THE HELICOPTER A CONSUMER PRODUCT - THE UK POLICE EC135 EXAMPLE.

This is a discussion paper presenting the perspective of a specialized completion agency on the process of adapting modern helicopters to meet specific roles. The author compares and contrasts the development process found in the helicopter and automotive industry and highlights the significant differences. The author reflects on how the automotive industry is able to create and manage customer aspiration in a manner which only the most specialized helicopter completion agency can remotely approach. The author ends with an appeal to helicopter manufacturers to note that the product leaving the factory is frequently only a starting point for the development of a helicopter and seeks that manufacturers do more to prepare their product for on-going modification.

Introduction

Few would disagree with the statement that in the late 20th and early 21st Century, the industrial entities which attempt to dominate our lives spend millions of Euros, Pounds, Dollars or Yen developing consumer products. The money is invested in a wide range of areas embracing everything from what new products could do for us in the future - WAP and third generation mobile telephony, to meeting the complex raft of consumer protection legislation present in Western Culture.

It is interesting to observe that if just some of the television advertising is to be believed, car manufacturers will resource their research and development staff to develop highly sophisticated gas-strut operated coffee cup holders on the one hand and highly sophisticated computer driven braking and engine control systems on the other because they know this will help them sell cars.

While I have not been able to confirm how many cars might be 'consumed' during the development of a new model, it is again fairly evident that the number lies not in the tens but more likely in the hundreds. Much of the testing particularly that associated with safety leads to the ultimate destruction of test vehicles but a significant portion of the testing involves simulated consumer use to achieve a product which will meet consumer expectations in the showroom, a positive response from the motoring press and develop a reputation as a well thought out and reliable product.

I have no links with Volkswagen at all but I very happily drive a Volkswagen Passat that has shown me how a team of engineers, researchers and evaluation staff have done an excellent job across the board, but I fear that the gas strut damped coffee holder is a bit wasted on me. In the context of what I will also propose in this paper, it is also interesting to note that the car fails in one area crucial to my work, which while it may be overcome is a surprising omission. The integration of a hands-free car kit is still a customized third party supplied activity involving significant disassembly.

The aeronautical challenge

The aeronautical engineer is faced with huge challenges when developing a new helicopter and will question the relevance of the first paragraphs of this paper to his and increasingly her own activity. This paper is intended to use the contrasts of modern

consumer product development with the development process required to produce a viable and developed helicopter for a demanding end-user - and the example in this case will be the UK police and the now nearly ubiquitous police helicopter.

It is not an unreasonable thought to contrast two sets of numbers:

- Typical helicopter production run for a series produced helicopter in civil and military service over a 20 year production life
- Number of cars written off or consumed during the development of a modern car for a 10-year product life.

The point I wish to make is that the helicopter industry, in car industry terms, hardly moves beyond product development in terms of numbers of vehicles actually produced. By the time the first production versions of a car have been superceded by the much better MK2 with improved 'this' and enhanced 'that', series production of the helicopter will have only just started and will end after the production of as few as 2000 vehicles. In numerical terms therefore the helicopter developer is in a rather different 'ball park' to their design and development counterparts working in Detroit, Wolfsburg or Stuttgart to name a few centres of car production.

Development resources

In the very specific cases of the Eurocopter EC135 helicopter, the programme team enjoyed the use of three development airframes and a number of static test examples. McDonnell Douglas Explorer team was able to utilize as many as 9 test airframes again for a combination of static testing and flight development.

Faced with these constraints the car development manager in the Cities mentioned would simply pack his briefcase, down-load his Outlook personal address book and leave to look for a new job. The helicopter engineer however takes this as the only possible starting point and perhaps would see the challenge of persuading management that a fourth or fifth development vehicle would speed the productivity of the project and even its ultimate profitability as one worthy to tackle.

There are significant differences of scale between these two apparently similar 'vehicle' development projects. If these are not recognized, it is quite likely that significant 'consumer expectation' in the helicopter World may find itself unfulfilled. Put bluntly, the helicopter does not come from the same stable as a car and it would be wise to help our future customers understand this. It may not be wise to over-sell and raise expectation only to fall at a later point when the expectation is not met. A car is car and a helicopter is a highly complex piece of machinery in limited series production adapted by specialists.

I would however propose that there are also significant similarities between consumer car development and the development of both civil and military helicopters. The use of a helicopter will be justified against the use of many other items of equipment and while the helicopter industrial community cannot readily change the nature of the product it produces, it must note that the product operates in the same consumer World as products including the car or the domestic office computer.

Cars in the main are a classic consumer product sharing the characteristics of their cousins including fast moving consumer goods - refrigerators, cookers and their like. The car industry has huge resources and significant expertise in developing both cars and the consumer expectation for their product. I am certain that the millions spent on consumer advertising are not simply spent for the benefit of the television companies. The money is 'invested' to develop in the mind of the consumer that the next 'car' will fulfill their dreams of freedom, carefree handling and choice. Soft and comfortable words will be used and ultimately, whether we know it or not, the industry will begin to persuade us that their new car will meet and exceed the expectations of those in the target market.

A much smaller group of cars will be the subject of significant customization for specific missions. The police and public services will employ vehicles for very specific tasks where in some cases sophisticated equipment will need to be integrated into the vehicle. I use the word 'integrated' carefully. The police service is treated by the car industry in much the same way that they treat the broader market but in a more directed and carefully crafted way. It is as important for the police service that they can safely use a digital trunk communication system in the police version of the car as it is for the more general consumer to safely skip to the next CD on his multi-player.

The car customization specialist is fortunate. By the time they see the vehicle, the manufacture has completed the development process. The vehicle will already have a credible reputation and while the integration of a digital map system in a car is subjected to some not un-reasonable constraints for safety, the car conversion specialist is far less regulated than those of us who work in the aviation industry.

The installation of the TETRA digital trunk radio system into a police car may have significant safety risk. EMC has become a challenge for the car engineer too. The interference of GSM telephony with computer controlled braking systems is well known. Cars rely increasingly on computers and their associated harnesses to provide power and sensor information when it is required and all of these systems are vulnerable to ill-considered modification.

I was surprised to read in the user manual for a Mercedes A Class a statement of electromagnetic susceptibility outlining what power levels and what frequency bands were acceptable to the car's safety case and by implication what levels were not. I need not remind the reader that an A Series Mercedes is a small family car. Mercedes are clearly being more than thorough in the product preparation.

The helicopters niche

Helicopters are expensive (in cash terms) and are complex vehicles surrounded by equally complex social and political issues. They are rarely purchased on a whim. They are procured whether by charter, lease or purchase to do something, which is usually quire specific. The corporate helicopter will be used to move the company's employees or customers from point A to point B for good reason. This may be to impress the customer with the company's dynamic approach or to enhance efficiency of some industrial process. The utility helicopter may be out-fitted to perform live-lift operations

to facilitate maintenance on high voltage power grids whilst allowing the grid to remain live. For the police the helicopter will be expected to perform surveillance, pursuit, command and control or even rescue operations. For all of these, like its distant cousin the police car it will need to be fitted with advanced and complex equipment.

It is reasonable to expect that when a multi-million Pound investment is planned for a helicopter, the purchaser might expect the opportunity to adapt the helicopter to meet their particular requirements and the police Word-wide are no exception to this. The challenges facing completion agencies were never simple. The added dimension of aviation safety and regulation has always ensured, at least in the UK, that the customization process is supervised and that the supervision will always address safety.

The rapid development and use of computer based mission management equipment and other technologies has not gone un-noticed by the police community. The typical police officer may be a computer user and will almost certainly own and operate a car. A police force considering a helicopter will need to ensure that the helicopter is at least as well prepared as a police vehicle as a pre-requisite and will look to the completion specialist to make this possible.

The issues

The low rate of build and life-cycle feed-back from those who operate the helicopters will inevitably result in a widely differing basic modification state for the 1000 or so helicopters. It is likely that groups of aircraft built in a given year may be similar, only small numbers will ever identical in significant respects. EMC engineers have appreciated this for many tears and allow for build tolerance in susceptibility assessments.

The low rate of production and the evolutionary nature of the production item form the moving foundation for the helicopter completion agency and is in marked contrast to the relatively stable foundation upon the which the car specialist can operate.

The issues the third-party helicopter specialist agency needs to confront are numerous. I have tabulated many below (the list is far from complete):

- The long-term viability of a role specific modification
- The development status of the production helicopter
- The certification status of the production helicopter
- The suitability of the airframe for additional hardware
- The sensitivity or otherwise of the airframe to RF emissions
- The overall robustness to EMC/RFI
- The operational needs of the potential customer
- The time-frame for development
- The relationship with the manufacturer of the helicopter
- The relationship with the manufacturer of the equipment to be installed
- The varying approaches to warranty adopted by all involved.
- The liability issues incurred by changing the manufacturer's product

The blend of engineering and commercial risk is not always easy to assess. In the case of the EC135 and the UK police role, MHL took the view that Eurocopter would underwrite the development of the EC135 to the SPIFR 2720 kg all up mass position. With this in mind and a belief that the market for a new technology JAR 27 build standard already existed, the company was prepared to develop its own UK based solution for police operations.

The company's faith in the helicopter's sound design has been confirmed both commercially through orders but in addition through product developments which now see a helicopter with a maximum gross mass of 2835 kg, capable of operating at as high as ISA plus 7 for Category A vertical operations and CAA certified for SPIFR operations when appropriately equipped and flown.

The MHL Mission pod

The process of developing MHL's police mission pod development has served to demonstrate how a relatively small but capable company (120 staff) can produce radical solutions to customer missions. The solutions have in the main been delivered on time and within the agreed customer budget under the vigilant supervision of the UK Home Office and the Home Office Framework Contract for the provision of helicopters to the public services of the UK and Northern Ireland.

Success of the EC135 as a police helicopter has highlighted the type's capability to other market sectors. Increasing interest ,shown by orders, has resulted. This was further reinforced when Eurocopter themselves were able to certify the EC135's digital auto-pilot. The combination of 3-axis auto-pilot and MHL pod offer a helicopter with significant capability even if the prime role of observation is only possible when in visual contact with the ground.

The UK Police Helicopter as an example

Over the last five years the UK has seen a significant up-grade of the police helicopter fleet made possible by the availability from Central Government of funds targeted specifically to maintain air support to the Police. Over the last 15 years utilizing the BO105 and AS355, the UK police have developed police air operations to a high level where the employment of dual-channel Thermal and visual camera systems, digital maps and video down-links to ground units have become common place.

The police helicopter of 2002 in the service of United Kingdom Forces has an impressive specification justified on the grounds of crime-fighting alone. This has not always been the case and it is essential to point out that the equipment levels employed today are the result of 15 years of police operations involving over 30 air support units countrywide. It is also important to note that the last BO105s and the remaining operational group of AS355N feature many of the advanced systems of the their new generation cousins.

A development period of fifteen years assured that when the first new generation police helicopters were to be delivered, customer expectation of the outcome was high. The

new helicopters, and in the case of this article, I will refer to the EC135, are now powerful category A helicopters capable of operating Category A at their maximum gross weight, but also offer single pilot flight in IMC (SPIFR) capability.

The challenge facing the police service was to procure and then operate a new police helicopter. These new helicopters were required to show improved performance both from the core airframe but from the newly supplied police role equipment. The new helicopters were to be a step-ahead of the technology they were planned to replace. The aspirations were set.

On the other hand, the completion agency, in this case my colleagues at McAlpine Helicopters, were faced with the challenge of how to fit the full suite of role modifications to a helicopter that they had never seen before. The customer group were also expecting that the 'new' installation would be 'better' than anything they had seen before.

The starting point

In the atmospheric early days of the UK EC135 police programme, MHL formed a User Group to identify and shape the user of the new helicopter. The group was consisted of police officers and pilots who were to manage the introduction of the first four new police helicopters.

It became clear very early that the Group believed that role equipment should complement the qualities of the new helicopter and have minimal impact on the helicopter's overall flight performance. The modifications of the AS355N and earlier Twin Squirrels had been a little 'too good' and led the police to believe that role equipment could be embodied efficiently with low impact on either the airframe or performance. The fifteen years of evolutionary development on what was a relatively mature helicopter type was a luxury not now available and a period which had caused expectations to reach dizzy heights. A development period of 12 months was all the programme allowed and the first system would also form the first production item. To make the process even more difficult, the design process would need to start before a single EC135 had been delivered to the UK and before the helicopter was certified in the UK.

The UK Police EC135 Advanced Police Helicopter (APH), as it was to become known, needed to be a Category A helicopter which could operate at maximum gross weight and as near to the maximum cruise speed as an efficient role conversion would allow. In addition it was vital that the helicopter should retain particularly good vertical performance at high all up weight - again at Category A conditions.

The MHL EC135 Mission Pod

The McAlpine Helicopters solution for the UK police appeared radical when first shown to the future police EC135 users. MHL proposed a centre-line mission pod mounted between the EC135's high skid undercarriage. The location provides two centre-line strong points for the helicopters prime sensor - a dual channel TV and thermal imaging pod and an airborne searchlight (figure 1). The pod approach offered a number of

benefits not least ensuring that the EC135's light and airy cabin could remain just that and not be filled with the essential racking which an extensive role fit would require (figure 2).

The centre-line position offered only a modest increase to the helicopters projected area (figure 3). The configuration would prove to have only minor impact on the helicopter's speed but in addition almost no impact at all on the helicopters vertical performance. The installation would predicate the use of high-skid undercarriage but since all UK operators of the AS355 series had adopted high-skids as a standard, this was not thought to be an issue. The value of high skid gear during off-site landing has been proven on countless occasions and while the MHL 'pod' is not seen as a crumple zone, the pod's outer casing is readily replaceable. This is more than can be said for the helicopter's underside should the inevitable rocky obstruction be encountered.

The down-side of the 'pod' configuration was also identified long before its first flight. High-skids flotation gear was not an early priority for Eurocopter to certify and thus the podded helicopter could not be fitted with in this manner until the flotation equipment was certified. The issue was accepted by the lead customers who saw little difficulty in operating within their Police Operators rules. Low exposure to over-water flight in a Category A Twin Turbine helicopter led to some strong feeling that the additional weight and expense was simply not worthwhile.

The position of the helicopter's prime sensor - the thermal imaging turret - is also key. Located forward under the pilot and police observer, the centre-line position ensured that the helicopter would not require a left or right hand bias for operations. In addition, from 1000 feet, a good all round view is possible with only minimal obstruction from the helicopter's own structure. The forward position selected for the turret was the end result of significant debate where the usual range of considerations needed to be taken into account. Space, centre-of-gravity, field-of-view and weight all needed to be considered and the resulting production location is now established.

The pod's position raised significant safety issues which needed to be considered and approved. The pod's position could not be allowed to interfere with the EC135's JAR27 build standard and had to complement the helicopters robust design. The modification's which would allow the installation of the pod to the EC135 were presented to Eurocopter who were quickly able to issue their statement of 'no technical objection'.

Flight Test

Large bodies have been attached to aircraft and helicopters previously. The 747/Shuttle combination is one example. The Tornado/JP233 combination is another. The aerodynamics of helicopters are less than predictable and from the outset of pod development it was known that only flight test would determine whether the pod and chosen TI/TV payload would fit comfortably beneath the EC135.

MHL employ two test pilots and on this occasion the tests were performed by Captain Nick Kidd, a Graduate of the ETPS, and at the time MHL's Chief Pilot. It was noted that on occasions even small projections from a helicopter could cause noticeable effects and Captain Kidd was required to explore the necessary operating envelope to ensure

that the pod would not interfere with the helicopter and that the performance characteristics could be quantified.

The pod's overall profile had been subjectively assessed by the MHL team as being conservative. A similar pod had been flown successfully on a BK117C1 but the team were conscious of the differences between the types and only flight trials could prove the issue. As is often the case, the installation comprising faired-in TI/TV turret, pod body and searchlight 'looked right' . The SX5 was smaller than the SX16 which had successfully flown beneath the AS355.

The flight test programme quickly showed that the EC135 with pod - the EC135 APH - was possible. No significant aerodynamic issues were raised and the helicopter had shown almost all of the performance expected of the bare airframe. The major hurdle was crossed and it was the possible to start series production of the pod for the lead customers.

The mission system

The MHL pod provides the police EC135 with a structure offering support for two turreted systems. It also offers space to accommodate the necessary line replaceable units for a number of mission equipments. It was decided at an early point that while the pod might be a 'home' for police tactical communication equipment, this was not attractive.

As designed the Police EC135 APH can be detached from its pod, if required for any reason, and function as a police helicopter but without the systems fitted to the pod. The police radios are installed in the Pelican avionics bay located in the cabin roof behind the last row of seats effectively forming the roof of the helicopter's boot or trunk. This decision also limited the electrical and mechanical interfaces necessary between pod and helicopter.

The pod concept has already show flexibility. At the time of initial development, the searchlight options available limited choice to the use of Spectro-lab's SX5 device. The SX16, the SX5's larger brother, was simply too large to fit beneath the EC135 even on high skids. The User Group members were consulted and concluded that with increasing reliance on the advanced TI/TV systems due to be delivered that the SX5 was adequate. Operational experience began to show that the reliance on the TI/TV was misplaced and that in use a much more powerful searchlight, as had been fitted to the AS355, was required.

Spectrolab must have also concluded that their increasingly ageing SX16 design needed replacement and in 2002 delivered to McAlpine the first production example of a new generation searchlight. MHL design staff evaluated the light and its mounting structure and have been able to integrate the new much more powerful device by the extension of the MHL EC135 pod.

The flying office

While the pod emphasizes the exterior of the helicopter, a range of systems need to be embodied within the helicopter for the crew to perform their mission:

- Police Tactical radios
- TI/TV displays for front and rear observer
- Video recorder system
- Video microwave down-link/up-link control
- Digital map and mission management suite
- Tracker (or similar vehicle tracking equipment)
- Helmet pointing systems
- Power points for hand help equipment - stabilized binoculars

The AS355 'model' based on 15 years of use proved valuable in locating user control units and displays in what have already been determined as 'good' places. The MHL innovation at this point was primarily focused not around the cockpit area but in the rear cabin where the company pioneered a range of flexible pillar-mounted work-stations. The pillar mount offers flexibility even allowing total removal of the equipment if necessary but also allows the use of large LCD screen and if required a computer keyboard for access to an installed mission management package.

The AS355N 'model' gave little guidance where equipment LRUs should be kept. To some extent the standard Eurocopter avionics bay location previously mentioned would prove useful. Located aft, the position was helpful when managing the centre-of-gravity issues, and equally was designed for ready access. This would prove useful in-service where increasingly complex role-equipment would require increasing levels of maintenance support. The challenge would be to install all the necessary mission LRU's around the essential helicopter systems which the company knew would become increasingly complex as the EC135 was developed from a VFR to an SPIFR helicopter.

The installation and successful operation of high-density avionics installations has proved to be a market niche where MHL has flourished. The World however is ever changing and the levels and complexity of equipment and their inter-connection are growing increasingly complex. The EMC/EMI challenge is becoming an increasing a significant element in every customization project and ultimately may lead to a limited series of tried-and-tested ' solutions.

A comfortable chair!

It is interesting to highlight the issues of crew seating. The EC135 is equipped as standard with comfortable and JAR27 crashworthy crew and passenger seats. The passenger seats however were designed for just that purpose and when used by a police observer constantly adjusting his or her position and often leaning forward, the seats' geometry is simply unsuitable for the UK police mission.

In earlier days, prior to JAR27, seat modification of even build was a relatively straightforward process. The provisions of JAR27 changed everything. For the EC135 APH to work it was also crucial that the seated work station in the rear should not only be comfortable but also provide a long-term safe environment for those who used them. It is also worthy of note that while the standard passenger seats offered three point

safety harnesses those in the cockpit offered a minimum of four points. The view taken quite seriously by Chief Officers of Police is that police officers must be offered the highest levels of protection possible and that this 'protection' must be applied uniformly.

The seat issue raised a potentially difficult issue. As an interim, seats designed for EMS operations were employed. While offering the necessary security, these seats were physically small well suited to a lightly equipped paramedic on a short flight. They were not however popular with their users who sought a physically larger seat to accommodate 90 kg police officers on 2 hour sorties.

The only solution appeared to be a custom designed seat which would need to go through the full range of type testing to permit certification and use in the UK. It is fortunate that Martin Baker Ltd, located only 30 miles from MHL, had chosen to expand their activity to embrace crashworthy seating and were able to offer within a relatively short lead time, a custom modified crew seat offering all that was required.

The point to be noted is how the level of customer concerns, in this case safety, can lead to the procurement of complex and sometimes expensive solutions. Had Martin Baker not been able to deliver a crew-seat, it is possible that the whole programme would have stalled, challenged by the concerns of liability for crew health and safety raised by a customer. This level of detail needs to be understood by all. It may only be possible to resolve issues like this through the services of specialized completion centres who are close, both geographically and culturally to their customer base.

Working together

The development of a helicopter is a complex undertaking. In a 'rate-of-return' driven Financial World it will become increasingly difficult to persuade investors to provide funds for complex and even technically risky projects. It is unlikely that the developers of future rotorcraft will be able to deploy more than a small handful of development vehicles for the programme's use. The result inevitably will be an occasionally stalled scheduled as key development airframes are modified or serviced.

The manufacturers are likely to be increasingly committed to a proven core helicopter with options only being developed as and when financed by a particular programme. The extensive lists of factory and dealer fitted options available to car manufacturers are expensive to replicate for helicopters. Each option is the end result of its own development programme and it may simply be impossible for a manufacturer to focus on, for example, the specific safety concerns of a group of customers.

It is the conclusion of this paper that as long as the helicopter remains a highly visible and expensive (large figure on budget) item, operational customers will expect them to perform the complex tasks for which they are to be procured. Manufacturers will find it increasingly expensive to develop the specialized additions necessary at what the market would consider as a reasonable cost.

A balance needs to be struck where manufacturers can design develop and introduce new variants and even on occasions new helicopters to a diverse market which could use them if suitably adapted. The EC135 has shown itself readily adaptable by a

skilled and experienced Completion agency willing and able to take on the task. The technical and commercial investment behind this is significant. Without the implicit support of the manufacturer, this process would not be possible.

The regionally located completion centre are far closer to their local operators than the factory ever can be. As informants they provide valuable insight into the behaviour of their market area and with encouragement may be able to develop modifications which could, if the commercial will exists and if the certifications means can be found, be shared around the World.

Building-in flexibility

The core or source helicopter must be of sound design and this is of course where the manufacturer must show all the expertise they have. Life could be made simpler for completion centres by the employment of for example common seat rail dimensions. Airframe designers always wish to reduce the weight of the bare airframe to the lowest value possible but it might pay future dividends if allowance could be made in key areas for future reinforcement to allow for the direct installation of a thermal imaging turret or similar item.

The sales volumes of computer based helicopter mission equipment will always be low by number. Even by value this equipment cannot be compared to the desk-top PC and the evolution of MS Windows but we might reasonably expect the development of a common standard fibre optic data-bus over the next few years. It would be of significant assistance to the completion agency if provision for these developments could be considered.

As an engineer myself I applaud all those who design, build and then sell helicopters. The enormous flows available in the car industry are simply not available. It should always be borne in mind that when a helicopter departs for the first time from its factory of manufacture that is not the end. It may be a laudable event but in Churchill's words the events is simply 'the end of the beginning' For the UK Police EC135, one million pounds of added value is included and the helicopter grows in mass from a light 1500 kg to a service weight just topping 2000 kg. Without the 500 kg of 'investment', the police helicopter is an expensive toy. With the equipment, the EC135 becomes an effective police tool.

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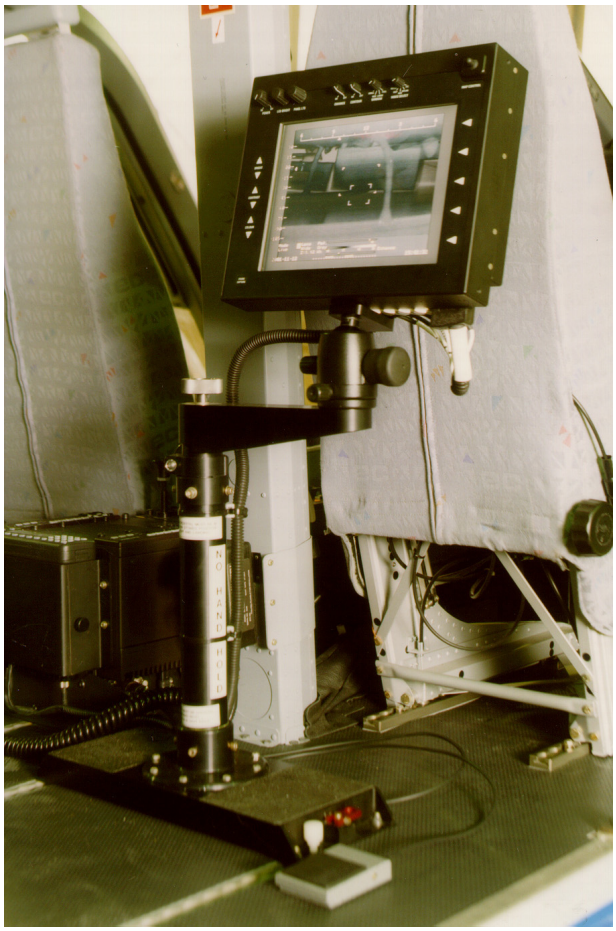
Figure 1.
Operational UK Police EC135 APH

Figure 2.
The view from a rear observer's seat in an EC135 APH

Figure 3.
Low projected frontal area of EC135 APH

Figure 4.
An example of MHL's flexible work station


NO HAND HOLD