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Software Interfaces for Ground-Based Monitoring Systems

FOREWORD

This SAE document seeks to improve the situation whereby current ground-based engine monitoring systems (EMS) cannot readily be integrated into one computing environment.

Following a consensus by the SAE E-32 Committee on the need for some form of standardization in these systems, ARD50002 was written. It reviewed the situation, laid out several methods of standardization which addressed the problems to varying degrees, and was the vehicle for canvassing the industry for user views.

The result was a clear mandate for standardization and a decision on the degree to which this process should be taken. The consensus was that it is the interfaces between the major functional elements in the EMS which should be standardized, so that elements from different manufacturers can work together.

This document describes the first steps into this standardization.

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1. SCOPE:

To establish a specification for software input and output interfaces for condition monitoring and performance programs used to monitor equipment from multiple manufacturers.

The purpose of standardizing these interfaces is to improve operational flexibility and efficiency of monitoring systems as an aid to cost effectiveness (e.g., easier implementation).

2. REFERENCES:

2.1 Applicable Documents:

The following publications form a part of this document to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other 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.

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

AIR1873	Guide to Limited Engine Monitoring Systems for Aircraft Gas Turbine Engines
AIR4175	A Guide for the Development of Ground Station for Condition Monitoring
ARD50002	A Discussion of Standardization Concepts for Condition Monitoring and Performance Analysis Software

2.2 Glossary:

2.2.1 Acronyms:

ACARS: Aircraft Communications, Addressing, and Reporting System
ACMS: Aircraft Condition Monitoring System
ADAS: Aircraft Data Acquisition System
AIMS: Aircraft Information Management System/Aircraft Integrated Monitoring System
APU: Auxiliary Power Unit
ASCII: American Standard Code for Information Interchange
CM: Condition Monitoring
DBMS: Database Management System
DMU: Data Management Unit
ECM: Engine Condition Monitoring
ECS: Environmental Control System
EMS: Engine Monitoring System
GUI: Graphical User Interface
OEM: Original Equipment Manufacturer
SQL: Structured Query Language

2.2.2 Definitions: Access Methods: Methods of accessing data stored in a computer, e.g., indexed, keyed, random, relational or sequential.

ALERT: A warning or notification issued based on the analysis of the data, indicating a possible negative change within an engine.

ANNOTATION DATA: Narrative text annotating operational experience derived from the pilot, maintenance technicians, or engine performance analysts.

BASELINE: A set of data defining standard basic operating conditions and performance for a nominal/new engine.

BINARY DATA: Variable length strings of binary information, which can represent bit map graphics, computer object code, compressed textual data, or digitally recorded data.

CHARACTER: A single unit of display or textual data stream (e.g., one letter or one number).

COMPRESSION: Mathematical reduction of any volume of digital data (e.g., in a historical plot or time-series data stream).

CONFIGURATION DATA: Data describing where and when engines and modules are installed and removed. The data can be accompanied by hours and cycles information.

CONTINUOUSLY RECORDED DATA: Typically, data recorded during exceedance conditions, for a brief duration in real time, encompassing several seconds of multiple channel engine and/or airframe sensor readings, or data recorded as the operation is in progress, for a length of time dictated by the configuration of the recording system.

DATA TYPE: Specific characteristics about representation/storing of data in the computer environment. Following types are covered: binary, character, field free text, integer, and real number.

DERIVED RESULTS OR QUANTITIES: Results from simulation or performance analysis of engine operational measurements which depict the health status or trends in operational performance.

EXCEEDANCE: (A flag which indicates that) the value of a parameter has gone above a high or below a low predefined threshold-value for a predefined minimum duration.

FILE: A collection of data stored in computer-compatible form, with a name assigned.

HOST (OEM Host SYSTEM): It is the core of the ECM software which provides non-analytical and optional functions.

2.2.2 (Continued):

INPUT DATA: Presentation of acquired data to the condition monitoring and performance program. Types of input data includes but not limited to: annotation data, configuration data, manual records, snapshot.

INTEGER: A representation of a positive or negative whole number.

INTERFACE: The link between two software programs or modules.

MAIDEN POINT: The value of a set of parameters in a historical plot, based on data acquired immediately following the installation of the engine (same as initial point).

MANUAL RECORDS: Data which are not recorded automatically.

OUTPUT DATA: Presentation to the user of a coherent set of textual data (measured and/or calculated).

PARAMETER: Data from one single signal source.

PLOT: A two dimensional graph of two or more parameters.

REAL NUMBER: A representation of a fractional number to some degree of precision and some exponential range. The range of real number representation must be sufficient to represent all data elements stored in the database.

RECORD: A group of related data in a defined format.

REPORT: OEM direct program results (Plots, Barcharts, Alerts)

SMOOTHED DATA: Output data where scatter is reduced by a mathematical process.

SNAPSHOT: A set of data recorded, from a specific time, or as a result of a specific predetermined condition or event in the operation of an aircraft or an engine.

TABLE: A list of alphanumeric characters which is related either in columns or rows.

TREND: A movement in a plot or value of one parameter plotted against time.

3. ECM SYSTEM OVERVIEW:

3.1 Introduction:

Figure 1 shows the different components and interfaces of an ECM System. The components are:

- Input contains the user generated input data to be supplied to an ECM Host System. Standardization is required.
- Input Interface defines a single generic format enabling data entry to any OEM Host System. Standardization is required.
- The OEM Host System containing the CM program and the OEM database, provides and performs all calculations as defined by the OEM.
- Output Interface defines a single generic format enabling for data transfer out of any OEM Host System. Standardization is required.
- Output contains the OEM Host System generated data which is supplied to the user, where
  - each OEM host system provides a standard reporting package in the typically available formats (Alerts, Plots, Bar Charts, etc.).
  - the OEM host system outputs data for customizable use by the airline.
- This additional output for customized use needs to be standardized.
- End-User Tools are developed and/or provided by the user to access the data stored in the user storage media which might retain and manage condition monitoring data from multiple manufacturers and perform any subsequent calculations or modifications to the data.

3.2 Input Interface:

The standardization of the input interface and format establishes the minimum input required by the OEM Host System while providing the user with the flexibility to input additional data for their own specific needs (including manual data entry, ground-based data selection, ACARS, etc.). The specifications for the Standard Input Format are described in this document, Section 4.

3.3 Output Interface:

The OEM Host System must supply an Output interface capable of generating files for all output data that results from processing either new input data or from reprocessing previously stored data. This Output interface must also provide assess to all input parameters and key values. The specifications for the Standard Output Format of these files can be found in Section 5 of this document.

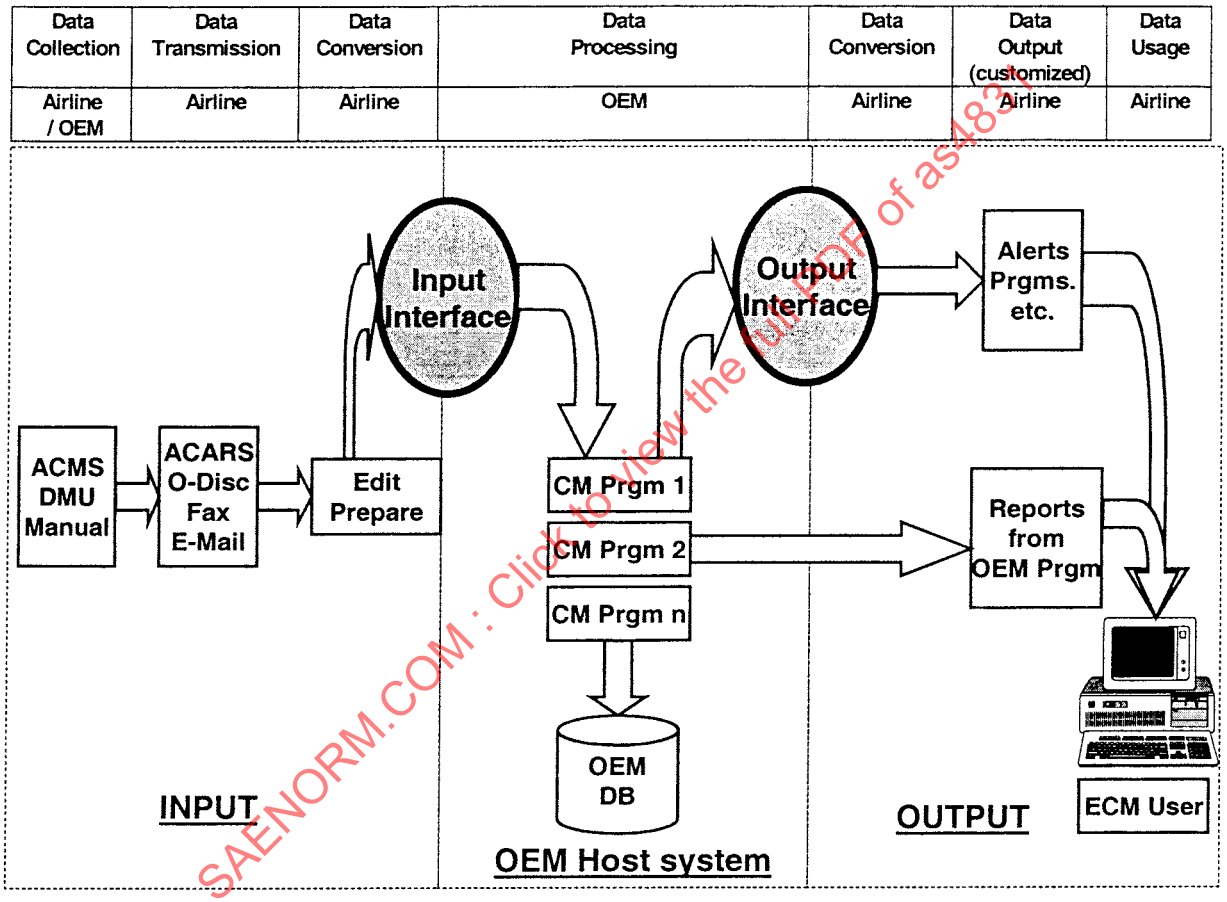

FIGURE 1

3.4 End-User Tools:

The End-User Tools are those software packages which access the User Storage Media to display, calculate, or manage the stored data. The User Storage Media is the data management system that the user chooses to store and manage their condition monitoring data. This media can be commercially available software or user developed software. The maintenance and support of the User Storage Media is the responsibility of the user.

Examples of these tools are: Oracle Reports, Excel or user developed tools.

OEM Host system(s) can also be used for this functionality.

3.5 OEM Host System:

An OEM Host System provides the functionality to read and store input data, executes the OEM analytical calculations, and provides results for output.

3.5.1 Input Interface: The Input Interface provides the OEM Host System with the capability to read user generated files and store them into the Host System database. The OEM Host System must supply an Input Interface capable of reading the Standard Input Format as specified in chapter 4 of this document. The Input Interface may also support reading other formats such as OEM legacy input formats.

3.5.2 OEM ECM Host System: The OEM Host System is the core of the ECM Software system which usually provides the following:

- non-analytical functions, e.g.:
  a. integration with the analytical functions
  b. data management of all input and output
  c. user interface (GUI or non-GUI interface)
  d. reports (definition and generation)
  e. multiple user access
  f. security
- key analytical functions, e.g.:
  a. data normalization
  b. trend recognition
  c. smoothing
  d. alerts
  e. compression
  f. maidening

3.5.3 OEM Output Reports: The output reports usually provides a set of default reports based on the OEM standards and supports flexible functionality to provide user-definable formats and presentations of any data available in the OEM database for the following output media and output types:

Output Media:

- printer
- screen
- file
- E-Mail

Output Types:

- semi-graphical plot
- table
- alert/notifier
- graph
- delimited data

3.5.4 Output Interface: The OEM Host System must supply an Output Interface capable of generating files in the Standard Output Format as specified in Section 5 of this document. The user is responsible for the tools to utilize this data in support of user specific requirements.

4. INPUT INTERFACE SPECIFICATIONS:

4.1 Introduction:

This section includes a more detailed specification of the standard for the interfaces into any OEM Host System. The Input Interface must provide the functionalities described in this document. This standard may be revised due to future technology development.

4.2 The Input Interface:

The Input Interface must provide the functionality to enter all data required by any of the OEM Host Systems and any data needed by the user. The user is responsible for segregating the input data and transferring it to the appropriate host system. Examples of data to be entered are:

a. Data from the operating aircraft (aircraft/engine records)

1. engine start records
2. takeoff records
3. exceedance records
4. stable cruise records
5. APU reports
6. ECS reports
7. Annunciated faults

b. Test cell data

1. Production test cell results, new engines
2. Test Cell results before/after overhaul

c. Data from previous processed points

1. calculated deltas
2. other derived data necessary for the process

d. Configuration data

1. engine installation/removal
2. module installation/removal
3. new/modified engine configuration definition
4. new/modified aircraft configuration definition
5. hours/cycle information

e. Annotation data (comments to events in the history of the engine)

1. component changes (e.g., control units, temperature probes)
2. comments to, for example an exceedance
3. other performed maintenance actions, for example a borescope inspection

The Input Interface must provide a flexible format which allows the input of parameter values, data types and parameters names. All parameters that are entered and defined within the OEM Host System, will be stored and output in standard output format.

4.3 The Input Interface Structure:

The standard input file contains the record structure definition before the actual data values. This may be thought of as a ”Format” section (for the record definition), followed by a ”Values” section which contains the actual data values.

- The first line of the file must state the delimiter to be used in the subsequent records.
- The format section will contain a format identifier and define an input parameter list of every input parameter, its units and its datatype (real, integer or character).
- Each values section contains the data for a record from an aircraft and its engine(s) (or just one engine for non-flight data record types), with each value separated by the delimiter defined in the format section.
- Multiple value sections may follow the format section, but each value section must map exactly to the format section.
- A value cannot be split between lines.
- If the delimiter is in a value string, it must be enclosed with double quotes (” ”). If blanks, commas, or other special characters are in a value string, it is advisable to use double quotes. Dates do not need to be enclosed in double quotes.
- Date/Time must be given in this format: DDMMMYYYY hhmmss
- MMM in the format is case insensitive and the English language 3-character abbreviation for months.

4.3.1 General Input File Format Requirements: The input data file must fulfill the following requirements:

- The file is to be ASCII text format.
- Lines may be any length with no imbedded control characters such as carriage return or line feed characters.
- Each line in the file is to be terminated with a 2-byte CRLF (carriage return line feed).
- The required file extension is ".ems".
- Nothing (not even a blank space) between two delimiter characters denotes a missing value.
- A parameter name or value cannot be separated between two lines.
- Alpha-numeric values which contain delimiters or embedded spaces must be closed in double quotes.
- Files include an End of File mark.

4.3.2 Delimiter Section: The first line in the file is the delimiter line. The format is:

DELIMITER = µ

where µ is the delimiter character to be used throughout as the field separator.

4.3.3 Format Section: This section starts on a new line and starting in column 1, contains the following:

- Section keyword "*FORMAT"
- A list of the parameters to be found in the values section, their type, and the units associated with the parameters

The format lines should look like :

PAR1µTYPE1µUNITS1µPAR2µTYPE2µUNITS2µ...PARnµTYPEn

where

µ = delimiter character (field separator) for the file as defined by the Delimiter keyword
PARx = parameter name for xth parameter
TYPEx = datatype of xth parameter
UNITSx = units of xth parameter

In the case where the existing OEM, or default, units are acceptable, a double delimiter would be used between the TYPE and the next PARAMETER.

4.3.3 (Continued):

The format line might look like:

PAR1µTYPE1µµPAR2µTYPE2µµPAR3µTYPE3µUNITS3µ...

Accepted datatypes will be:

I = integer
R = real or float
A = alphanumeric or character string

OEM Systems which do not require datatype will ignore this input.

No parameter name or value can be divided between lines. Parameters that are not stored or used by the system can be included in the file and will be ignored. No parameters should be included that will not have values in the values section. The user may provide a ”missing value” by consecutive delimiters, for example ”µµ” means there is no value.

All engine parameters must have a suffix designating the engine position consisting of a hyphen and the engine position number (i.e., XYZ-2). The order of the engine parameters is not important.

The user parameter names are assumed to be associated with a parameter in the OEM Host System. This association must be provided with each OEM Host System. If the input name is not found in the OEM Host System parameter list, it is simply ignored.

4.3.4 Values Section: This section contains the data values for a single record from an aircraft or test cell. The following rules apply to the construction of the values section:

- The section starts on a new line and in column 1, keyword ”*VALUES”.
- The values must be in the same order and of the same type as that declared in the format section.
- No parameter value can be divided between lines.
- Parameters that are not stored or used by the system can be included in the file, but that name cannot be included in the OEM Host System’s alias or parameter list.
- No values can be included that are not also included in the format section. In other words, every value must have its parameter defined in the format section. Values cannot contain the delimiter unless it is a string value enclosed in double quotes.

4.4 The Input Interface Keys:

Each record processed by the input interface must include all key values which are used to uniquely identify each record for the OEM Host System for storage and subsequent processing. The input keys are:

TABLE 1

Type of Data	Record Type	Keys
Aircraft data	Flight data Aircraft configuration Aircraft maintenance	Aircraft registration, date/time, phase
Engine data	Engine install/removal Engine configuration Engine maintenance	Engine serial number OR Aircraft registration/position, engine model, date/time, phase
Test cell data	Test	Test cell ident, engine serial number, engine model, date, time

4.5 Requirements of the OEM Host System for the Input Interface:

The OEM Host System must provide the capability to associate user defined parameter names with the parameter names required by the OEM Host software (i.e., Input Aliasing). A utility to create and maintain this association should also be provided by the Host System.

The user must be able to control which parameters are stored for input for each of the input record types. A utility to create and maintain this control should also be provided by the OEM Host System.

5. OUTPUT INTERFACE SPECIFICATIONS:

5.1 Introduction:

This section includes a more detailed specification of the standard for the output of the OEM Host System. The Output Interface must provide the functionality described in this document. This standard may be revised due to future technology development.

The output interface provides a standardized output file format which enables all of the data stored in the OEM Host System to be output for End User use. This includes access to all data entered via the input interface and, all calculated values generated from the analytical and non-analytical processing performed within the OEM Host System.

The output data must utilize the same keys as the input data.

5.2 Requirements and Structure of the OEM Host System for the Output Interface:

The format of the output data is identical to the input data structure as detailed in 4.3.

The output data is organized according to categories where each category must be output to a separate file. During the write process from the OEM Host System, the file will be named as a temporary file and then renamed to a filename of category_date_time_seqno, where category is the Category Name from below, date and time are taken from the date/time of the platform writing the file, and seqno is a sequence number used to avoid the possibility of duplicate file names. Accomplished files include an end of file mark.

Categories of data available for output include (but are not limited to):

TABLE 2

Category of Data	Filename (Windows/Office 95 and Later)
Input values	Input_yyyymmmdd_hhmmss_seqno
Raw calculated values	Raw_yyyymmmdd_hhmmss_seqno
Smoothed values	Smooth_yyyymmmdd_hhmmss_seqno
Alerts	Alerts_yyyymmmdd_hhmmss_seqno
Exceedances	Exceedance_yyyymmmdd_hhmmss_seqno
Initialization or maiden values	Initialization_yyyymmmdd_hhmmss_seqno
Compressed values	Compressed_yyyymmmdd_hhmmss_seqno

Each OEM Host System must provide the capability for the user to control the categories of data to be output within the scope of the functionality provided by the OEM Host System. In addition, the parameters within each category of data must be user configurable.

The OEM Host System must provide the capability to map all parameters to internal OEM Host names and external user names. Both input and output interfaces must be able to use external user names.

5.3 The Output Interface Keys:

The Output Keys are identical to the input keys:

Each record printed by the output interface must include all key values which are used to uniquely identify each record. The keys are:

TABLE 3

Type of Data	Record Type	Keys
Aircraft data	Flight data Aircraft configuration Aircraft maintenance	Aircraft registration, date, time, phase
Engine data	Engine install/removal Engine configuration Engine maintenance	Engine serial number OR Aircraft registration/position, engine model, date, time, phase
Test cell data	Test	Test cell ident, engine serial number, engine model, date, time