SAE The Engineering Society For Advancing Mobility Land Sea Air and Space® INTERNATIONAL
400 Commonwealth Drive, Warrendale, PA 15096-0001

AEROSPACE INFORMATION REPORT

SAE AIR4061 REV. A

Issued 1990-08
Revised 1996-06
Reaffirmed 1999-03

Guidelines for Integration of Engine Monitoring Functions With On-Board Aircraft Systems

FOREWORD

The integration of aircraft on-board systems is proceeding rapidly. To ensure technical currency, the E-32 Committee intends to begin revision of this document as soon as it is published. We, therefore, solicit inputs, which the reader may consider relevant to the revision process.

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1. SCOPE:

This SAE Aerospace Information Report (AIR) discusses physical and functional integration of main engine and auxiliary power unit (APU) monitoring with other on-board systems. It includes General Considerations, Parameter Selection and Requirements, Signal Sources, Signal Conditioning, Data Processing, Data Storage, and Data Retrieval.

Engine monitoring hardware and software are discussed so that they may be properly considered in an integrated design.

Civil and military aviation applications are included and delineated where requirements differ.

1.1 Purpose:

This AIR provides guidelines for the integration of engine monitoring system (EMS) functions with other on-board aircraft systems and subsystems. It supplements ARP1587 by providing additional guidance on the EMS requirements and architecture, and their effect on integration with other on-board systems.

It assists the designers of other systems in taking account of the engine monitoring requirements when considering both physical and functional integration.

2. REFERENCES:

The following publications form a part of this document to the extent specified herein. The applicable issue of all publications shall be the issue in effect on the date of the purchase order. In the event of conflict between the text of this document and references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

2.1 Applicable Documents:

2.1.1 SAE Publications: Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

ARP1587	Aircraft Gas Turbine Engine Monitoring Systems Guide (8-86)
AIR1828	Guide to Oil System Monitoring in Aircraft Gas Turbine Engines (3-1-84)
AIR1839	A Guide to Aircraft Turbine Engine Vibration Monitoring Systems (10-86)
AIR1871	Lessons Learned from Developmental and Operational Turbine Engine Monitoring Systems (Revision B - 1-88)
AIR1872	Guide to Life Usage Monitoring and Parts Management for Aircraft Gas Turbine Engines (2-29-88)
AIR1873	Guide to Limited Engine Monitoring Systems for Aircraft Gas Turbine Engines (5-5-88)
AIR1900	Guide for Temperature Monitoring for Aircraft Gas Turbine Engines (Not published)

3. GENERAL INTRODUCTION:

Figure 1 shows the functional interfaces broken down into sections corresponding to the sections in this AIR. Sections 5 through 10 cover aspects of parameter signal treatment on board the aircraft.

The principle functions of engine monitoring are to assess engine condition, gather event data, perform diagnostics, gather data for trending and performance analysis, and gather data to assess life usage of life-limited parts. Use is made of engine variables which are primarily sensed for other purposes (e.g., engine control or flight deck display) and other parameters incorporated specifically for engine monitoring.

With the advent of digital systems and data buses, the costs of providing engine monitoring capability could be reduced through partial or total integration with other on-board systems. Integration of EMS functions could result in fewer replaceable units (LRUs), reduced costs, and lower weight.

Figure 2 illustrates possibilities for integration, relating these to the sections of this AIR.

It should be noted that a recent trend has been to perform as much signal conditioning of engine parameters as possible on the engine to reduce the number of wires in the engine/airframe interface.

Retrofit of engine monitoring capability into an existing vehicle may have limited opportunities. This should not deter the designer from investigating the possibilities, as functional integration may indeed be the only hope for implementing some level of engine monitoring in a cost-effective manner.

4. GENERAL CONSIDERATIONS:

4.1 Introduction:

A systematic approach is essential for effective management of the integration process. From the EMS requirements document and the available documents of candidate on-board systems, a list of potential function assignments for these systems is developed. These documents are then analyzed to determine appropriate integration approaches. Trade studies, cost benefit analyses, etc., may be considered. A formal integration plan is then developed.

4.2 Functional Interactions:

The criticality of each function, at the subsystem and global level, must be established as part of system architecture, operability, and reliability considerations.

Correlation between systems must likewise be considered. Two examples are:

a. The use of other systems' self-test capability to validate parameters that are used by the EMS in order to prevent bad data from generating incorrect engine health diagnostics.

4.2 (Continued):

b. The output of the engine control unit self-test may be time correlated with other data recorded by the EMS so that detected failures can be associated with performance anomalies.

Both of these examples rely on a configuration that allows real-time access to data that is possibly resident in another subsystem. Awareness of such data exchange requirements could impact the choice of physical integration.

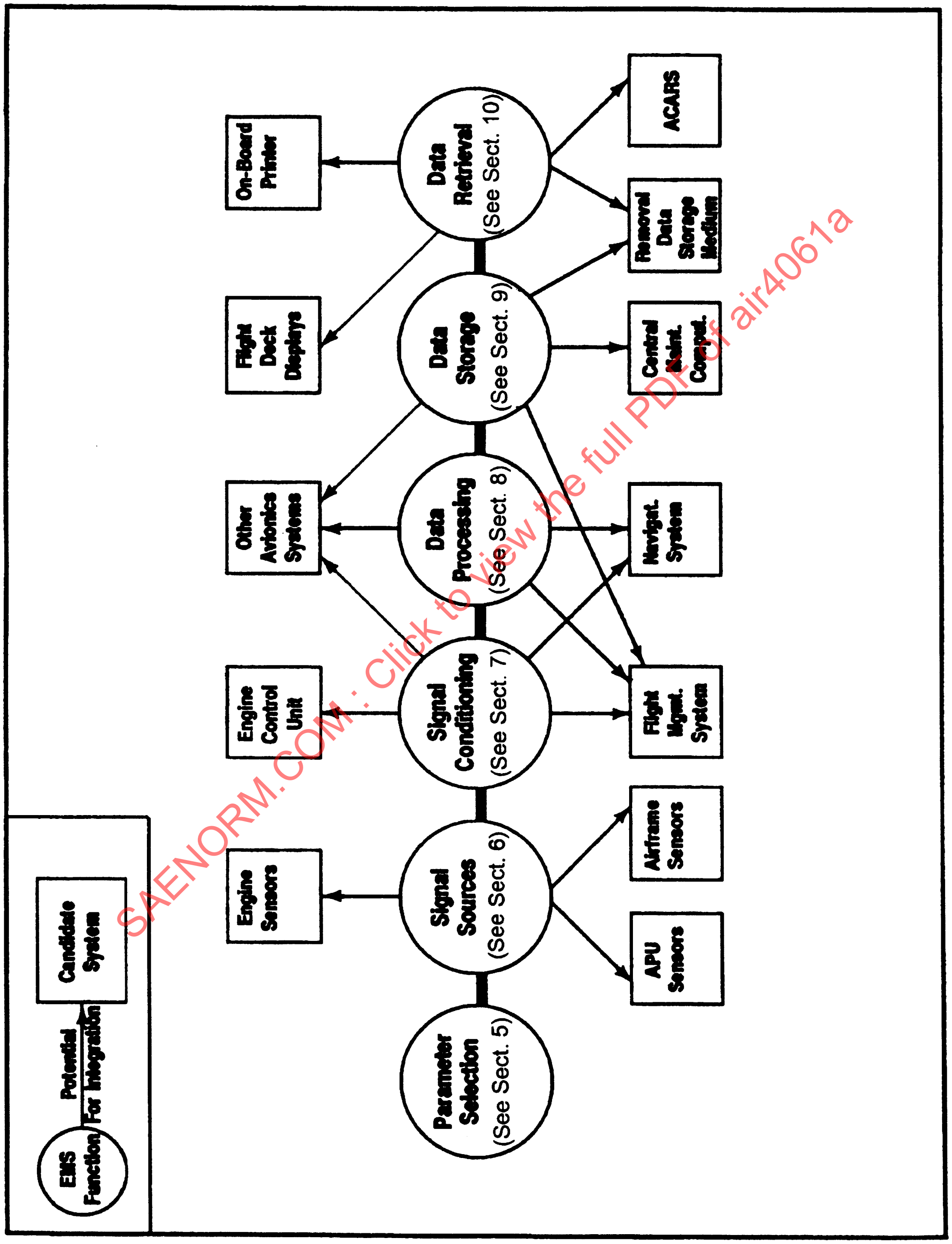

FIGURE 1 - EMS Elements and Typical Integration Candidates

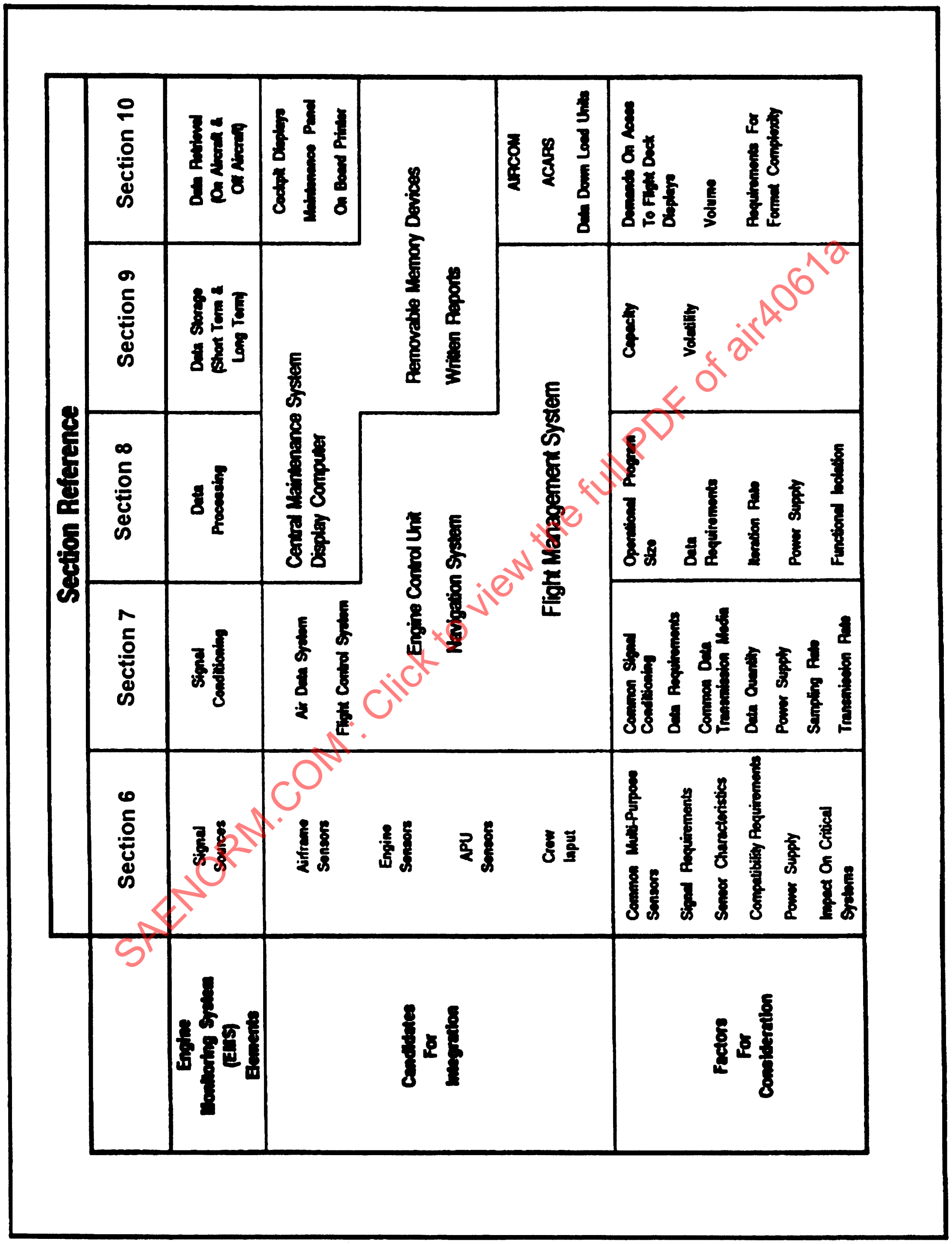

FIGURE 2 - EMS Integration Relationships

4.3 Isolation:

Safety considerations may dictate functional independence among the various components of an integrated set of subsystems to protect against effects of common mode signals, coupling and crosstalk, bus interactions, and failure propagation. For example, it may be desired to duplicate sensors to provide isolation, although redundancy and databus transmission have largely negated this concern.

4.4 Environmental Effects:

If the EMS is noncritical, relaxed protection standards for lightning, electromagnetic interference (EMI), and external radio frequency environment (ERFE), may apply. Care must be taken to ensure that critical systems, e.g., flight controls, are not compromised. Should high protection standards become necessary for shared parts of the EMS, e.g., amplification of an EMS signal within a control system box, the cost-effectiveness of sharing will need careful examination.

4.5 Maintainability:

Integration of EMS functions with other aircraft systems may impact maintainability. The designer should consider the following aspects:

a. Maintenance personnel should be provided with a single information source. If, for example, the maintenance staff has to consult built-in-test equipment (BITE), EMS, flight logs, and warning computers separately and has to correlate this data, they may be tempted to use only one source and not use all available information.

b. Fault-finding is often carried out by a process of elimination. Integration may reduce the number of LRUs and improve fault isolation capability.

c. The elimination of multiple data sources will remove possible disagreements at the possible expense of masking defects.

d. Physical integration of EMS functions with other systems that require complex installation procedures may cause problems. An operator may be reluctant to perform maintenance just to clear an EMS fault.

e. Physical integration of EMS functions with other systems may also require that these systems provide self-test capability for the added functions.

4.6 Reliability:

The use of other systems to perform EMS tasks and process EMS data could adversely affect the reliability of these systems. It will be necessary to evaluate the effects of integrating the EMS functions both in hardware and software. The evaluation could result in integration design constraints and may lead to a decision that some elements of the EMS not be integrated.

4.7 Electrical Power:

Consideration must be given to the characteristics of the electrical power system. Typically, an aircraft electrical power distribution system comprises multiple independently protected distribution buses. Each bus has a particular characteristic when an engine fails, or an electrical generator drops out, ranging from transient disturbances to complete electrical power loss. Interruption of electrical power should not result in the loss or corruption of EMS data. Additionally, data related to a particular engine should not be corrupted by the failure of that engine or its associated subsystems.

Consideration must also be given to the possibility of low voltage or the absence of power generated by a main engine when monitoring that engine during start or shut down. The highest integrity bus is frequently battery-direct or the emergency AC bus. These buses may be available for power during starting but often have severely restricted load capability.

Where the EMS uses multiplexed data distribution buses, close attention should be paid to the data bus power source. The times when power disturbances are most likely to occur, such as during engine start or shutdown or during load switching, are some of the most important to monitor. The use of redundant data bus structures fed from alternate power sources may be considered to enhance the integrity of the EMS.

Many sensors rely on electrical power to provide excitation or secondary services such as heaters. In the development of system power architecture, care should be taken to evaluate the effect of power loss on sensors.

4.8 Data Bus Sharing:

When considering the sharing of system data buses, consideration should be given to the following:

a. Bus integrity
b. Bus capacity/data rate
c. Bus configuration and routing

4.8.1 Bus Integrity: Most modern aircraft, commercial and military, have flight critical data buses. The integrity of these buses, and the systems connected to them, must be carefully maintained. It may be possible to transmit engine monitoring data on these buses or to pick off data that are already on the bus, but the sources and destinations of the data must comply with the bus interface requirements. In some cases a bus may be "off limits" entirely.

4.8.2 Bus Capacity: The capacity of a candidate bus to handle the extra data needed for engine monitoring function must be evaluated. The primary considerations are:

a. Availability of labels or addresses for the EMS data
b. Impact on growth margin for the primary bus users
c. Resolution and update rate requirements of the EMS and primary user data.

4.8.3 Bus Configuration and Routing: The selection of a bus for transmitting EMS data should consider bus configuration and routing. The primary considerations are:

a. Ability of the bus structure to accept additional terminals.
b. Ability of the bus protocol to accept additional terminals and labels.
c. Impact on EMI, ERFE, and lightning protection of additional wiring or re-routing of wiring.
d. Impact on cost and weight of additional wiring or re-routing of wiring.

4.9 Software:

Software integration should be considered at the earliest opportunity. Factors to consider are:

a. Commonality of routines such as input and output
b. Computational capacity
c. Timing requirements/duty cycle
d. Memory capacity
e. Common language
f. Operating systems
g. Software quality and configuration management requirements
h. Reprogrammability

4.10 Future Architectural Concepts:

New ways of packaging avionics systems are being considered. One approach uses "core" boxes, or cabinets, which contain power supplies, standard I/O modules, processors, and operating system software. Function-dependent I/O modules and software programs would plug into slots in the box, resulting in a multifunction unit.

For such a system, several considerations are involved in selecting the functions to be grouped together in a cabinet. Among these are: functional relationships, physical relationships, common sensor needs, and supplier expertise. In such a situation, the EMS functions, together with any special requirements or constraints that pertain to them, should be included in the total list of candidate functions to be distributed among the various cabinets.

4.11 Growth:

Care must be taken to ensure that the integration process does not compromise the hardware and software growth margins of the integrated systems.

5. PARAMETERS SELECTION AND REQUIREMENTS:

5.1 Introduction:

The number of parameters required for EMS may range from a few for limit exceedance and trending, to many for diagnostics, performance analysis and life usage. Some of the parameters may exist for other purposes, e.g., engine control or indication; additional parameters may be needed solely for engine monitoring.

5.2 Parameter Requirements:

Each parameter will have requirements unique to monitoring. The requirements come under the following headings:

a. Accuracy (both static and dynamic)
b. Resolution
c. Repeatability
d. Flight phase
e. Sampling rate
f. Update (processing) rate
g. Output rate
h. Availability

5.3 Parameter Uses:

(References 2-6 contain additional detail).

Parameters may have multiple uses, each requiring different treatment. Figures 3a and 3b indicate parameters which are useful for the EMS functions identified below and helps the system designer to match the parameter selection with user needs. For some installations, other parameters may also be needed.

a. Limit/exceedance monitoring
b. Life usage monitoring
c. Performance trending
d. Performance diagnosis (modular analysis)
e. Mechanical trending
f. Mechanical diagnosis
g. Fleet averaging
h. Engine control system trend and diagnosis
i. Incident detection and analysis
j. Engine start-up monitoring
k. Engine shutdown monitoring

Typical parameter requirements for each of the EMS functions are provided in Appendix A.

6. SIGNAL SOURCES:

6.1 Introduction:

It may be cost-effective to use the same sensor for providing inputs to the EMS and to other systems. In order to do this, the requirements for the engine monitoring function, discussed in Sections 3 and 4, must be addressed as well as the requirements for the other system's function. It may well be that the monitoring function requires a change to the specification of an existing sensor before its output can be shared. Further details are provided in AIR1873.

6.2 Selection:

The selection of signal sources must include consideration of all error contributions, data format and characteristics, compatibility with signal conditioning and processing capability, as well as reliability and integrity. Some sensors require that the associated system provide electrical power or excitation. Other sensors may require heaters, special compensation, etc. Data interruptions during built-in test of the data source must be accommodated.

6.3 Source Sharing:

Given specific signal requirements, there are four possibilities for source sharing:

a. The desired signal already exists from a source, either the sensor itself or a conditioner, that can easily be shared.

b. The desired signal already exists but the sensor or signal conditioner must be replaced by a new one to allow signal sharing.

c. The desired signal already exists but signal sharing is not practical or cost-effective, and a new source must be provided for the EMS.

d. The desired signal does not exist and a new source must be provided.

EMS Usage vs. Parameter Coverage Matrix

Usage / Parameter	Limit Monit.	Life Usage Monit.	Perf. Trend.	Perf. Diag.	Mech. Trend.	Mech. Diag.	Fleet Avg.	Control Sys. Diag.	Incident Anal.	Start Up Monit.	Shut Down Monit.	
A/C Identification	X	X	X	X	X	X	X	X	X	X	X	FLIGHT DATA
Date	X	X	X	X	X	X	X	X	X	X	X	
GMT	X	X	X	X	X	X	X	X	X	X	X	
Flight Origin	X	X	X	X	X	X	X	X	X	X	X	
Planned Destination	X	X	X	X	X	X	X	X	X	X	X	
Actual Destination	X	X	X	X	X	X	X	X	X	X	X	
Flight Number	X	X	X	X	X	X	X	X	X	X	X	
Flight Phase	X	X	X	X	X	X	X	X	X	X	X	AIRCRAFT DATA
Auto Throttle Status	X		X	X	X	X	X	X	X	X	X	
Total Air Temp.	X	X	X	X	X	X	X	X	X	X	X	
Mach. Number	X	X	X	X	X	X	X	X	X	X	X	
Altitude	X	X	X	X	X	X	X	X	X	X	X	
Angle of Attack	X		X	X		X		X	X	X	X	
Side - Slip	X		X	X		X		X	X	X	X	
Cas	X	X	X	X	X	X	X	X	X	X	X	
Gross Weight	X	X	X	X	X	X	X	X	X			
C of G							X					
Auto Pilot Status			X	X		X		X	X			
Air Bleed Selection	X	X	X	X	X	X	X	X	X	X	X	
Anti-ice Selection	X		X	X	X	X	X	X	X	X	X	
FWD Acceleration	X								X			
Lat Acceleration	X								X			
Vert Acceleration	X								X			
A/C on Ground	X	X	X	X	X	X	X	X	X	X	X	

FIGURE 3a

EMS Usage vs. Parameter Coverage Matrix

Usage / Parameter	Limit Monit.	Life Usage Monit.	Perf. Trend.	Perf. Diag.	Mech. Trend.	Mech. Diag.	Fleet Avg.	Control Sys. Diag.	Incident Anal.	Start Up Monit.	Shut Down Monit.	
Thrust Lever Angle						x		x	x	x	x	
RPM 1,2, or 3	x	x	x	x	x	x	x	x	x	x	x	
EGT and/or Turbine Blade Temperature	x	x	x	x	x	x	x	x	x	x	x	
EPR Actual	x	x	x	x	x	x	x	x	x	x	x	ENGINE
EPR Command								x	x			
HP Compressor Press.		x	x	x	x	x	x	x	x	x		
HP Compressor Temp.		x	x	x	x	x	x	x	x			
Comp. Press. 1 or 2			x	x			x		x			
Turb. Press. 1 or 2			x	x			x		x			
Turb. Temp. 1 or 2			x	x			x		x			
Fuel Flow			x	x	x	x	x	x	x	x	x	
Oil Pressure	x				x	x	x		x	x	x	
Oil Temp.	x				x	x	x	x	x	x	x	
Oil Qty. Consumption					x	x	x		x		x	
Oil Particle Count	x				x	x	x		x			
Oil Filt. Delta Press.	x				x	x	x		x	x	x	
Nacelle Temp.	x				x	x	x	x	x		x	
Var. Guide Vane Ang.			x	x	x	x	x	x	x	x		
T/R Selection		x	x	x			x	x	x	x	x	
Water Injection Sel.	x	x	x	x			x			x	x	
Eng Start Selection										x		
S/O Valve Position									x		x	
Starter Duct Press.										x		
Torque	x	x	x	x			x	x	x			
Vib. Tracked Rotor 1, 2 or 3	x		x	x	x	x	x		x		x	
Vib. Broad Band	x		x	x	x	x	x		x			
Vibration Channel			x	x	x	x	x		x			
Fan Trim Balance Phase Angle					x	x	x					DATA
Fuel Temperature	x						x	x	x		x	
Fuel Filter Delta Pressure						x	x	x	x		x	
Fuel Low/Interstage Pressure						x	x	x	x		x	
Engine Serial No.	x	x	x	x	x	x	x	x	x	x	x	
Status Words						x		x	x			
Maintenance Words						x		x	x			
Discrete Switch Signals						x		x	x	x	x	

FIGURE 3b

6.4 Aircraft Parameters:

The following parameters are representative of signals from aircraft systems, or from crew entry into an on-board system, that may be used for engine monitoring purposes:

a. Air temperature (SAT and/or TAT)
b. Altitude
c. Airspeed (Mach Number, IAS, and/or CAS)
d. Gross weight
e. Air/ground logic
f. Flight mode
g. Flight leg
h. Time
i. Auto thrust/auto throttle mode
j. Anti-ice on/off
k. Engine bleed status, environmental control system pack status (ON-OFF) and, when available, flow rate, pressure and temperature
l. Cross bleed
m. Angle of attack
n. Gun fire
o. Throttle lever angle
p. Total engine fuel flow
q. Normal acceleration
r. Rotor speed (helicopter)
s. Aircraft identification number
t. Engine control parameters, e.g., EGT, EPR, fuel flow, spool speeds, PLA, and CDP

7. SIGNAL CONDITIONING AND TRANSMISSION:

7.1 Signal Conditioning:

Source data, in digital or analog form, may be transmitted to and shared by a number of independent systems for reasons of cost, weight and space. The output of independent systems may be combined. The following should be considered during the integration effort:

a. Isolation
b. Common mode rejection
c. Analog to digital (A/D) and digital to analog (D/A) conversion
d. Environment, including lightning, EMI, and ERFE
e. Failure propagation
f. Coupling and crosstalk

7.2 Signal Transmission:

Signal transmission, both prior to and after conditioning and/or processing, must be given sufficient attention to ensure that the integrity and accuracy of the data are not compromised. Once the sensor signal has been conditioned, the problem resolves into how the output of one system is introduced to the other. Various formats, such as the well known ARINC data transmission protocol, allow for multiple users to acquire broadcast data.

In cases where a supplementary output is provided, due consideration must be given to the design load capability. Use of incorrect loads may well incur an accuracy penalty and may also allow fault propagation across otherwise independent system boundaries.

Consideration must be given to:

a. Source and load impedance
b. Field strengths and types
c. Lightning, EMI, and ERFE
d. Load filtering and susceptibility
e. Data timing
f. Interconnect
g. Cable movement

Wiring methods, designed to preclude signal corruption, include:

a. Twisted cables
b. Twisted-shielded cables
c. Single-shielded cables
d. Double-shielded cables
e. Single cables run as a pair
f. Random cable run
g. Grouping and separation for noninterference
h. Fiber optics

8. DATA PROCESSING:

8.1 Introduction:

This section discusses requirements for processing information collected for engine monitoring. The system integrator must ensure that the computing capability requirements for EMS and other integrated systems are established as early as possible. The system integrator should ensure that sufficient memory and processing throughput are provided to allow for growth and that the processing hardware does not compromise data accuracy.

8.2 Rates:

Different engine monitoring functions require different data processing rates.

Some techniques for vibration monitoring may even require a separate processor due to high iteration rate. See Appendix A for typical requirements.

8.3 Integration Considerations:

8.3.1 Integration with Flight Critical Systems: Numerous system processors could be considered for integration of EMS processing. These include, but are not limited to, central maintenance computers, display computers, navigation computers, flight control computers, and the electronic engine control.

Integration of the EMS into a flight-critical system will require that EMS failures not affect the functions of that system. Furthermore, modification of EMS software shall not require requalification of other, flight critical, software. The complications arising from these factors may preclude integration.

8.3.2 Calculation Capability: The integrator must ensure that the candidate processing hardware is compatible with the EMS accuracy requirements. See Appendix A.

8.3.3 Software Growth and Priority Requirements: Ideally, when the EMS first goes into production, it should have a 100% expansion capability in terms of memory and processor time to allow for future developments. When integrating EMS processing with another system, particularly a flight critical one, it is likely that processing developments of the flight critical system will take priority over those of EMS. Care must be taken early in the design to avoid having the higher priority system limit the EMS processing expansion capabilities in terms of memory availability and processor time.

8.3.4 Data Validation: Data validation is an important consideration of the EMS as well as other on-board systems. The integration process must preserve these data validation functions.

9. DATA STORAGE:

9.1 Introduction:

On-board data storage, whether for short-term or long-term use, is required and must be provided in an integrated system. Again, 100% expansion capability must be maintained.

9.2 Requirements:

Short-term storage addresses the need to record parameters relating to an occurrence during the current flight or mission. This data will normally relate either to a parameter exceedance or an engine malfunction.

It is important that data be recorded prior to an incident, as well as during and after it. For this reason, a buffer memory must be available that is normally continuously refreshed, but which is frozen and stored when an incident takes place. This type of memory requirement will generally be met with "volatile" RAM so care must be taken to prevent power interrupts from causing loss of stored data. This data "snapshot" is normally transferred to a more permanent medium and the buffer memory released to continue its data collection task.

Data for long-term purposes must be stored on-board until such time as it can be off-loaded onto ground computers. Attention must be paid to ensure that the long term data is not unintentionally overwritten or erased by other systems sharing the storage medium. The software required to perform the long term analyses usually is not available on the aircraft. There may be a requirement, however, to perform limited trend analysis on board. In this case nonvolatile storage must be provided that can maintain certain data from flight to flight.

9.3 Forms of Data Storage:

Typical storage options available are:

a. Printer output: Printouts may be kept for further analysis
b. BITE indicators: Malfunction data could be stored in the form of BITE messages
c. Internal solid-state memory: Devices should be nonvolatile and alterable
d. Removable memory devices: Cassettes, discs, and solid-state modules may be available
e. Written report: Flight crew hand recording is a form of storage but it has limited scope
f. Ground storage: Data transmitted from aircraft to ground-based systems

9.4 Candidates for Integration:

Typical systems that should be considered as candidates for integration of stored data are flight management, performance management, inertial navigation, airborne integrated monitoring, on-board maintenance, and mission systems.

Because of the specialized nature of mandatory flight data recorders, integration of functions in these devices should not be considered.

10. DATA RETRIEVAL:

10.1 Introduction:

Access to information is an important requirement of an EMS. The key considerations are:

a. How quickly is the information required?
b. By what means can it be made available?

10.2 Data Access Requirements:

10.2.1 Quick-Look Data: The primary concern is for quick access to a limited quantity of processed data in a format that can be readily assimilated and understood by flight-deck and flight-line personnel.

The form in which the data is retrieved may be volatile or permanent.

10.2.2 Ground Analysis Data: These data are required primarily for further processing by ground-based systems. The requirement is the retrieval of large quantities of processed or raw data by means of a nonvolatile medium.

10.3 Retrieval Means:

10.3.1 The following retrieval means are candidates for the integration of both long- and short-term data requirements:

a. On-board printers
b. ARINC communication and reporting system (ACARS)
c. Solid-state memory modules
d. Removable magnetic/optical storage media
e. Data bus down link

10.3.2 The following retrieval means are candidates for the integration of short-term data requirements only:

a. Primary (multifunction) cockpit displays
b. Maintenance displays
c. Dial indicator
d. Written reports

10.4 Integration Considerations:

10.4.1 Candidates for Integration: Data display can be via primary cockpit instrumentation, data entry display panels, or a printer. Integration of cockpit displays is well advanced and specifications for common data entry panels and printers are being worked on. Cockpit CRT displays, particularly if they are integrated with the aircraft multiplex data bus, are good candidates for EMS display purposes. Removable memory modules that serve other functions can be used for EMS event recording provided that sufficient spare memory is available.

In the civil world, ACARS/air to ground communication systems (AIRCOM) provide a standard interface between the aircraft and ground installations that may be used for EMS data.

10.4.2 Factors for Concern: Sharing of multifunction displays could restrict access to EMS results due to a number of users requiring service at the same time.

11. CONCLUSION:

With the advent of digital systems and data buses, the cost, weight, and space of providing engine monitoring capability could be reduced through partial or total integration with other on-board systems.

The number of parameters required for EMS may range from a few, for limit exceedance and trending, to many for diagnostics, performance analysis, and life usage. Some of the parameters may exist for other purposes. It may be cost-effective to use the same sensor for providing an input to the EMS as well as for another system. Source data, in digital or analog form, may be transmitted to and shared by a number of independent systems for cost, weight, and space reasons. The output of the independent systems may be combined.

Data that will be used for engine monitoring as well as in another system must be processed to the more stringent requirement. On-board data storage is required and must be provided in an integrated system. The complexity of on-board processing and the amount of data to be stored for engine monitoring should not be underestimated. Ease of data access is important in an EMS.

Functional integration is a complex process which requires a systematic approach and management support. The potential for integration should be studied at the earliest opportunity to ensure success. A late attempt to integrate monitoring into other functions may result in compromise of the monitoring system.

12. GLOSSARY:

ACARS	ARINC Communication and Reporting System
A/D	Analog to Digital
AIR	Aerospace Information Report
AIRCOM	Air to Ground Communication
APU	Auxiliary Power Unit
ARINC	Aeronautical Radio, Inc.
ARP	Aerospace Recommended Practice
BITE	Built-in Test Equipment
CAS	Calibrated Air Speed
CDP	Compressor Discharge (or Delivery) Pressure
CRT	Cathode Ray Tube
D/A	Digital to Analog
ECU	Engine Control Unit
EGT	Exhaust Gas Temperature
EMI	Electromagnetic Interference
EMS	Engine Monitoring System
EPR	Engine Pressure Ratio
ERFE	External Radio Frequency Environment - High Energy Radio Frequency
GMT	Greenwich Mean Time
HP	High Pressure