Advancing DC-9 Maintenance Techniques through Multiparameter Recording

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The installation of a multiparameter recording system on TWA's DC-9 jet fleet has provided an important tool for advancing the maintenance state-of-the-art on twin-engine jet aircraft. The use of recorded data in establishing performance trends on engine and fire-warning systems is discussed. Real-time applications of computer data processing to facilitate field maintenance in trouble-shooting specific aircraft systems are described. Specific examples of trouble detection and definition are given and samples of recorded data are illustrated and their significance explained. Parameter expansion of the DC-9 recorder system and the use of this basic concept in more advanced s[illegible]r the Boeing model 747 and supersonic transport (SST) aircraft are also presented.

I. Introduction

THE application of statistical analysis as a means of monitoring jet engine performance is currently being utilized by most major U.S. air carriers as a beneficial maintenance tool. The techniques of implementing such a program vary widely among the airlines. This is primarily due to the advantages of tailoring such efforts to the airlines' operational and maintenance needs. The procedures, however, are essentially the same: 1) engine information, along with associated environmental parameters, is recorded, usually manually; 2) the recorded data are sent to a central location; 3) it is assembled and processed there; 4) the processed results are reviewed by maintenance personnel; and 5) action is initiated as required.

TWA pioneered application of this concept, which we call "flight log analysis," and which utilizes existing teletype and computer facilities in order to take advantage of the rapid transmission and analysis features that they afford. Cockpit engine instrument readings are recorded manually by the flight engineer on a form provided in the aircraft's log book. Readings are taken at least once a day on each aircraft during cruise flight.

II. DC-9 ADAS Operation

The advent of the two-engine Douglas DC-9 jet aircraft into TWA's operation required additional considerations in the flight log analysis program. The DC-9 is designed to be flown by a two-man crew and is used by TWA on its shorter flight segments. In order not to burden the flight crews with the additional task of providing manual recordings of engine data, an automated recording system has been installed. It is called automatic data acquisition system (ADAS). Table 1 lists the DC-9 parameters currently monitored by this system. The system itself consists of four units: 1) a data entry unit located in the cockpit; 2) a remote-multiplexing unit located near the engines; 3) an electronic unit located in the aircraft's electronics compartment; and 4) a teletype tape unit also located in the electronics compartment near the access door.

As parameters are monitored, their readings are recorded on punch-paper tape in the teletype tape unit. Paper tape is used in order to maintain compatibility with the existing ground teletype communication equipment and its associated network. A record of all parameters, shown in Table 1, is taken automatically three times each flight: just after takeoff, in climb out, and during cruise. Additional sets of data are taken at the flight crew's discretion by pressing the record button on the data entry unit (Fig. 1).

The data entry unit also allows insertion of information such as flight number, flight leg, day, month, and takeoff gross weight. For these reasons it is located in the cockpit

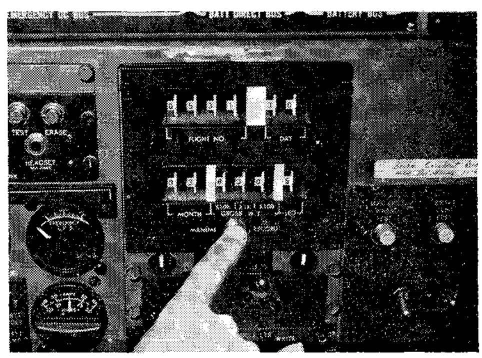

Fig. 1 ADAS data entry unit.

within easy reach of the flight crews. This selected information is not recorded until just prior to flight termination in order to allow flight crews time to enter the data at their convenience anytime during the flight. The aircraft number is recorded at the start of the flight and is hand wired into the aircraft as a permanent part of the system's wiring.

At flight termination or at the end of the day's operation, whichever is desired, the punched tape is torn off the tape unit (Fig. 2) and given to the local teletype operator. The tape contains its own sending address and can be fed directly into a teletype transmitter without requiring the operator to insert sending or receiving station information. The transmitted data are received in the TWA computer room at Mid-Continent International Airport at Kansas City, Missouri and is handled according to requested priority. If it contains only routine information it is stored for later input into the computer where it is processed and analyzed as part of the flight log analysis and other performance monitoring programs. Priority information is fed directly into the computer on an interrupt basis. This feature will be described in detail shortly.

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Table 1 DC-9 ADAS monitored parameters

	Parameter	Range	Signal pick-up location
1.	Time	Hr, min, sec	ADAS electronics unit
2.	Fuel quantity	0–10,200 lb	Cockpit indicator
3.	Oil quantity	0–4.0 gal	Engine pylon disk, P1-801
4.	Altitude	−1,000 to 50,000 ft	No. 1 air data computer
5.	Mach	0.2 to 1.0	No. 1 air data computer
6.	Total ram air temp.	−50° to +50°C	Cockpit indicator
7.	N1 turbine	50 to 110%	Cockpit indicator
8.	Engine-pressure ratio	0.75 to 2.5	Cockpit indicator
9.	Exhaust gas temp.	200° to 700°C°	EGT balance resistor, forward cargo compartment
10.	Fuel flow	410 to 12,000 lb/hr	Cockpit indicator
11.	N2 turbine	50 to 110%	Cockpit indicator
12.	Airborne vibration monitor	0–5 mils	(System not installed)
13.	Throttle position	0°–75°	Inside throttle pedestal, forward
14.	Oil temp.	32° to 160°C	Cockpit indicator
15.	Oil pressure	20 to 100 psig	Cockpit indicator
16.	Oil filter pressure	0 to 60 psid	Sensor on engine
17.	Oil breather pressure	0–16 in.	Sensor on engine
18.	Chip rate	open-short	(Sensor not installed)
19.	Fire warning	100,000 ohms to ground	Fire-warning test switch
20.	Engine anti-ice off-on	off-on	Anti-ice switch, overhead panel
21.	Cabin altitude	0 to 8,000 ft	STA 544, ceiling
22.	Cabin temp.	50° to 100°F	STA 544, ceiling
23.	Air cycle pack pressure	0 to 50 psi	Overhead panel
24.	Cabin inlet duct temp.	32° to 200°F	STA 800, ceiling
25.	Bleed manifold pressure	0 to 100 psi	Overhead panel
26.	Scavenge oil chip detectors	open-short	Sensors on engine
27.	Flight no.	XXXX, no. of digits	ADAS data entry panel
28.	Flight leg	X	ADAS data entry panel
29.	Date, month and day	XX XX	ADAS data entry panel
30.	Takeoff gross	XXXXX	ADAS data entry panel

III. ADAS Functional Operation

A functional block diagram of ADAS is shown in Fig. 3. Electrical signals from various aircraft sources are fed into the multiplex portion of the system. Since the DC-9 has its engines mounted at the rear of the aircraft quite remote from the electronics compartment, two multiplexing units are used. The local unit at the electronics compartment handles 96 2-wire input data signals and is a part of the system's electronic unit. The remote multiplexing unit will handle up to 32 additional 2-wire input signals. This unit (Fig. 4) is located in the rear cargo compartment near the two engines. A saving in wire weight of approximately 2 lb per parameter has resulted from using the remote multiplexing technique in the DC-9 installation, instead of running shielded wire to the electronic unit for each parameter picked up at the engines. The system also has the capability of handling signals from 11 additional multiplexing units located at other remote locations throughout the aircraft. In its fully expanded form, a total of 512 2-wire input signals can be multiplexed.

After being sampled, the various electrical signals are fed in serial order into the signal conditioning unit which forms a part of the system's electronic unit. Figure 5 shows the electronic unit installed in a DC-9 aircraft. General-purpose signal conditioners translate the electrical signals into values consistent with the level of monitored information.

These general-purpose signal conditioners will handle over 90% of all electrical signals generated on present-day American-built jet aircraft. The a.c. and d.c. signals are converted to a d.c. voltage that is representative of the input signal. The d.c. voltage is then digitized in the system's analog-to-digital converter. The synchro, frequency, and off-on identification signals are converted directly to digital form and bypass the analog-to-digital converter. The logic module formats the data for recording on teletype tape. This module also has the capability of providing data in IBM compatible format for magnetic tape recording if desired.

ADAS, as specified by TWA, has the capability of providing three distinct sets of output data: one on teletype tape, another on magnetic tape for maintenance recording, and a third output to a crash-proof flight recorder. Within minor limitations, each output is independent of the others both from the standpoint of what information is recorded and the rate at which these data are recorded. Thus systems of this type, properly designed, can serve a multitude of purposes.

Time is maintained internally in ADAS and can be reset through the dials on the front of the electronic unit. The clock module has its own battery power supply which is recharged from aircraft power. This allows the clock to maintain accurate time with or without aircraft power to ADAS. Greenwich mean time (GMT) is used as the time reference. Time is reset by dialing in the desired value on the GMT preset register located on the front of the electronic unit (see Fig. 5) and pushing the GMT reset button. The clock will continue to run for up to 48 hr without needing to have its

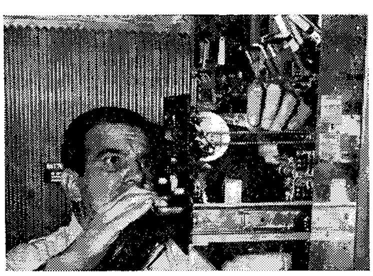

Fig. 2 ADAS teletype tape unit.

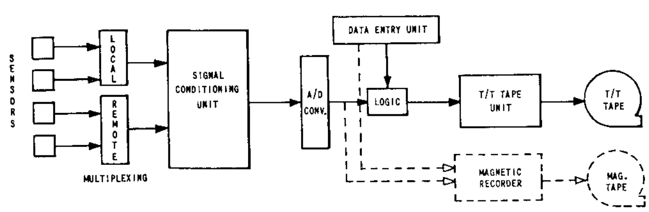

Fig. 3 ADAS functional block diagram.

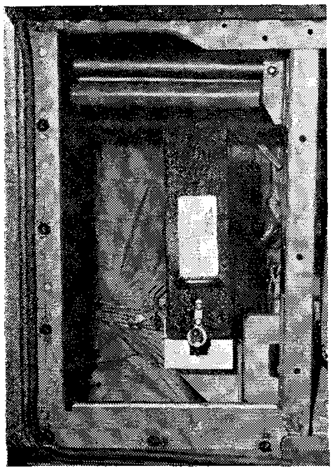

Fig. 4 ADAS remote-multiplexing unit.

battery recharged by application of aircraft power to the system.

IV. Computer On-Line Response

As mentioned previously, recorded data can be fed directly into the computer at Kansas City for processing. This represents the first airline industry application of on-line computer assistance for maintenance action. If an item of specific interest to maintenance has developed during flight, such as an engine-pressure ratio (EPR) instrument readout becoming erroneous, the flight crew has been instructed to push the manual record button on the data entry panel, thus recording at that moment, a scan of all parameters on teletype tape. At the termination of the flight, maintenance personnel would remove the tape and transmit it along with a special pilot tape which denoted that this is a priority message and gave the address of the station desiring the reply. This station does not necessarily need to be the sending station. Any number of stations designated on the pilot tape could receive the return message.

The data are received over the teletype lines and converted into engineering units by an IBM computer at TWA's Overhaul Base in Kansas City. The average time required for the IBM 360-30 to receive, translate, and send a plain language reply message is 20 sec. Total time from line station back to line station is usually under 5 min. An example of a processed flight scan sent by the computer to a line station is shown in Table 2. As noted, these readings were recorded by ADAS during takeoff. The engineering units for these data are denoted in Table 1. A copy of all messages returned to the line stations is sent to the applicable engineering department responsible for that particular system's maintenance. In this way, engineering personnel will have the same information to assist in helping line maintenance pinpoint a problem.

To localize the difficulty, for example, in the case of the erroneous EPR instrument readout mentioned previously, the problem could be caused either by a malfunctioning transmitter on the engine or by a malfunctioning indicator in the cockpit. (It could also, in rare instances, be caused by a problem in the wiring or electrical connector at either location.) The ADAS recorded value for EPR is obtained only from the engine EPR transmitter. Thus, if the recorded value is erroneous as is the indicator readout, the problem is pinpointed to the transmitter. If the recorded value is normal, the problem is probably a malfunctioning indicator. Receipt of the translated flight data will permit replacement of the defective unit without running ground tests or "shotgunning" the system, i.e., replacing both units to insure the problem is corrected on the first try. Correlation of the EPR value with other engine readings, such as exhaust gas temperature or fuel flow, will substantiate that it is indeed an erroneous readout problem being investigated and not an actual engine problem.

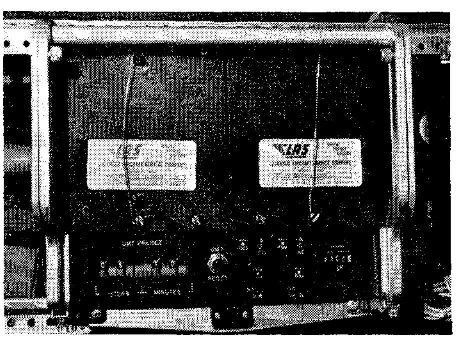

Fig. 5 ADAS electronic unit.

V. Engine Performance Monitoring

The DC-9 flight log analysis program has been extended to cover takeoff and climb engine performance information in addition to cruise readings as analyzed on other jet fleets. Deteriorations in engine performance in many instances will show up earlier from information obtained during takeoff than from that taken during steady-state conditions in cruise flight.

Figure 6 shows the trend performance chart for a DC-9 engine on data obtained during the takeoff mode of flight. Similar performance charts are printed by the computer on data obtained during the climb and cruise flight modes.

The performance standard against which these readings are plotted is that established by the engine manufacturer and is commonly referred to as the "gas generator curves." The various engine performance parameters being plotted are identified in Fig. 6. Changes in the patterns of individual parameters point out to the experienced powerplant engineer changes in that engine's "state-of-health." This is much the same sort of thing as a doctor detecting a change in the health of one of his patients by monitoring the heart beat on an electrocardiogram. A circle is drawn around the performance values plotted in Fig. 6 which correspond to the converted data of Table 2 which was also sent back to a line station.

Figure 7 shows one example of how day-to-day monitoring of an engine's performance permits an airline to schedule that

Table 2 Example of computer processed data returned to line station

	DC-9 data A/C 1055	
Initial	8 hr, 35 min	5 sec
Oil quantity	14.2	13.2
Takeoff	8 hr, 39 min	12 sec
Item	Engine 1	Engine 2
Oil quantity	16.2	14.1
Altitude	2015	...
N1	88.5	88.2
Engine pressure ratio	1.84	1.85
Exhaust gas temp	453	458
F/F	6966	7139
N2	91.2	91.2
T/L position	48.0	48.3
Oil temp	44.7	46.6
Oil pressure	45.4	44.9
Differential pressure	2.8	4.7
Breather pressure	6.2	8.1
Fire warning-A	0.277	0.302
Fire warning-B	0.274	0.292
Chip light	0	0
Pack pressure	25.1	23.2
Duct temp	98	42
Bleed manifold pressure	26.6	...

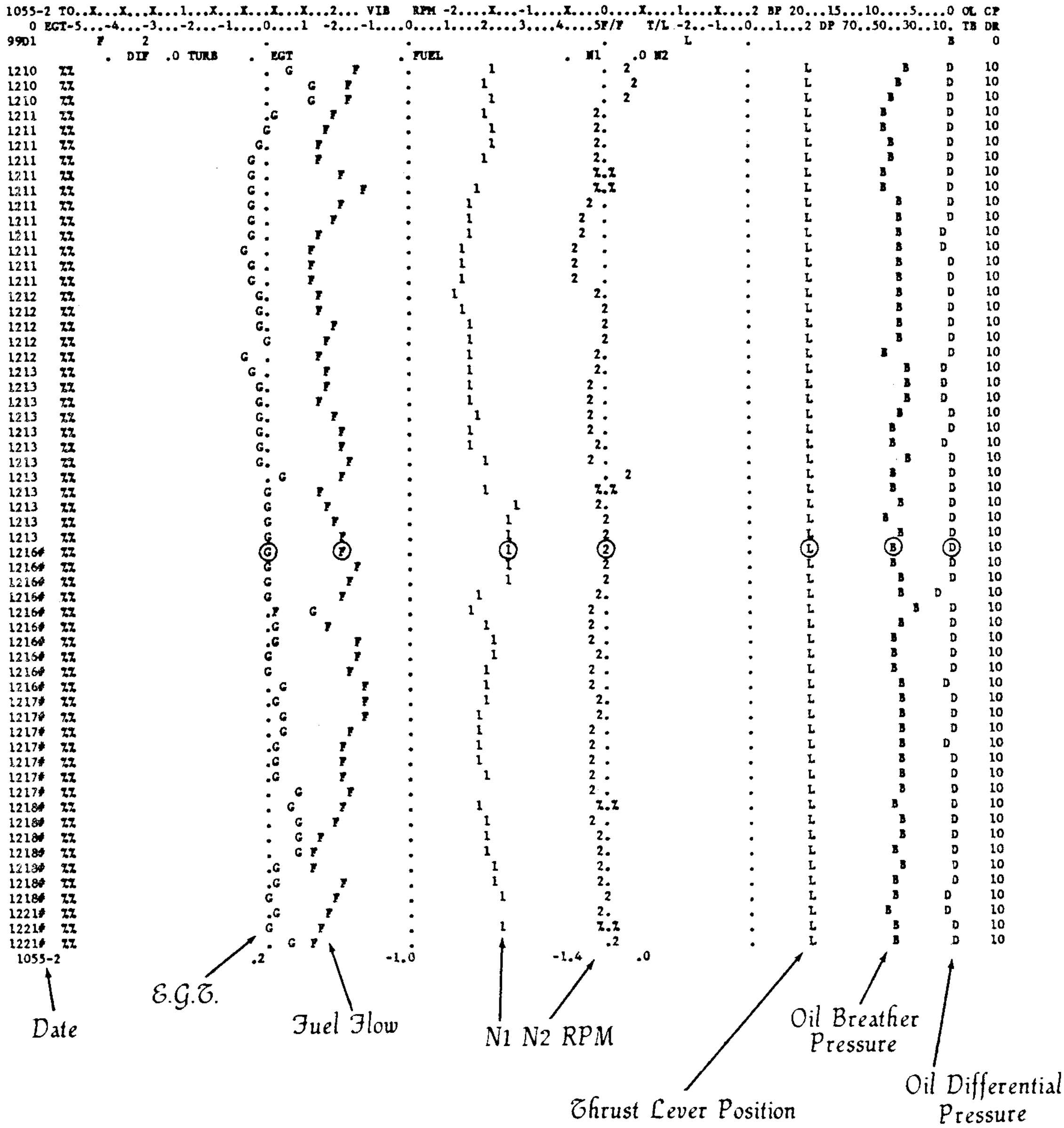

Fig. 6 Flight log analysis data takeoff plot.

engine's unscheduled removal. This chart shows a trend of one engine toward high oil breather pressure. The readings shown were recorded by the ADA system over a 22-day period. Monitoring of this trend permitted TWA's powerplant maintenance engineering personnel to schedule this engine's removal 5 days in advance of when it was predicted to reach the minimum acceptable performance level. The aircraft was set up for an overnight layover at Kansas City, and that opportunity was used to remove the engine without affecting scheduled operation.

VI. Fire-Warning System Trends

Another DC-9 application of performance analysis is the case of in-flight monitoring of the fire-warning loop, which permits a degree of system evaluation not possible through ground measurements. As can be seen in Fig. 8, the rate of change of fire-warning loop resistance with temperature is a decaying exponential function. The resistance level which triggers an overtemperature alert is 400 ohms. This corresponds to an ambient loop temperature of 350°F. For many years the airline industry has been plagued with nuisance alarms from these systems, that is, false indications of high-temperature conditions on the engines when none actually exist.

This situation is primarily due to the manner in which the sensing circuit measures the loop resistance. The sensor measures loop resistance variations using aircraft ground potential as a reference. Although this simplifies the design of the fire-warning system itself, it makes its reliability highly unsatisfactory. Items such as moisture in the connectors at the engine, chafing of the loop against a piece of engine structure, and/or aging due to loop time-temperature cycling will all cause a shift in loop resistance toward ground potential. A typical example of this situation is illustrated by the dotted curve in Fig. 8.

This condition usually will go undetected since any resistance check by maintenance personnel is of necessity made on the ground where values on the order of several hundred thousand ohms will be measured. This is several orders of magnitude greater than the loop's resistance at the alarm level. Thus, a significant shift in loop resistance would be indistinguishable in the high values encountered in ground measurements. In the past, such changes have gone undetected and continued to progress until a false warning occurred. Most false warnings which are experienced during climb out are

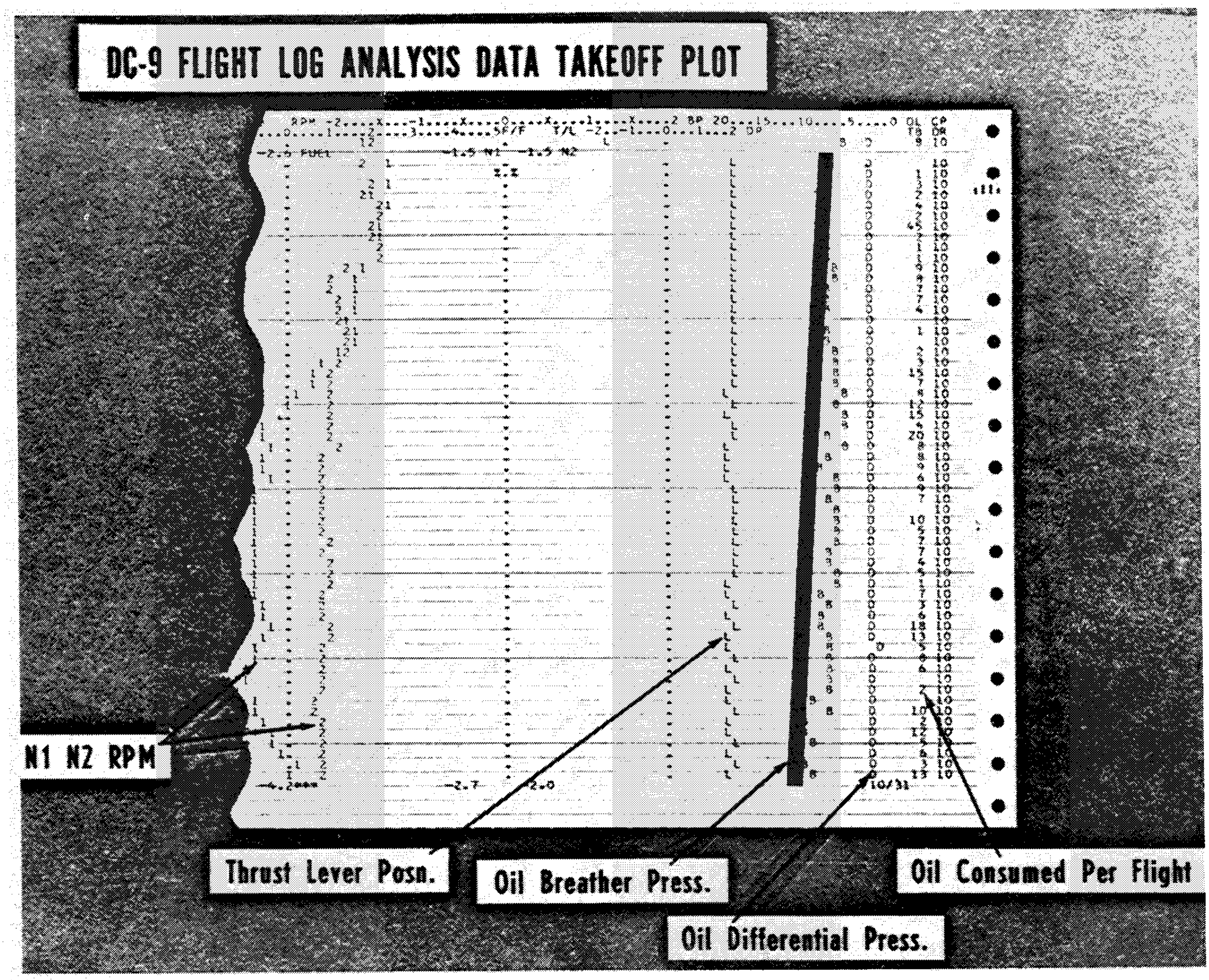

Fig. 7 High oil breather pressure trend.

caused by such deteriorations. From data obtained by TWA during a large-scale multiparameter maintenance recording evaluation program (1962–1964), it was substantiated that the maximum engine ambient temperature occurs from 5 to 15 min after takeoff instead of during takeoff as many had previously thought. Measurements taken at 3-sec intervals for both fire-warning loop resistance and engine ambient temperatures verified an almost instant time correlation between changes in engine ambient temperature and corresponding changes in loop resistance. However, the exact time at which

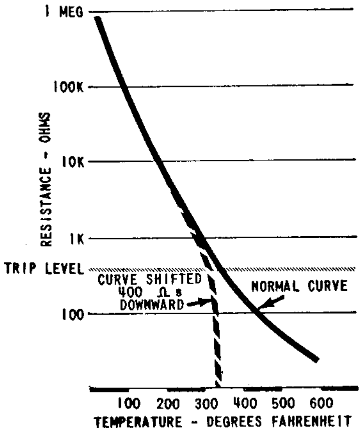

Fig. 8 Engine fire-warning loop characteristic curve.

the lowest loop resistance occurs during climb out was dependent on flight profile and a time-temperature integration of takeoff engine exhaust gas temperature (EGT). These data proved highly significant in establishing the DC-9 fire-warning monitoring program.

The fire-warning readings shown in Table 2 are represented as a ratio with respect to the alarm point. That is, a reading taken at the alarm point would be represented as 1.000.

As in the case of the flight log analysis program, for analysis to be meaningful it must be referenced to a standard or mathematical model. Without such a basis for reference, data could not be evaluated due to the variances in dynamic conditions under which they were recorded. In other words, a change in the recorded value of a fire-warning ratio reading on tandem flights may be normal if one takeoff is at a different gross weight from the other.

Thus, in order to make the DC-9 fire-warning loop measurements meaningful, a correlation with another parameter was required. It is apparent that the loop readings on the other engine would not be very satisfactory for this purpose since both engines may not be generating the same ambient case temperatures. Also, small variations in one loop could not be identified from equal but opposite variations in the other loops. An independent parameter was needed for meaningful correlation.

Engine oil temperature proved to be such a parameter. Its readings closely correlated with the engine's ambient temperature and therefore the value of the fire-warning loop resistance.

It should be pointed out, however, that all loops will not read exactly the same for a given oil temperature. This is due in part to the manner in which the loop is installed and routed on the engine. Installations will vary sufficiently, such that some areas of one loop will be slightly closer to certain engine sections than on another loop. It is, therefore, the variations in readings between flights after they are normalized, which are meaningful.

VII. Aircraft Performance Monitoring

A third trend analysis application is the DC-9 aircraft performance analysis program. The program utilizes the engines performance characteristics derived from the flight log analysis program in establishing the aerodynamic performance characteristics of each aircraft. Deviations from standard for Mach, fuel flow, nautical mile per pound, thrust, and speed are tabulated and graphically plotted for individual aircraft as well as a fleet average.

From this information, trends deviating from standard are determined and aircraft are investigated as to the causes of not performing up to the prescribed level. Once the causes are determined and corrective action taken, subsequent data processed through the program show the improvement obtained as a result of these efforts. Trend variations to date have been of a minor nature due primarily to the DC-9 still being a relatively new aircraft.

A similar type of correlation can be established for analysis of the air-conditioning parameters: air cycle pack pressure, cabin inlet duct temperature, bleed manifold pressure, cabin temperature, and cabin altitude. Here again it is the variations between corresponding readings and successive flights which is important.

VIII. Evaluation of the DC-9 ADAS Program

In retrospect, the ADAS installation on the DC-9 aircraft has established a number of notable results:

1) The utilization of remote multiplexing and time sharing of signal conditioning has been shown not to contribute measurably (0.1%) to degrade system accuracy.

2) Engine exhaust gas temperature readings can be accurately picked up and recorded ($\pm 0.5\%$ of absolute thermocouple value) from the same system that supplies information for cockpit display. However, the signal must be picked up from the engine side of the calibration resistor which is used for adjusting the cockpit indicator's reading. A temperature-regulated cold-junction connection also must be provided at the point of change over to copper wiring.

3) The use of punched paper tape and the teletype transmission network has proven to be a highly reliable, accurate, and rapid means of getting the data to a central location for analysis and/or conversion to engineering units for return transmission.

4) Very little additional aircraft maintenance has been needed in order to keep ADAS parameters operational. This is due primarily to the fact that most ADAS signals are obtained from the same sources that supply information for cockpit display.

5) The flight log analysis program has produced significantly more accurate and repeatable trending information using ADAS recorded data than from those taken through manual recording means.

On the negative side, the installation for measuring throttle position has proven to be of some difficulty due to the accuracy required for properly aligning the transducer to throttle structure. The engine throttle moves through a zero-to-full-scale range of only 75°. Thus, variations of even $\pm 1°$ in initial alignment are significant. However, hand adjusting the potentiometer to the desired setting within $\pm 1°$, even when using the new plastic potentiometer, requires a setting, as compared to total range, of $\pm 0.3\%$—a task not easily accomplished when the potentiometer is out in the open, much less during aircraft installation.

Three solutions are currently under investigation. One would include throttle position readings as part of the "header" information, which as mentioned previously is taken just after engine start when the throttles would be at their "zero" position. Thus, individual alignment data would be available to accurately compute each throttle's location during flight without requiring precise alignment during installation. Another solution would replace the existing potentiometers with a multiturn type and thereby reduce the accuracy with which the initial alignment must be made. The third solution would be to retain in the computer an individual calibration equation for each throttle position on each aircraft. Although this would not be too difficult a solution for the DC-9 fleet, it would become impractical if this requirement were extended in the computer as other fleets of aircraft were equipped with ADA systems.

With the initial phases of the program behind us, we are looking into other areas where ADAS recording on the DC-9 would prove beneficial. One area particularly deserving of attention is the application of spectrum analysis as a part of engine performance monitoring. TWA is investigating the feasibility of installing accelerometer transducers on the DC-9's engines in place of the velocity-type now commonly used. It is anticipated that by mounting accelerometer transducers in strategic locations, information which denotes deterioration of specific items, such as engine bearings, can be measured. Tests by engine manufacturers and airlines have shown that changes in vibration amplitude at specified frequencies can denote changes in performance levels of engine components. On the ADA system these measurements would be accomplished by passing the accelerometer signals through band-pass filters and recording the resultant amplitudes. Variations in these amplitudes would be trended.

We also recognize the National Transportation Safety Board's and Federal Aviation Agency's interest in improving the flight recorder's capabilities for incident investigation. TWA expects to evaluate possible means of achieving these objectives by making use of the DC-9 ADA system's magnetic tape capabilities which were discussed previously.

IX. More Advanced Systems

Although the DC-9 ADAS represents an important innovation for advancing airline maintenance techniques, it in itself represents only the embryo of an important new concept. As mentioned previously, the DC-9 ADAS can be expanded to 512 parameters sampled at the rate of 100 per sec with up to three distinct and independent outputs. This basic design also can be systematically expanded into more advanced airborne data management systems. Such a proposed system for the supersonic transport (SST) has been previously discussed by the author in other papers.[1,2] The system diagram is shown in Fig. 9.

Briefly, the supersonic data management system would employ the basic DC-9 system up to the A-to-D converter but then would incorporate additional refinements through the addition of a small airborne computer. This computer would serve as a central data management center and would contain programming for recognizing abnormal equipment or system operation. It could then display to the flight crew information pertinent to aircraft operation such as optimum power settings for various flight modes and the state-of-health of various airborne systems and units. Computations, such as reducing the significant engine parameters to the basic gas generator curves, could also be made and trend information established.

Urgent information, such as maintenance items, of more immediate interest to ground personnel at the station ahead, could be stored in a small memory and transmitted from air-to-ground at the command of the flight crew or upon

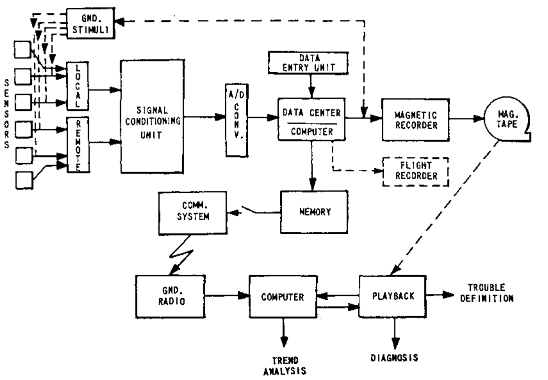

Fig. 9 Advanced AIDS concept for the SST.

ground interrogation. This would assist greatly in reducing the time spent in nonroutine maintenance since units which would require changing at flight termination or maintenance checks which would need to be performed prior to the next flight departure could be scheduled in advance of aircraft arrival and started immediately upon termination of the flight.

Another application visualized is that of checkout in which stimuli could be fed into the various aircraft systems while the aircraft is on the ground, thus providing a procedure not dissimilar to that presently used for missile checkout. A condition of health for the aircraft could thus be determined just prior to flight departure.

Along with the advantages that such a system affords come many challenges. In the past, one of the major deterrents to the implementation of continuous maintenance recording systems has been managing the voluminous amount of data recorded by such systems. A recording system, sampling 100 parameters per sec, will generate approximately 43,200,000 bits of data, in a binary coded decimal (BCD) format, in one day's operation. Thus a fleet of 100 aircraft would produce over 4 billion bits of data per day. Such tremendous quantities of data would completely saturate all but the most sophisticated communications network and data processing equipment. One approach for solving this problem is currently being investigated by TWA for its Boeing model 747 aircraft.

X. 747 Aircraft AIDS Concept

The system diagram for the 747 AIDS† is shown in Fig. 10 The system is the same as that described for the DC-9 ADAS up to the logic module. At this point, all monitored information is recorded on a 5-min continuous loop recorder. If a problem develops in any of the systems being monitored, a permanent record of the associated parameters for subsequent trouble detection and analysis is retained by dialing the system into the data entry panel and pushing a "permanent record" button.

Information stored on the 5-min continuous loop recorder is read back into the logic module and compared with a core listing of the desired parameters for that system. These readings are then recorded on an incremental maintenance recorder for permanent retention and/or feed into the memory unit for air-to-ground transmission. The 5 min of data prior to the time the permanent record button is pushed is retained.

Automatic initiation of a permanent record, for items such as turbulent penetration studies, can be incorporated in the system by providing a vertical acceleration input trigger to the logic module. Other automatic inputs can serve as the means for retaining trend information on various units and systems under desired flight conditions.

† AIDS (aircraft integrated data system) is the name accepted universally by the aircraft industry to designate multiparameter recording systems of the type under discussion in this paper.

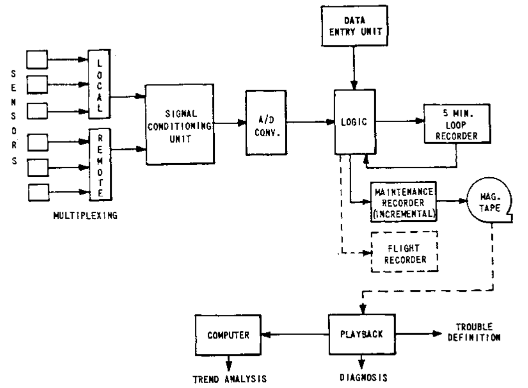

Fig. 10 747 AIDS concept.

XI. Advantages

In summary, a system of this type would offer a number of advantages over continuous recording AID systems: 1) retention of significant trouble analysis and trend information without recording large amounts of unnecessary data; 2) utilization of the flight crew's experience in pinpointing specific problem areas requiring maintenance action; 3) quick access to significant information either by means of air-to-ground transmission or readout of the maintenance recorder tape; 4) compatibility with existing communication networks and computer capability due to the small amount of data retained for analysis; 5) application of proven data gathering techniques and equipment design from DC-9 ADAS experience; and 6) monitoring of a larger number of parameters and systems efficiently.

XII. Conclusion

It is additional experience that holds the key to effective use of AIDS as a maintenance tool. Many questions are still only partially answered and need further definition; for example: 1) What parameters need to be recorded? 2) How frequently should they be sampled? 3) What type of automatic and manual analysis must be performed in order to pinpoint problem items and extract trend information? 4) What recorder system design provides the most benefits for the airlines' economic investment? 5) How effectively can a maintenance and flight recorder be integrated into the same equipment design?

Complete answers to these questions can be obtained only through utilization of AIDS on aircraft flying under the stimuli of day-to-day operation. Airlines have and are continuing to invest large sums of money and much talent into the development of such systems for both maintenance and incident analysis. These efforts are being expended without governmental subsidy or pressure. It is only under this environment that true competition can be brought to bear and suitable equipment designed, evaluated, and perfected. As pointed out in this paper, a logical and systematic path lies between the AID systems of today and those envisioned for more complex aircraft such as the 747 and SST. Only time and continued effort fortified by experience are needed to make these concepts a reality. From today's outlook, AIDS has the potential of becoming an even more integral part and highly beneficial maintenance asset to the airlines in the near future.

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