machine gun turret

Some of these systems updates are being applied already to existing Lynx.

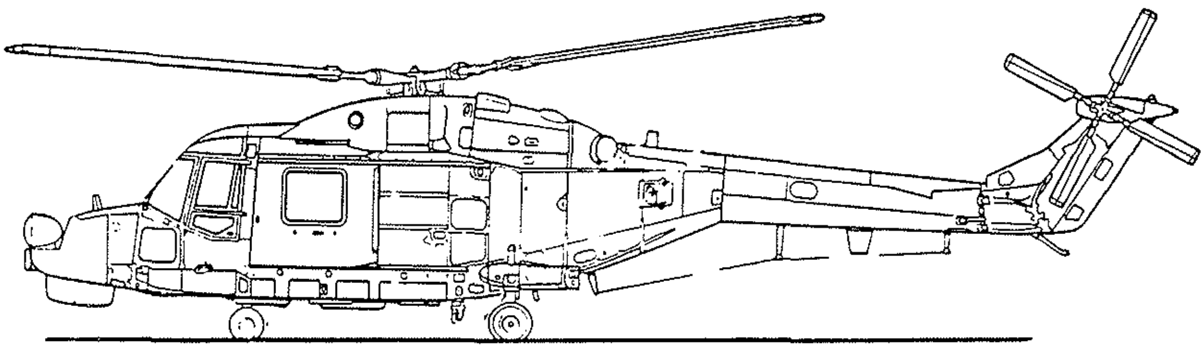
This additional uprating package will have the following effects on performance according to the measures given earlier:-

	5.1t	**5.6t**
Weight of fuel + payload (kg) (excluding 2 crew)	1605	1840
Vno ISA 2000' @ max weight (kts)	135	146
Vno ISA 2000' @ 4.4t (kts)	151	158
Max height for hover OGE ISA+10° (m)	1200	1860
Max continuous power (kw)	1373	1462

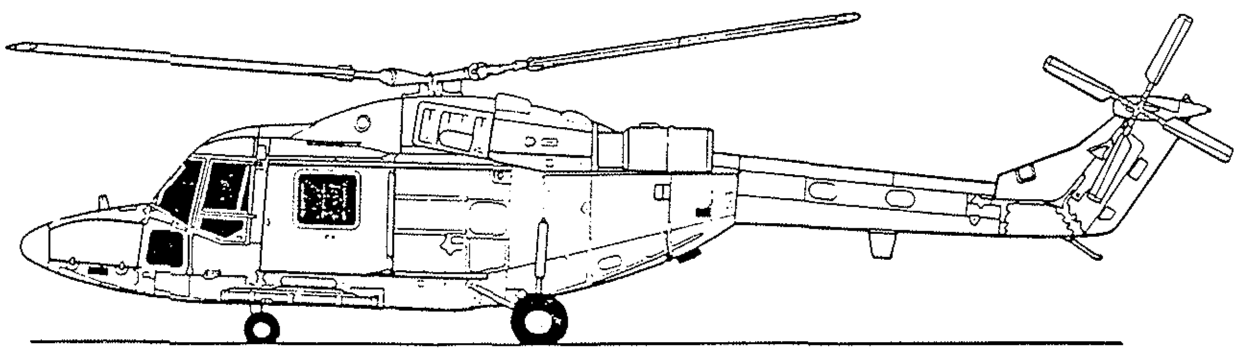
The 5.6t Lynx will be a very effective machine retaining the proven virtues of compactness and agility which are so attractive at sea or on the battlefield but with the enhanced capabilities and reduced operating costs afforded by the developed rotor head (still with the existing CMRB) and either new generation engine. This competitive machine should ensure sales and production through the nineties and beyond the turn of the century. As with previous Lynx developments, retrofit to existing aircraft is quite feasible.

Installation of either new engine requires the embodiment of one extra frame which also happens to be the mounting for the Army Lynx undercarriage oleos. Otherwise the changes are all external to the main structure. Nevertheless, it remains to be seen whether operators with considerable investment and experience in Gem engines will decide to change or whether they will instead look at enhancing sensors and systems in 5.1t aircraft. We envisage that the British Army is likely to follow the latter route and make a large investment in a mid life update of their Mk7 and Mk9 fleet involving a change of role to complement their acquisition of an attack helicopter fleet. Thus, they and other operators will be investing substantially but effectively in Lynx through the next decade.

7. I suggest that this paper has demonstrated that because of the inbuilt qualities and potential of the Lynx' basic design, Westland has been able to define and implement an effective long term development strategy which should ensure that the aircraft continues as an effective military machine well into the next century. Indeed we expect to see significant numbers still in service when we celebrate the 50th Anniversary of its first flight in 2021.



NAVY LYNX



BATTLEFIELD LYNX