Elliott-Automation in Aviation
Farnborough 1962

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FARNBOROUGH 1962–4000 SQUARE FEET PRESENTATION OF
‘ELLIOTT-AUTOMATION IN AVIATION’

Elliotts unique ability to approach aviation problems on a broad front

Elliott-Automation is dedicated to the task of promoting the concept of Automation over the whole range of technical activity.

In the military sphere, World War II gave a sharp stimulus to technological development in electronics, computing and control engineering. In the succeeding years, phenomenal advances have been made under the pressure of ever more exacting military requirements. In the industrial sphere the application of these same techniques lies at the very roots of our future economic wellbeing in what has been termed 'a Second Industrial Revolution'. To this extent Elliott-Automation has a sense of mission and purpose which transcends purely business interests.

By definition, Automation implies the use of a whole range of diverse techniques in wondrous combinations according to requirements; indeed we believe that the solution to the problems of the future can only come from an organisation which can approach these problems on a broad systems basis. Yet a company which sets out to do this must be strong in all these aspects if its proposals are to be purposeful, free from bias and based upon solid engineering experience.

Elliott-Automation has, in fact, succeeded in building an organisation which encompasses the whole range of technology required and has created two Systems Companies — military and industrial — not only to make system proposals over a wide front, but also to give full expression to the creative ideas and concepts which spring naturally from the continued lateral action of so comprehensive a group of activities.

The role in Aviation

In aviation, Elliott-Automation's breadth of engineering know-how has a particularly vital role to play: the ever-increasing performance of aircraft, the mounting density of air traffic, the simultaneous demand for greater safety, more reliability and greater regularity of operations are in turn creating the demand for more and more sophisticated and reliable equipment both in the air and on the ground control.

Elliott-Automation's unique ability to approach the aviation problems of the future on a broad front is admirably demonstrated in the special 4,000 sq. ft. exhibition at this year's R.A.C. Show at Farnborough. The products of no less than 24 Divisions and Companies of the Group illustrate activities in civil and military avionics, air data systems, instruments, inertial navigation systems, airborne digital computer, airborne radar, communications and navigation systems, air traffic control systems, blind landing systems, precision guns and components, relays, and automatic checkout equipment.

Our concept of Automation

A mistaken impression has been created that the introduction of Automation involves the wholesale elimination of the human being. While there will undoubtedly be some re-employment of human tasks, our concept of automation is primarily aimed at providing a means whereby human beings can work with far greater efficiency and harmony. This is particularly true in aviation. The objective is certainly not to replace any part of the crew, but rather to make their task more manageable at a time when the performance requirements of aircraft are becoming less forgiving of human error and defined reactions in emergency conditions. As more and more difficulties and complexities are imposed upon the pilot, automation techniques can play their part by helping him to more purposefully concentrate on those aspects on which the human being must exercise his critical judgement.

Commander H. Poiley-Tyler R.N.V.R.,
Group General Manager, Elliott-Automation Limited, and Chairman, E.A. Flight Automation Limited

Part of the special 4,000 sq. ft. "Elliott-Automation in Aviation" displays in the Radar Area

We cordially invite you to visit our 4,000 square foot integrated presentation of Elliotts comprehensive activities in the whole sphere of aviation.

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Towards all-weather operations

By P. F. MARINER, Assistant General Manager (Radar and Communications Group), Elliott Brothers (London) Limited, and R. W. HOWARD, Manager, Transport Aircraft Controls Division, E.A. Flight Automation Limited

Photograph courtesy of Lockheed Aircraft Corporation

Plane or Train

Is air travel safe, reliable and regular? Jet aircraft have reduced potential travelling time and so increased travelling comfort, but this has been wrestled and the physical inconvenience caused by delays and diversions has become evident.

Air lines throughout the world will say that if you put your own flights arrive at their scheduled destination more or less on time. Statistically then there is less than one in 20 chance of missing an appointment when travelling by air. On the face of it this doesn’t seem too bad, but what does the frequent traveller remember about the winter months – long hours of waiting in Prestwick and Keflavik, overcrowded cars, buses and hotels at alternates such as Halflin, dismisse in Frankfurt and Heston and perhaps an unpleasant journey on a crowded ‘special’ train from Manchester to London. The 1 in 20 case features a lasting impression and the effects he makes to avoid them are seen in many ways. For example, originating flights are more popular than transit flights which have had time to accumulate successive delays. Can it really be said that the airlines schedules are sufficiently reliable?

The faster the travel, the more important is precision to the business man – and if this is provided his contribution to airways finesses can increase enormously. All travellers on the other hand want improved safety, and both precision and safety can be met by the introduction of all-weather facilities – must we seriously consider yesterday’s trundled by train, bus and ship – or channel tunnel?

Men and Machines

Several years ago an eminent politician predicted that there would be little future for manned military aircraft. There was much speculation as to how this rather revolutionary thinking might affect the world of civil aviation. Would the application of military systems development to civil aviation ultimately lead to automated world transport? Fortunately the magnitudes of the technical problems of the all-weather philosophy are now better appreciated, and thinking may be described as less ad hoc, but the necessity for furthering automatic systems applications cannot be questioned. This is particularly so in the case of all-weather landing.

The requirement for precision is a safe master for long periods en route, and for accurate manoeuvring in approach control area has already caused the step to be passed where the pilot wishes to be best use is made of past experience for the future.

Little by Little

In the various countries where work is being done on all-weather landing the precision is based upon similar philosophies to govern their programmes. The safety requirement that each step is so clearly acceptable that an unacceptable fact is built up to the system as a whole. In other words development shall continue as it has in the past by improving designs with proven techniques and where necessary be employing redundancy in an intelligent and selective manner.

Any breakthrough must be so apparent that long-term proof of high integrity is unnecessary.

The Jig Saw Puzzle

Having taken off, each aircraft must be directed through a complex of other aircraft paths to duly assigned altitudes. Then various facilities take the aircraft to the point where once again it must carry out the reverse operation hoping that all the Timmy Aunts know where it is.

Much of this jigsaw puzzle is being solved our homework. Data processing will soon provide the air traffic controller with more powerful means of handling the increasing traffic and for deciding just how each aircraft should proceed in order sequence through the complex traffic pattern regardless of weather conditions.

The iceberg

The problems have been discussed and written about by many nationalities. The partial successes that have been achieved and the enthusiasm that they engender have tended to overshadow the economic, financial, technical and service problems which have still to be tackled. These equipment problems in turn may be small compared with the political and international operational problems on the ground when this battle really begins. Our reminder is the legendary story of the iceberg which looks so beautiful in the sunlight but is merely distracting arrows from the rearster below. Let us hope that the apparent lack of universal appreciation of the overall problem does not lead to a Titanic disaster.

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The problems of systems in aircraft

The systems concept

The concept of considering a complete system comprising aircraft, aerodynamic equipment, weapons and ground-based support facilities, has received considerable attention in recent years. The objective of this concept is to optimize system effectiveness, a term which must be carefully defined for each aircraft requirement. While the effectiveness must not fail below some minimum standard, a balance must be made between development costs and maintenance costs. At the same time equipment must be capable of being expanded over one of the parameters in this balance, at least until it becomes obvious that no further action can be taken to its unsatisfactory essentials are. A start has been made in the military aircraft field where the aerodynamic equipment is particularly complex, compact and various aerodynamic costs. The need to pursue the concept in the civil field increases in view of supercruise designs.

Earlier in time, a similar concept was required in the development of guided weapons due to the high density of varied equipment in the missile. The requirements of safety were not quite as severe as those in the design of manned aircraft. With certain notable exceptions the proper system balance was not achieved, particularly with respect to development time-scale and costs. However, the failure here only serves to emphasize the need to go forward towards more complete acceptance of the conditions necessary for the systems concept to work.

The technical problem

The problems which arise, as of course, technical and economical, but it is not at all easy to draw a clear distinction between them. Inherent technical problems and inadequate solutions of them are the essence of development, and there will always be some which are unforeseen. However, many technical problems arise out of an almost unconscious performance in the field acceptance of the idea of optimizing system effectiveness when it conflicts with perfection in a specialist field. The aeronautical designer of a high performance aircraft is naturally loath to blemish it with unnecessary or to suffer it to facilitate automatic control. The radar designer could improve his equipment performance if the antenna were larger or the radome less thick. The control engineer would alleviate his backhead problems or his mental irritation if the thrusters were smaller in area, or more rigid, or both.

There are many such examples of interaction between technical specialist fields. It is a fact that each one must be made with care and considerable thought, these problems give rise to frustration because of the unduly long time required for their resolution stemming from a frame of mind not yet adjusted to the systems conception. It is clear that they must be tackled by a technical management group, wherein a broad systems knowledge must result. The basis of decision are the rates of exchanges of system effectiveness with the mass parameters research specialist field.

Other problems, often technical, which should not arise at all are due to the fact that project management has not yet been applied as a science in itself. Again it is very often due to a failure to appreciate system problems right across the board. For instance, once the main characteristics of the aerodynamic are derived from general performance requirements the structural design can proceed fairly rapidly, whereas the specification of equipment moves rather slowly in the initial stages due to intricate cross-connections between sub-systems and because it is the area requiring the most detailed integration from mechanical, electrical and electronic points of view. When other equipment considerations throw up the need for structural changes to achieve optimum system performance, the change can perhaps only be made at high cost in money and time, and hence may not be made at all.

Let us consider the overall technical problem. There is a requirement with certain essentials arising from the task or tasks allotted to the aircraft, and with certain desirable features which could be regarded as firm until assessment work has been done. It is an essential part of the organization that the customer is informed in the assessment phase. All possible means of solutions to the overall system problem must be investigated to a depth which lays bare the problems to be solved in development, trials, production and service use. Development plans can evolve concurrently so as to attempt system effectiveness with time-scale and cost. It is also wise at this point to draw up a possible equipment revision programme applicable to the life use of the aircraft. It should be possible to reduce the results to the following—

1. Two or three alternative system proposals.
2. The basis of exchange of effectiveness with main parameters.
3. Two or three alternative development programmes with the distribution in time of man power and costs.

Decision is now required and the customer is fully informed. It should be possible to choose the system most likely to meet the need. However, the authority to decide is often diffuse and it is at this phase that much time may be lost. When the choice is made, the system proposal must undergo a further phase of assessment, leading to specifications of sub-systems calling for contract specifications of performance, safety, power supplies, packaging, reliability, accessibility, conditioning etc. The development, programme and financial contractual programme is made more and more detailed, with special consideration to the planning of environmental testing and flight trials of equipment in logical stages; this latter is carefully adequately planned. The efficiency of development depends critically upon the speed at which test and trials data is fed back to the designer and management; hence it is necessary to consider communications in the plan. Provided financial commitments can be made at the right time, the assessment leads smoothly into the development programmes. The development programme is often regarded as something fixed, in fact it should be re-optimized in very frequent intervals, say once a week or once a fortnight. This is perfectly logical since unforeseen day-to-day problems arise and estimated times are found to be in need of correction, and as these facts come to light it would be surprising if the programme initially laid down remained optimum.

The managerial problem

Let us now consider the management problem. A complex project, to be completed in the minimum time within budget, requires efficient day-to-day management and enthusiastic leadership from someone with a broad appreciation of the systems as a technical entity. However, as aircraft systems become more and more complex, the number of interested authorities in a satisfactory solution to this conflict has not yet emerged. It is only necessary to compare the financial commitment per day for any project in order to realize how important it is to make decisions at the right time, and to react rapidly to the problems arising from day-to-day. One possible solution to this problem is to appoint a systems manager, supported by a team of systems engineers, for the day-to-day control of the project. This man must combine in himself the technical appreciation and the ability to apply the principles of management. His job would be to plan a project and to resolve day-to-day problems, to inform the customer of progress periodically and to provide the facts and figures on which major decisions by the customer can be based. The customer may take the form of a management committee or group in order to embrace all interested authorities. Experience shows, however, that a package of technical efficiency when such a management group comprises no more than six members is much of Elliott's rationale in supplying completely integrated flight control systems for supersonic aircraft stems from the fact that only Elliott's are in production with proved and tested aerodynamic digital computer. As speeds increase to figures eluding contemplation of a few years ago, however, the control reaction can no longer match the necessary values of control correction and "autostabilization in the sky" assumes great importance. The immense grouped resources of Elliott's Automatics have continued leadership in all aspects of flight control in the years ahead.
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Farnborough 1962
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MODERN COMMUNICATIONS & AERONAUTICS

By W. R. Thomas, BSc, MIEE, AFRAeS, Joint General Manager, Radar & Communications Group, Elliott Brothers (London) Limited

The large industrial plant of today has so many parameters requiring monitoring that it has become impracticable to display all the values in a single sheet of paper. remote monitoring and control function to be carried out usually. Consequently, the system is being used for digital transmission systems receiving information into a data processing installation which, after performing the evaluation presented to the controller, the minimum amount of data necessary for action to be taken and, in particular of course, presents any necessary or desirable information immediately. In a very large plant this evaluation may be carried out at some intermediate stage from which reduced data is sent to one central control room. This communication system using its a second transmission system to an agreed specification. These systems being designed to operate in a digital band to both telecommunication and local telephone systems. With the advent of the new radio communications systems, the accuracy of the data transmitted can be improved and the cost of the communication reduced. The development of integrated data transmission and analysis systems is in a very large extent for the betterment of the overall control of a large industrial plant.

Air Traffic Control

The modern aircraft is becoming increasingly complex. The introduction of modern navigation systems does not reduce the work load of the pilot. In fact, modern radio navigation developments tend to present an ever-increasing amount of information to the pilot rather than to some other member. The necessity for improving air traffic control systems will necessitate the transmission of data from aircraft to ground control points and vice versa, to be in a suitable form for feeding into digital data processing systems. Consequently, some automatic data communication system from air to ground is becoming an urgent necessity.

An automatic calling system is available in the civil and military aircraft and receives its signals from a number of different sources. In the case of military aircraft, the call may consist of a particular aircraft to be called. The provision of ready information has still to be passed by voice. With the increasing speed of modern aircraft, improved air traffic control is becoming essential. This, if it is to achieve adequate results, will require improved reporting from all aircraft to the control centre. Some attempt has been made to go some way towards achieving this by the superposition of coded information on to the secondary radar transponder. But this can only be a stopgap in that the amount of information that can be transmitted is limited.

Automatic ground-air-ground communications

Work has been proceeding in the U.S.A. on the development of a wide variety of automatic ground-air-ground communication systems, thus providing experience of what such a system could achieve, and we in this country are in danger of once again falling behind. This could be catastrophic when one considers that in the ground industrial era we were in fact behind the U.S. in the development of integrated data communication systems. It must be appreciated that in the development of such a system for use with aircraft there are no imponderable problems to solve; it is not necessary to battle at the frontiers of physics. The task required is to translate the philosophy and to extend the technology to meet the aviation environment. After all, one is only applying a modern guise to the age-old method of communication used by the native with his tom-tom. An integrated system can be designed with an electronic computer evaluating information from many measuring points in an aircraft, processing the information and presenting it to the pilot, in addition, on information, transmitting relevant data to the ground, in digital form on one of the normal communication channels for analysis at the control centre. Agreement has to be reached that future economical and reliable operation of modern aircraft requires a flexible, high-capacity, digital data transmission system, operating over the normal air-ground radio links, in order to enable adequate information to pass between ground and air without the need for human intervention.
The Digital Computer approach in Aviation


The normal instruments that pilots are familiar with are the result of long and arduous development. By that we mean that the instrument position has been refined until the pointer can take up smoothly any position on the scale depending on the circumstances. It was natural, therefore, that aircraft controls, as they became more and more automatic, would come to use analogical technique to carry out the calculations involved. This approach set up the situation of "one man for one function". This is a perfectly reasonable situation when the number of functions and hours of black boxes is small. The pilot himself is always active like a digital computer in that he can switch his attention from one particular situation to another and usually carry out his operations successfully using his own brain, sometimes from explicit instructions, but more often from intricate wiring diagrams and acquired behaviour patterns from a lifetime of experience.

Scope of the Computer

The method of operation is the basic way a computer works. It carries out one single operation at a time, much faster than a man can. He has, however, an almost endless memory. He can access this memory directly through his brain. This is the only possible way to utilize the human brain, and it is therefore the only way to make a computer work. Then there is the "one man for one function" situation, a digital computer, if fast enough and with sufficient memory capacity, can not only carry out a complex function but also the basic hardware can carry out any function that it is possible to specify in simple steps and, indeed, the one man can spread milliseconds on each step and then switch its attention to another and better given the impression of being continuously in control of many complex situations at the same time.

The essence of using a digital computer is to be able to break down a complex operation into simple steps. Many routine situations fall to this approach and in routine situations they are usually the hardest ones. The computer may be more effective than a man. In real life situations there are many functions, particularly emergency ones and truly subtle ones, that cannot be specified as a series of simple steps. Here the man steps in and will always score.

As the computer is so much faster it is capable of doing jobs a man cannot do for dear lack of time. This is why computers were first applied to complex mathematical problems. In fact, neither the design of modern aircraft nor the use of nuclear power—certainly not the control of myriad classified operations—would have been possible without the use of mathematical computers.

The next major application field was to business data processing in which the machine's memory is extended by the use of magnetic disks and tapes. In both these applications the actual moment that the machine carries out its job is usually immaterial within a few hours and hence a type of use is called "off-line". These must be many thousands of computers operating in this mode in the world by now.

A vast number of interesting computer users are possible if a digital machine can be used "on-line" where it is computing moment for moment for real-time. The earlier computers used valves whose mean time for failure was such that preventative maintenance routines were necessary. This meant that a machine was deliberately taken off the air at least once a week, even if it was working correctly.

New fields of application

The coming of transistors with failure rates perhaps a thousand or more times better than their equivalent vacuum tubes, means that preventative maintenance of the type is now quite unnecessary. Transistorized computers have run thousands of hours without failure in some cases. This has opened up many new fields of application. The "on-line" use of digital computers in process control, in power stations, chemical plants and so on, is now well established, although not widespread. Component failures are still very real and at situations where the system reliability is essential. Nevertheless, the computer can both be doing useful and different jobs and so that the top priority job is held by whichever machine is working.

An Hypothetical Aircraft System

The illustration below of an hypothetical aircraft system shows an aircraft with an inertial navigation, air data transducer and radar system. These all act as sensors for the Verdan central digital computer which takes in their information and computes the outputs to the pilot's displays, armament and weapons systems. The outputs could include, for example, steering and position information via the displays and autopilot, weapon release, etc. Along with flexibility an increased accuracy, and the real gain of a common digital language between the aircraft system and the computer aid the "computerized" air traffic or air defense system on the ground.

Exciting New Developments

But it is the fact that the computer uses repetitively only a limited number of type of components and circuits which leads to the most exciting possibilities of all. This limitation of circuit types is ideal for the application of micro-manufacturing techniques which, for example, complete flip flops can be made on one single chip. Computers using such elements are already in the design stage and promise orders of magnitude in reliability yet with a much smaller weight and size.
The implication of SPACE TECHNOLOGY

Space programmes are well advanced in the USA and USSR—can we afford to lag behind?

Space programmes are well advanced in the U.S.A. and U.S.S.R., but in Europe, and particularly this country, our efforts have been limited so far to a high altitude rocket research programme and a restricted U.K.-U.S. co-operative satellite programme, both of which are aimed at making certain scientific measurements which will provide much useful information about various spatial phenomena but will not contribute appreciably towards the advance of Space Technology in this country.

One must ask the question, is it important to build up experience and ‘know-how’ in Space Technology in this country? The answer is undoubtedly in the affirmative if this country wishes to remain abreast of the frontiers of technical progress. Because every new sphere of activity such as Space Aeronautics forces and leads the development of new techniques and processes which then spread, revitalize and influence many other established industries. In addition, new industries can develop from the application to other fields of advances made in the process of Space Development. Space technology is providing the driving force in the U.S.A. for research work into such things as new materials for the construction of satellites and for bearing surface running in a vacuum, microcomputers of electronic units, satellite-stabilized platforms, the development of long-life microwave tubes, capable of running for two or more years, high standards of reliability in mechanical and electronic components; nuclear batteries and many others. All of which will have considerable impact on other fields of activity in due course.

The ELDOS Organisation

Some progress has been made by the U.K. along the Space Road by initiating the setting up of the ELDOS organisation which will provide a launching vehicle in 1966/67, but plans for the use of this arc still vague.

There are, undoubtedly, a number of useful experimental areas such as the launching of an astronomical satellite into an orbit to allow measurements to be made from a space-stabilized platform free from the earth’s atmosphere, but the most feasible satellite programme to follow has already been highlighted in America—namely that of establishing a Communications Satellite System.

Profitable in three ways: (1) it demands the solution of a number of advanced technical problems (2) it provides a highly desirable step forward in communication facilities for many parts of the world with a consequent benefit to civilization and (3) it is the one satellite programme with a reasonable prospect of providing a financial return on the investment.

Communication Satellite programme

Britain and the British Commonwealth are pre-eminent in the field of International Telecommunications by virtue of Amendment at the right time in radio telephone systems and long distance submarine cables. We shall lose this position if we do not make an immediate decision to launch a Communications Satellite programme designed to meet the needs of Europe and the Commonwealth.

The earliest such a system could be in operation is 1973 and it is undoubtedly true that an American system will be in operation before this time. So how can a European/ Commonwealth system be justified. On two principal counts firstly the need to acquire the techniques as described above, and secondly the fact that the planned American systems do not serve the real needs of Europe and the Commonwealth. The nature of the American economy and approach to the problem has led to a conception of broad trunk routes similar to and supplementing the present cable routes round the world. There is, however, a large latent demand for adequate communications facilities between a large number of users throughout the world, whose individual requirements are small, e.g. for a few telephone circuits. It can be shown that there is more traffic in volume to be collected from this large number of widely scattered sources than from the traditional trunk routes and that it amounts to the equivalent of several hundred telephone circuits at all round the world. Many of these small users have traditional associations and connections with Europe and wish to communicate with Europe.

Two-way Telephone channels

The design of a system to meet this requirement is likely to culminate in a technical solution different in detail to that of the American system. Such a system has been proposed in outline by the British Post Office in conjunction with the Royal Aircraft Establishment. In this system, a station-keeping satellites go round in a circular equatorial orbit at approximately 6,600 miles providing 600 two-way telephone channels. The system has been studied by the consortium of British Companies known as the British Space Development Company and detailed proposals are being made to the Government for a development programme which could be carried out by B.A.S.C. In that through its member companies it can provide all the various types of expertise necessary to bring the programme to a successful conclusion and achieve an operational communications satellite system utilizing the ELDOS launching vehicle.

The Go-Ahead is urgent

The development of the Geosynchronous geostationary tracking station provides a good starting point for the ground station equipment but there are many problems still to be solved to achieve the quality and reliability of service needed. Even greater problems have to be solved in the satellite itself; the Go-Ahead is urgently needed. As usual, the requirement is an allocation of funds by the Treasury to start the programme, but in this case with the enthusiastic knowledge that it is an investment that will pay off in hard cash and not just in some intangible form of security. Cooperation with our partners in ELDOS is essential, but the commencement of the communications satellite programme has to await agreement with all these countries then much valuable time will be wasted. Certain specific development tasks should be started with limited expenditure which would save time and money in the overall programme.

This article was written by W.W. Thomas, BSc, MIEE, ARPA, Fellow of the British Institute of Telecommunications, General Manager (Radio & Communications Group), Elliott & Sons (London) Limited.

The special Elliot display at Farnborough incorporates an illustration of developments in Space Technology.

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