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HUMAN FACTOR IMPLICATIONS OF THE AEROSPATIALE AS332L SUPER PUMA COCKPIT

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ABSTRACT

International accident statistics, based on military and civilian flight operations, prove that 70-80% of aircraft incidents and accidents are caused by human factors.

The purpose of this paper is to alert helicopter designers and manufacturers to the types of human factor problems that can occur in modern civilian helicopters by examining the human factor implications of the cockpit design of the Aerospatiale AS332L Super Puma.

The information contained in this report comes from over five years and 2000 hours of flying experience in the AS332L Super Puma and from over 600 hours of instruction and observation of other pilots in a 6-axis AS332L Rediffusion simulator.

It is the author's belief that the optimum cockpit design for any aircraft will not be found by the manufacturer alone. Line pilots and instructors can and should help manufacturers improve their products and decrease the incidence of human factor errors by providing enlightened feedback about ergonomic problems encountered in the cockpit.

1 INTRODUCTION TO HUMAN FACTORS

Generally, people adapt well to many design deficiencies in their working environment, even though their overall working efficiency may be reduced. The purpose of the applied technology of human factors is to improve the efficiency of the system while providing for the well-being of the individual. When this objective is achieved, an increase in both safety and efficiency of the man-machine interface is realized.

The SHELL Model (Fig. 1) is one conceptual model of human factors (also called "ergonomics"). In the center of the model, is the human operator, or LIVEWARE. When working with a machine, the operator must contend with SOFTWARE, HARDWARE, the ENVIRONMENT, and other LIVEWARE. A mismatch anywhere in the system causes stress, which decreases efficiency and safety.

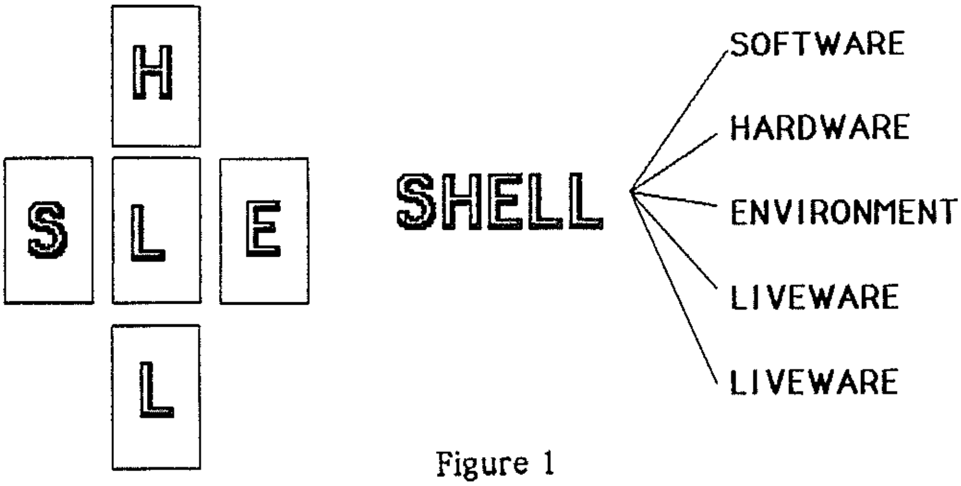


Figure 1

HARDWARE relates to the machine itself and, with respect to aircraft, includes such things as controls, displays, warning systems, safety equipment, seat design, and cabin facilities.

SOFTWARE, again in relation to aircraft, includes operating procedures, format of manuals, checklist design, language of information, symbology, and graphs/tabulation design.

ENVIRONMENT includes temperature, noise, vibration, humidity, pressure, light, pollution, and circadian/biorhythmic cycles.

LIVEWARE includes leadership, communications, crew coordination, personal relations, and discipline.

Most environmental factors are well-known and generally provided for, although far from optimally. Liveware factors, i.e. the human-to-human interactions, are generally outside the realm of the designer's influence. Therefore, these two areas are outside the scope of this paper.

2 HARDWARE FACTORS OF THE AS332L COCKPIT

2.1 Engine Malfunction Warnings

2.1.1 "OVSPD" warning light

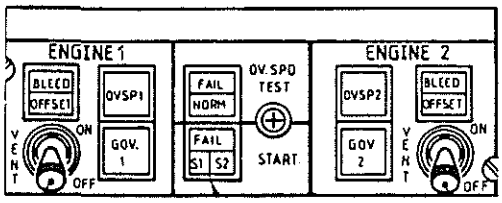


Figure 2

To protect against an engine and rotor overspeed, the fuel control on the Aerospatiale AS332 Super Puma is designed to shut down the engine automatically if the power turbine rpms go too high. Because the main conditions that can cause a power turbine overspeed (high speed shaft or free-wheeling unit failure) happen so quickly, an overspeed warning light is provided so that the pilots realize the engine has shut itself down due to an overspeed. This is a good thing to know because one should normally not re-start an engine if this happens.

A relevant point is that the "OVSPD" light burns steadily when the engine is shut down normally, but the light flashes when the overspeed mechanism shuts the engine down.

This creates a human factor problem. Most pilots have a built-in aversion (although actually it is a conditioned response) to flashing lights in the cockpit. Their immediate gut reaction to a flashing lighted switch is to press the switch to make it stop blinking. A typical example is the master caution light in most aircraft. Another example is the RACAL Avionics RNAV 1 DECCA system which flashes a warning light that must be depressed when there is a problem. There are certainly numerous other good examples.

How can a flashing light be a problem? Consider the following scenario. First, one engine fails due to an overspeed. The copilot sees the flashing "OVSPD" light, says nothing, and then, unconsciously presses the light to stop it flashing. (Many companies specify that the first action during any emergency procedure is to cancel the master warning light.)

A few minutes later, the captain, who up to this point has been concentrating on flying the aircraft, considers trying a restart because he hadn't seen the overspeed warning and the light is now not flashing. The copilot , who cancelled the only indication that would tell them they had an engine overspeed, whole-heartily agrees to a restart because he can't remember cancelling the light since he did it without consciously thinking about it. The engine starts normally, because the broken engine-to-MGB shaft has no effect during the starting sequence, but as soon as the pilots increase power, the unburdened power turbine and it's broken shaft turn faster and faster with the probable result of further damage to the helicopter. (There is one instance of a Super Puma engine being re-started by a mechanic on the ground after the engine had shut down due to an overspeed. The aircraft caught fire and was destroyed.)

The result? A carefully engineered warning system is rendered useless because a human factor reaction to a blinking light was not recognized by the system designers. If such an accident ever happens in flight, the cause will no doubt be put down as "pilot error," when in reality it is "designer error."

2.1.2 "POWER" light

Another engine light that causes problems is the "POWER" light. The "POWER" light is under the direction of the power calculation system which uses a relatively sophisticated logic to help the pilots determine which engine is malfunctioning under various conditions. Very basically, the power calculation system examines the Ng readings from both engines and the Nr to determine which engine has malfunctioned and why; then it illuminates the "POWER 1" or "POWER 2" light as appropriate.

This is particularly good information to provide the pilot when the automatic fuel control of one engine fails and the engine, although still operating, must be controlled manually. Because the other engine automatically varies its power output in order to maintain Nr within limits, it can be difficult to determine which engine is malfunctioning.

The problem with the "POWER" lights is that they don't illuminate until Nr varies approximately 6-7% above or below the usual in-flight setting of 100-101%. Although these Nr values are neither dangerously high nor low, they are well outside the "usual" Nr values.

Notice I said "usual" and not "normal." After one hundred or so hours in an aircraft, most pilots know what the "usual" values are for pressures, temperatures, rpms, etc, and become suspicious when they observe "unusual" values, even if these values are within specified "normal" limits. So when a pilot observes an "unusually" high or low Nr, his first reaction is to adjust collective pitch to bring that Nr back to its "usual" normal value.

What happens when an automatic fuel control malfunctions and causes the Nr to vary is that the pilot instinctively adjusts the collective pitch to bring the Nr back to where it belongs. This defeats the intention of the power calculator system because it cannot illuminate a "POWER" light unless the Nr is above 107% or below 94%. The pilot is left to figure out which engine is malfunctioning by interpreting the Ng and T4 indications . . . or he can choose to raise or lower the collective until the Nr changes enough to cause the power calculator to illuminate a "POWER" light, an action which many pilots are reluctant to do.

2.2 Autopilot System

2.2.1 General

Any pilot who has every worked with an advanced autopilot knows that the most frequent mistakes made by pilots, even after they know how the system operates, are 1) pushing the wrong buttons at the right time, 2) pushing the right buttons at the wrong time, 3) pushing the right buttons in the wrong sequence, 4) thinking that an autopilot function is off when it is on, and 5) thinking that an autopilot function is on when it is off. Many of these kinds of errors could be eliminated if designers pay more attention to human factors.

A primary cause of ergonomic-type errors is the manner by which the autopilot functions are displayed. Usually, the annunciator lights are shown on one central autopilot panel, which is often on the center cockpit console (easy to reach, but out of sight). Sometimes the annunciators are duplicated elsewhere in the cockpit, on the panels in front of the pilots or even on a flight instruments themselves (Fig. 3, #1). For example, airspeed hold may be displayed on the airspeed indicator, altitude hold on the barometric or radar altimeter, localizer and glide slope hold on the HSI (Horizontal Situation Indicator) or artificial horizon (ADI).

Of the three methods, the last one is the best because this is the method the autopilot annunciators will most likely and most often be seen by the pilot. The simple reason is that the flight instruments are an integral part of every experienced pilot's cockpit scan. The autopilot annunciator panel on the center console is not a frequent part of most pilots' instrument cross-check.

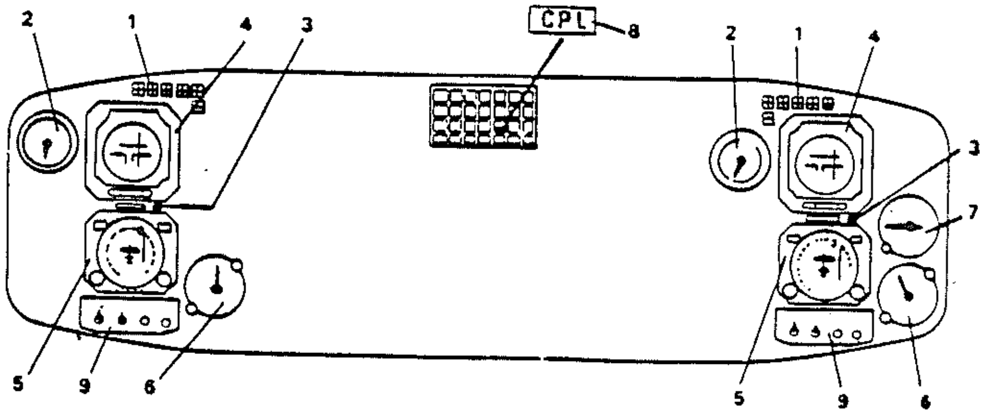


Figure 3 Autopilot and Related Systems on the Instrument Panel

2.2.2 AS332L autopilot system

The Helikopter Service AS332L Super Pumas are equipped with SFIM 155 duplex autopilot systems, SFIM CDV 85 four axis couplers, Collins ADI-77 Attitude Direction Indicators, and Astronautics 133640 Horizontal Situation Indicators.

Mixing boxes from different manufacturers may not always be desirable, but due to economic reasons (mixing may be less expensive), operational considerations (one system may not provide all things to all operators), and marketing aspects (compatibility of systems means greater potential sales), mixing systems is not going to go away. As a consequence, designers of the various components have to pay even more attention to human factor problems and, just as importantly, there must be someone in the loop who is able to examine the resulting system in its entirety.

With respect to the autopilots in Helikopter Service's Super Pumas, when they work as designed, the autopilots are truly impressive. If there is a malfunction, there are, for the most part, sufficient back-ups and warnings for the pilot. In other words, the autopilot hardware, per se, is generally very good.

However, of all the systems in the Super Puma, it is universally agreed in Helikopter Service that the autopilot is the most difficult for pilots to master. Many of the difficulties with the autopilot stem from human factor problems in the design of the system.

2.2.2.1 Single- or dual-pilot system?

The most basic problem with the system is that it can not be fully operated from the left seat. Certain functions, for example coupled ILS and coupled vertical speed, can only be controlled by the pilot in the right seat. The system favors the captain's side of the cockpit to the detriment of the copilot's side.

The reason for this, I have been told, was Aerospatiale's original intention to obtain single-pilot IFR certification for the Super Puma. This has not been obtained and probably never will be, but we are now left with an autopilot system that makes it difficult or impossible to set up, among other things, coupled ILS approaches from the left seat.

(With respect to single-pilot IFR, the following policy statement from the International Federation of Air Line Pilot Associations is appropriate. "Although IFALPA recognizes that presently single pilot commercial operations are in widespread use, this type of operation is not acceptable during international public transport flights, including all off-shore flights, because of the reduced level of safety." Single-pilot IFR capability is great, but it should be available to both captain and copilot alike.)

Why is this lack of full dual-pilot capability not good? Consider this scenario: The captain becomes incapacitated, the weather at the airport is at minima, and the copilot is young and inexperienced. He needs all the help he can get, but because he can't reach the necessary switches on the right side of the cockpit, he has to fly the ILS uncoupled.

A good general principle to use when designing autopilot and coupler systems is to make all autopilot functions fully controllable from both sides of the cockpit. There should also be one switch, easily accessible to both pilots, that passes autopilot authority from left to right and back again. And there must be a well-defined annunciator prominently located on the front panel (the best place would be right on the artificial horizon) telling the pilots who has the authority.

2.2.2.2 Heading select switch

Figure 4

The Helikopter Service machines have a switch which is used to transfer authority between the pilot and copilot, however it only controls the heading select function of the system. Both pilots have a selected heading index, or heading "bug," on their horizontal situation indicator (HSI) which is used to set a desired heading the autopilot coupler should maintain. The heading select switch tells the autopilot which heading index to follow.

The idea is simple enough and easy to understand, but the switch and its associated annunciator lights indicating who has heading authority are located on the pedestal console between the pilots, far away from the HSIs and other primary flight instruments. The error, which happens frequently, is that one pilot sets his heading index to the desired heading and, forgetting to check the heading select switch, engages the coupler heading hold. If the switch is still set to the other pilot and his heading index is set at another heading, the autopilot will obviously turn the helicopter to an undesired heading.

This problem could have been avoided by putting the annunciator lights for the heading select switch on the heading indices of the HSIs. When the pilot has heading control, his index is illuminated (or some other way highlighted); when the copilot has heading control, his heading index is highlighted. .

2.2.2.3 Localizer and glide slope capture modes

The problem with these modes is deceptively small, yet potentially extremely dangerous. The "fix" is probably relatively simple, given the complexities of the rest of the autopilot system.

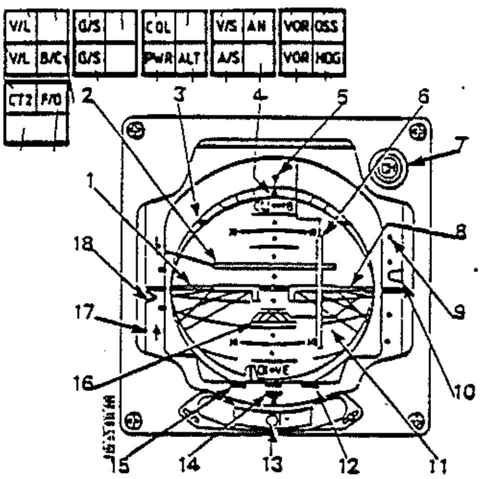
An Instrument Landing System (ILS) provides precision guidance to a runway while providing very specific obstruction clearances throughout the approach. By regulation and common sense, a pilot is not allowed to descend on the glide path until the aircraft is established on the localizer course.

With the SFIM CDV 85 four axis coupler, it is possible to arm both the localizer and glide slope modes before being established on either one. This makes sense because the pilots can set up the autopilot before they reach the ILS. What doesn't make sense is that it is possible to capture the glide slope before the localizer is captured, and, in fact, even with the localizer mode un-armed. This means that the aircraft will descend on the glide slope beam while outside the limits of the localizer, which means that the aircraft could be descended below the minimum altitudes designated for that part of the approach.

2.2.2.4 Coupler and flight director annunciation

It was mentioned in Section 1 that man is very adaptable. One way Super Puma pilots have adapted to the poor annunciation of the coupler functions is to use the flight director command bars (Fig. 5, #2 & 6) on the ADI as an indication to them that the coupler is on. With the command bars right on the instrument they look at most often, the presence of the bars is not hard to overlook. The pilots simply make it a personal habit to always engage the flight director whenever they engage the coupler.

Figure 5 Attitude Deviation Indicator (ADI)



This practice does, however, have one big disadvantage. If the autopilot disengages, due to a malfunction, on purpose, or inadvertently (and it is disengaged inadvertently from time to time), the coupler drops out, too, but not the flight director. This makes sense because it is useful to have flight direction when the autopilot is out. The problem occurs when the autopilot is switched back on.

It is not difficult to know when the autopilot is disengaged --- you notice the difference in the feel of the cyclic at once. The non-flying pilot usually notices the difference, too, and if he is alert, he reaches down and re-engages the autopilot within seconds. Both pilots breathe a sigh of relief.

Unfortunately, their problems are not over. For although the autopilot is on and the flight director command bars are still in view on the ADIs, the coupler is not engaged. The only indication that tells the pilots the green coupler function lights are sending signals to the flight director only and <u>not</u> to the autopilot, is a small, dimly-lit "F/D" light tucked away above the ADIs.

It usually takes some time and perhaps large heading or altitude deviations before the pilots discover that the autopilot coupler functions are not flying the helicopter for them. If this happens during a critical phase of flight, such as during an instrument approach to an oil rig at night, the consequences could be tragic.

2.2.2.5 "CPL" warning light

Whenever a coupler function fails or <u>is turned off</u>, the "CPL" light (Fig. 3, #8) on the master annunciator panel and the master "WARN" lights illuminate. Pilots like to have warnings when something fails, but to receive a warning every time something is purposely switched off is counter-productive.

The human factor reason is so obvious that it is difficult to understand how it was overlooked: <u>If a warning light comes on numerous times, every time you fly, eventually it is going to be ignored</u>.

The first time a pilot new to the Super Puma switches off a coupler hold function he immediately notices the "CPL" and "WARN" lights illuminating, and, being new to the machine, he logically assumes something has failed. However, by his third or fourth flight, he is already ignoring the "CPL" light or canceling it without thought.

The story about the boy who cried "Wolf!" is a good lesson in human nature which was apparently forgotten when the SFIM designers were working on this part of the CDV 85 four axis coupler.

2.3 Navigation Equipment

2.3.1 Nav HSI switching panel

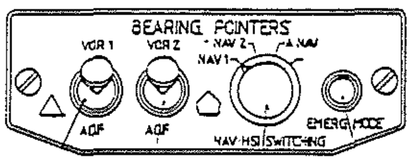


Figure 6

Another very confusing part of the Super Puma is the navigation switching panel. Basically, each pilot has two pointers on the HSI, and he has switches by which he can choose which navigation radios he wants to monitor. There is also a switch that controls the Course Direction Indicator (CDI) which accepts signals from VOR 1 or VOR 2. However, there is an inflexibility in the system in that the autopilot will only accept coupled ILS signals from VOR 2 <u>and</u> only when the right-seat pilot has selected VOR 2 on his CDI <u>and</u> only when the heading select switch is set to "PILOT." This automatically, restricts the pilots' choices if they want to fly a coupled ILS.

The number 1 (green) pointer on both pilots' HSIs takes signals from either VOR 1 or the ADF (or ADF 1 if two are installed). The number 2 (orange) pointer takes signals from VOR 2 and the ADF (or ADF 2 if two are installed).

The confusion occurs because BOTH pointers can indicate either VORs or ADFs and it is common to use both a VOR and an ADF during many VOR and ILS approaches. What can easily happen is that the copilot has the ADF on pointer 1 and the VOR on pointer 2 and the pilot has the opposite indications.

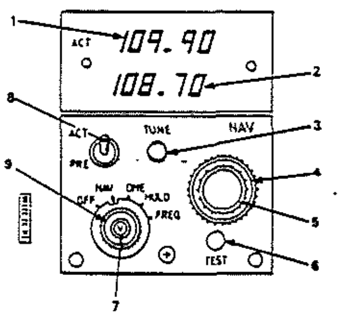
A better system, given the limitations of only two pointers, would be to designate one pointer as the VOR pointer and the other pointer as the ADF pointer, with a switch to reverse these functions in case of a pointer failure. That way both pilots would always know that they have VOR information on the green pointer, for example, and ADF information on the orange pointer. To remove the question of which VOR or ADF is being monitored, the pointers themselves could display a "1" or "2," indicating, respectively, VOR 1 or VOR 2 on the VOR pointer and ADF 1 or ADF 2 on the ADF pointer.

One could monitor two VORs on the same HSI by switching the CDI to one VOR and the VOR pointer to the other. It would not be possible to monitor two ADFs simultaneously on one HSI, but this is a relatively infrequent requirement. (The Helikopter Service Super Pumas are only equipped with one ADF anyway.) If there is a requirement to monitor two ADFs, the pilot could monitor one and the copilot the other, or, as an alternative, either pilot could switch between ADF 1 and ADF 2 every few minutes to check the relative bearings to the NDB stations.

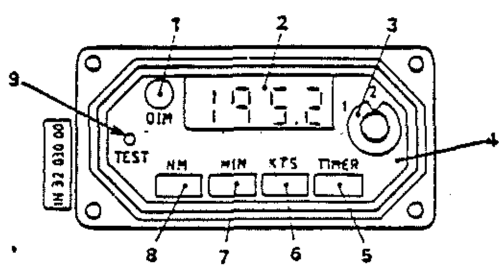
2.3.2 DME selection

It is possible to monitor one of six different DME stations depending on how the switches are set. However, the only indication of which VOR frequency is giving the DME reading is by the position of the switch and a light on the radio itself. The light indicates that the DME is coming from that box (number one or two), but it could be from one of three possible frequencies, one of which may not be displayed, depending on the position of the HOLD switch.

Figure 7



Collins VIR 31H



Collins DME 40 Indicator

This can and does create so much confusion that Helikopter Service instructors recommend setting the DME function switch to VOR 2 (because this is the only VOR that can be used to fly a coupled ILS approach) and just leaving it there all the time, except in those rare cases when DME information from a second VOR is required. The problem is that there are just too many choices, too many frequencies from which one can receive DME information - - - and in the heat of an approach or a missed approach, it's easy to forget which DME one is monitoring.

2.3.3 Radio frequency selection

This is a generic problem to many aircraft, not just the Super Puma. Many operators do not have 100% standardized fleets. In fact, there are probably very few operators that have the same radios in all their aircraft. This is obviously a matter of economics that pilots just have to live with.

With most radios, the frequency selected increases when you rotate the knobs clockwise, but in a few the frequencies increase when you rotate the knobs counter-clockwise. Some radios allow you to rotate past the highest useable frequency and continue turning to the lowest frequency on the scale, and vice verse. Others stop at the highest and lowest frequencies and make you turn back the other way. Most two-tiered knobs (like wedding cakes) work so that the lower, bigger knob adjusts the numbers in the left window (therefore the higher numbers) and the higher, smaller knob adjusts the numbers in the right window (therefore the lower numbers); other radios work just the opposite.

It goes without saying that pilots are going to have trouble tuning frequencies when they have to use different radio sets. This may seem like a relatively small thing, and most of the time it is, but it can be a time-waster. In the worst case a pilot may accidently set the wrong frequency, not have time to check the windows, and miss a critical radio call. Standardizing how frequencies are dialed in will eliminate one area in the cockpit that is prone to mistakes.

2.4 Landing Lights

When you push down on the search light knob in the Super Puma, the search light moves up. When you push up on the knob, the search light moves down.

This is exactly opposite from the way the moveable search light in the S-61 and Bell 212 work and since all of our pilots flew one or both of these helicopters before transitioning to the Super Puma, it is no wonder that this causes difficulty.

One really doesn't need landing lights until one is on short final. By that time, you need to position the light quickly and accurately. When it moves in the opposite direction from what one expects --- away from where you want it --- it's not only irritating, but potentially dangerous as well.

As a general rule, the landing light should move up when you push the switch up and move down when you push the switch down.

2.5 Intercom Switching

The pilot's and co-pilot's intercom switches are two-position switches, "NORM" and "EMER". In the normal position, the voice-actuated system works, which is an extremely good system to use. The emergency position is there in case the normal power supply to the system is lost. When in "EMER," the pilots have to key the microphone switches on the cyclics or the intercom control panel in order to talk to each other.

The intercom system would be better if the need to switch to "EMER" in case of a normal supply failure were eliminated. In other words, once the pilots discover that the voice-actuated system no longer works, all they have to do is use the cyclic or panel microphone switches.

Trouble-shooting an electrical fire is one emergency when the emergency intercom system is needed. Various electrical suppliers must be switched off, including the normal power supply to the intercom and the autopilot. One pilot must therefore concentrate exclusively on flying while the other pilot is trying to isolate the fire. This is no time for communication difficulties. Requiring both pilots to switch to "EMER" just adds an additional burden and stress factor to the emergency.

3 SOFTWARE FACTORS OF THE AS332L COCKPIT

3.1 General

As noted before, software factors include many items, all of them concerned with information. Often, good, well-designed operating procedures and checklists can make up for design faults in the aircraft. For example, with reference to the flashing "OVSPD" light problem mentioned in Section 2.1.1, Helikopter Service has a prominent note in the Emergency Checklist under "Engine Malfunctions," stating that a failed engine should not be re-started if the "OVSPD" light is flashing.

It is not the intention of this paper to try to examine the flight manual, operating procedures, and all other information sources about the Super Puma, but rather to limit the discussion to the information presented to the pilot in the cockpit. However, I want to mention the "AS332 Super Puma Instruction Manual." This manual is, beyond a doubt, the best aircraft instruction manual I have ever seen and I can honestly say that I learned more from it than I have from any other manual.

However, there are two main problems with the Manual, which also apply to the cockpit indications. The first is the occasional inconsistency among terms and the second is occasional poor translations from French to English, including abbreviations. I suspect the two problems may be related in some cases.

An example of the first is the use of both "generator" and "alternator" to describe the same thing in the electrical chapter. Examples of the second type of problems, translations and abbreviations, are discussed below.

3.2 "MGB COOL" Warning Light

The Super Puma main gear box has two lubrication pumps, a normal and an emergency one. Both pumps are essentially the same and both run continuously. The main differences are that the main pump delivers a slightly higher pressure and that the input to the emergency pump is lower than the input to main pump. Basically, if the main pump stops delivering oil, either due to a leak in the system or failure of the pump itself, the emergency pump will continue to supply oil to the main gear box. The only thing the emergency pump bypasses is the transmission oil cooler, because, the reasoning goes, if there is a leak somewhere in the system, it will most likely be in the plumbing to the oil cooler. Everything in the main gear box is still lubricated, but the oil is no longer cooled. Therefore, one can expect a gradual rise in transmission oil temperature with a failure of the main pump or a leak.

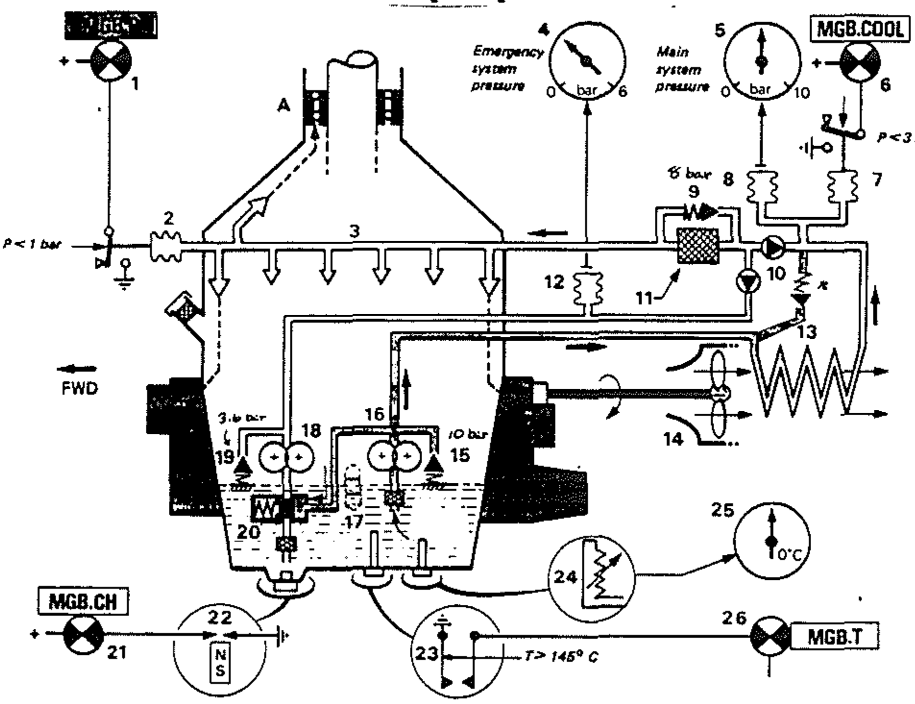


Figure 8 Main Gear Box Lubrication System

It's obviously important to warn the pilot that this has happened and the "MGB COOL" light (Fig. 8, #6) serves this function. It is triggered by a pressure switch which senses the drop in pressure in the line downstream of the oil cooler. What it means is that the oil cooler has now been bypassed.

The theory is very good and the light works in practice, but the language on the light creates confusion. "MGB COOL" does not mean that the MGB is now cool or will become cool, but rather that it will become hot. Nor does it mean that the MGB cooler has failed. If the cooler fails, due to the drive shaft or the blades breaking (this has happened quite often), the light does not illuminate; what one sees is a rise in MGB temperature and eventually a "MGB TEMP" warning light. "MGB COOL" means that the MGB cooler has been <u>bypassed</u>. This is not, however, the most important thing the pilot needs to know at this point, even if he does remember what the light signifies.

The important thing is that the main pump is no longer delivering oil to the system, either because of a failure or a leakage. Therefore, it would seem to make more sense for the light to be labelled "MGB PUMP." This would alert the pilots to the actual <u>cause</u> of the pressure drop, not to a less important <u>consequence</u>, which is what bypassing the cooler is.

3.3 Hydraulic Panel

The labelling on the hydraulic panel is particularly confusing, even to pilots who have flown the Super Puma for many years. The problem is that the abbreviations are not consistent, and I suspect this was a result of translating abbreviations from French to English.

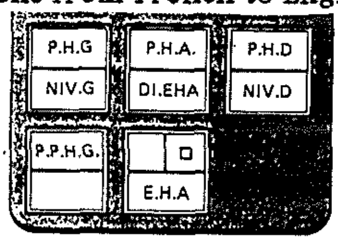
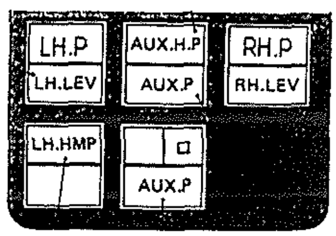


Figure 9



French

English

The culprits on the English switches are the letters "P" and "H." On some of the switches, the letter "P" stands for "pump" and on other switches it stands for "pressure." On every switch "P" appears, it could logically stand for either "pump" or "pressure."

On some of the switches, the letter "H" stands for "hand" and on others it stands for "hydraulic." On many of the switches, "H" could stand for either "hand" or "hydraulic." On one switch, "H" stands for <u>both</u> "hand" and "hydraulic."

The correct meanings are as follows:

LH.P - LEFT HAND PRESSURE (low)
LH.LEV = LEFT HAND LEVEL (low)
LH.H.MP = LEFT HAND HYDRAULIC MAIN PUMP (failure)
AP.H.P = AUTOPILOT HYDRAULIC PRESSURE (low)
AUX.HP = AUXILIARY HYDRAULIC PRESSURE (low)
AUX.P = AUXILIARY PUMP (failure)
AUX.P = AUXILIARY PUMP (on/off switch)
RH.P - RIGHT HAND PRESSURE (low)
RH.LEV - RIGHT HAND LEVEL (low)

It's easy to understand how this creates confusion. Anything that does this, particularly during an emergency, is going to increase the stress level and the chances for mistakes.

3.4 "THROT" Light

This light indicates that one or both of the fuel flow control levers (FFCL) is not in the "FLIGHT" position, where they normally should be if they are working normally. It's a useful light with an engine failure and subsequent shut-down because it is the only warning light that remains illuminated after the FFCL has been set in the shut-off position. (The "DIFF NG" and "PRESS 1" or "PRESS 2" lights extinguish when the FFCL is in the shut-off position.)

But why is it called the "THROT" light, and not, for example, the "FFCL" light? The term "throttle" is not used anywhere in the Instruction Manual or the Flight Manual. The proper term is "Fuel Flow Control Lever." The use of the word "throttle" and its abbreviation "THROT" is, I suspect, either a carry-over from the days helicopters actually had throttles (admittedly, some still do) or another translation problem from French to English.

3.5 Autopilot Panel

The hardware aspects of the autopilot were discussed thoroughly in Section 2.2.2. The software aspects of the panel are actually quite good, with only a few minor exceptions.

To test the main autopilot, one moves the test switch from "TEST" to "RUN," meaning, apparently, that one is "running the test." On the other hand, to test the collective part of the autopilot (the fourth-axis), one moves the test switch from "NORMAL" to "TEST."

3.6 "RB. SAFE" and "ROT.BR" Lights

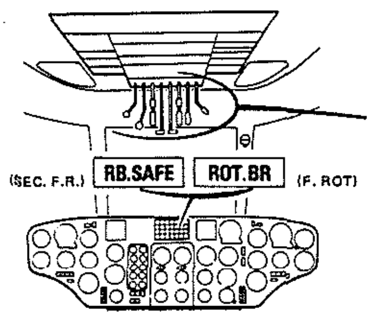


Figure 10

The Super Puma has a two-lever rotor brake system, the rotor brake safe lever and the rotor brake lever. It is possible to move the rotor brake to the braking position in flight (which obviously should not be done), but it will do nothing more than cause the "ROT.BR" light to illuminate. You can only obtain rotor braking when both levers are pushed forward, a sensible system which just about guarantees that the rotor brake won't be engaged inadvertently at the wrong time.

"RB. SAFE" means that the rotor brake safety lever is in the forward position, not, as one may be lead to suspect, that the rotor brake is safe. Actually, one could argue that with the safety lever in the forward position, the rotor brake system is armed because, now, if you move the rotor brake lever forward, braking pressure will be applied to the rotor system. Therefore, the rotor brake system is, in a sense, unsafe when the rotor brake safety lever is forward and the "RB SAFE" light is illuminated.

So why not call the light "RB ARM" instead? One could also change the "ROT.BR" light to "RB ON" to make the two lights consistent.

3.7 Heater Distributor Valve Control

The heater has a three-position distributor valve control lever so that the pilots can choose where they want the heat directed. In the forward position, the heat is divided between the cockpit and the autopilot; in the middle position, heat goes to the cockpit, the autopilot, and the cabin; in the aft position, all heat distribution to the aircraft is cut off. The problem with the heater lies in the fact that the distributor valve control lever has been poorly labelled.

The forward position is labelled "COCKPIT POSTE PILOTE." This looks like a blending of English and French --- it probably means the cockpit will be heated. But what about the autopilot?

The middle position is labelled "O." If you know a little French, you might know that "O" is an abbreviation for "ouvert" which means "open." But what is being heated with the switch open? If you don't know French, you might think it is a "0" (zero) instead of an "O" (oh) and that it means closed.

The aft position is labelled vertically "F C." Again, if you know a little French, the "F" might stand for "fermé" which means "closed" and the "C" might be an English abbreviation for "closed." Then again, "F C" both may be French abbreviations or English abbreviations. It's very hard to tell.

This may all seem very picky and perhaps it is. But it is also confusing, annoying, and totally unnecessary. With only a bit more thought and effort, the lever could have been labelled so that the function of the three positions were obvious.

4 SPURIOUS WARNINGS

As was mentioned before in Section 2.2.2.5 concerning the "CPL" light illuminating every time a coupler function is switched off, continuous unnecessary warnings eventually are ignored. Complacency with respect to the warning is the result. In some aircraft, pilots have gone so far as to pull circuit breakers for certain specific warning lights because they were so prone to false warnings. MGB chip warning lights are notorious examples.

Sophisticated electronic systems seem to be all too prone to spurious warnings. The numerous landing gear switches in the Super Puma are particularly sensitive, and if it weren't for the aircraft's emergency electrical and hydraulic extension possibilities, there would be a lot of gear-up landings at Helikopter Service. The landing gear switches are not, however, just a problem for the landing gear, but also for all the auxiliary equipment which receive "GROUND" or "FLIGHT" signals, as well.

For example, a common problem with the Super Puma is for the area navigation system (be it VLF/OMEGA, DECCA, LORAN, or whatever) to "freeze up" in flight. The solution is to re-cycle the landing gear. The cause is the loss of the "FLIGHT" signal to the area nav system because one of the gear has moved out of position enough to open a switch which should have been closed.

Another related problem concerns the autopilot. I one time found it impossible to get the autopilot to test. Everything worked all right, but the test just wouldn't run. I signalled the mechanic and he immediately realized the problem was a switch in the nose gear. He grabbed a tow bar, jiggled the nose wheel, and the autopilot test worked perfectly.

Incorrect fire warning system tests during start-up are another headache. Mechanics have nearly gone crazy changing PCB cards, wiring harnesses and fire detectors, but the problem is one of moisture. Nine times out of ten the system will test properly if the engines are started and everything is allowed to warm up and dry out.

The point is that pilots can quickly loose faith in warning systems if they continually give false warnings. When a warning system cries "Wolf!" all the time when there is no wolf, the one time there really is a problem, it may be ignored. The increased use of electronics and computers in helicopters promises numerous advantages for the pilots, but the systems must be constructed so that they are not adversely affected by the environment.

5 FUTURE CONSIDERATIONS

"New technologies incorporating multiple redundancy and fail-safe concepts are becoming so reliable that, in future years, the proportion of human factor accidents may reach 100 percent simply because the total, irrecoverable failure of machine components of the man-aircraft system will be eliminated."

Dr. Robert B. Lee
Australian Bureau of Air Safety Investigation

"The Space Invader-playing kids of today will be the fighter and bomber pilots of tomorrow."

Ronald Reagan
40th President of the United States

Even though former President Reagan didn't mention helicopter pilots in the above quote, they certainly could be included. What is also certain is that his prediction is already coming true.

How will this effect human factor problems in the cockpit?

Not more than ten or fifteen years ago, the space and aircraft industries were the epitome of high-tech. In many ways, they still are, but since the advent of inexpensive micro-chips, "smart" machines are now commonplace in most homes. Today, the gap between sophisticated aircraft and sophisticated household machines has narrowed. Entire houses can now be controlled by a central computer. In late 1988, the Electronic Industries Association/Consumer Electronics Group announced a new wiring standard called the Consumer Electronics Bus which will enable microprocessor-equipped appliances built by one company to communicate with those built by another.

This means that more and more people will use sophisticated electronic and computer-controlled devices on a daily basis. Today, many children learn to operate machines even before they can read. At age four, my youngest son knew how to operate the remote controls to our video cassette recorder and television, find and play games on our Macintosh computer, use various cassette players, and heat food in a microwave oven. Operating machines is second nature to him.

Aircraft designers will have a new human factor element to consider. Instead of the automobile, electronic, and other industries mimicking the designs of equipment found in aircraft, the aircraft manufacturers may find themselves copying panel designs from these industries in order to avoid human factor problems in the cockpit. This is not to say that aircraft will loose their place on the cutting edge of technology, but that aircraft designers will have to be more aware of the designs of equipment made by other industries.

For example, affordable NAVSTAR systems for automobiles are not far in the future. If these car systems are very dissimilar from what pilots find in their aircraft, human factor errors will occur.

In the past, pilots had to contend with transfer of learning problems between their airplanes and their automobiles. These problems will seem minor to the pilots of future generations who will have to contend with transfer of learning problems between their aircraft and their cars, their computers, their home entertainment systems, and numerous other gadgets, appliances, and machines, some of which have yet to be invented.

There will be international "standards" developed and accepted, sometimes by agreements and official decrees, but perhaps more often by the company that is able to sell the most of a particular product first. If a similar machine does not fit the accepted "norm" or the standard that people have become accustomed to, problems will arise.

This was illustrated to me when my company installed a new security system which required the use of magnetic-strip identity cards. The old system required one to insert a card and punch in a four-digit code before the door would open. The new system required that the code be punched in first, then the card inserted. If you inserted the card first, a red light blinked indicating something was wrong.

On the first day, nobody could get in the building! Even though instructions had been sent to everyone, no one thought to insert the code first.

Everyone assumed there was something wrong with their card or that they had the wrong code. The problem was the system itself; the fault was that of the designer who had not considered that a "standard" for card-and-code door opening systems had already been accepted.

There may have to be a radical change in the way aircraft are designed. In the past, the machine was foremost. The goal was to make the machine work and if a switch or lever was in an awkward position for the pilot, then he just had to adapt. This has changed a great deal since World War II and aircraft designers spend much more attention to ergonomic factors inside the cockpit.

My point is that designers must now also look outside the cockpit when considering human factors, at the numerous other sophisticated machines that are becoming or are already commonplace.

Everything in the cockpit will have to be considered in this light. From the simplest mechanical things, such as the way the seats are adjusted, to the most sophisticated the computer systems. Designers will have to stay up-to-date with current accepted standards in the "outside world." Are pull-down menus on computers so widespread that they can be considered a "standard" which should be used in the cockpit? Should the QWERTY typewriter keyboard be the standard for aircraft navigation and computer systems? Should the artificial feel in a fly-by-wire control stick have the same "feel" as a Space Invader joystick? Should the clock be digital or analog, or both? These are the kinds of questions that must be constantly and continually asked.

In addition, manufacturers must establish, promote, and use an effective feedback system so that ideas and suggestions from line pilots can be obtained. Never in my career as a pilot have I seen such a system from any manufacturer. Perhaps a system exists, but if it does, the word has not gone out to the people that are flying the machines every day.

Every successful company believes it is "the man on the shop floor" who best knows how to do his job and who has the most useful suggestions about how to do it better. Good companies solicit information from every level.

In my experience, aviation companies are often very conservative and many even have military-like organizations. Information in military hierarchies goes up and down the chain of command, usually flowing down a lot easier than it goes up. If the chief pilot or chief of maintenance does not agree with a line pilot's or mechanic's suggestion, the idea stops there and never gets to the manufacturer where it might have been accepted. The only exception is in the case of an accident. Then people are listened to.

A reporting system connecting line pilots directly to manufacturers would be an excellent way to get feedback about present and future cockpits. If Dr. Lee's predictions about the proportion of human factor accidents reaching 100% is right, then constant awareness of and attention to human factor problems will be the only way to prevent aircraft accidents in the future.

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