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COMPUTERIZED TEST ANALYSIS SYSTEM

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ABSTRACT

In response to an ever-increasing volume of test results, work began in 1985 at the Aérospatiale Helicopter Division on developing a computerized test analysis system known as SEE[1]. The system was developed in FORTRAN-77 on an IBM 3090 under VM, but is portable to workstation environments running under UNIX. It accepts any type of data that can be presented in tabular form: time-dependent measurements, means, spectrum analysis, etc. The system provides the engineer with a full set of tools including data management, graphic plots, statistical analysis, sorting, conversions, multilinear regression, etc.

This document describes the package and its implementation: the program is used by about one hundred persons in the Helicopter Division, and has also been adopted by the CEV[2] and ONERA[3]. The integration of SEE into the flight test measurement acquisition system is described in detail, and examples of use by the Design Office are also discussed. The paper concludes with a review of the progress achieved and planned improvements in test data application techniques at Marignane.

CONTENTS

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1 SEE: Système d'Exploitation d'Essais

2 CEV: Centre des Essais en Vol (Flight Test Center)

3 ONERA: Office National d'Etudes et de Recherches Aérospatiales (National Office for Aerospace Investigation and Research)

1 - INTRODUCTION

New measurement techniques related to progress in instrumentation and telemetry, and to generalized computerization now make it possible to acquire and archive a considerable volume of data during a single test. This situation is evolving rapidly.

At the same time, increasing use of complex predictive models to design new aircraft, and simulation models to meet stringent aircraft certification criteria, require correlation of large masses of test results covering the entire flight envelope, and are possible only with computerized data processing methods.

The conventional measurement analysis procedures used at Marignane in the early 1980s were unable to take advantage of the wealth of test data available. Computerized techniques already widely implemented for data acquisition thus had to be extended to analysis and interpretation of the results in order to cut time requirements, analyze a maximum of data and improve test procedures.

From the beginning of the 1980s, the Design Office was confronted with the problem of utilizing huge masses of data in research projects, and developed a number of computer tools for specific tasks: analysis of blade pressure measurements, interpretation of wind-tunnel tests involving fully equipped rotors, etc.

A more general system known as SEE[1] was developed in 1985 in conjunction with a series of tests involving the SA 330 PUMA for which the measured flight test results were systematically correlated with simulation data from the S80 flight model.

Since that time, SEE has been widely adopted throughout the Helicopter Division. The software has been continually upgraded to meet the needs of the Design Office and flight test centers, and is now the basic computer tool at Marignane for processing most flight, wind-tunnel or laboratory test results as well as for many analysis results.

This overview of the SEE system describes the principles underlying the design and architecture of the program and discusses the results obtained in actual use. First, the initial context is recalled, with a description of the conventional measurement acquisition and analysis procedures used in the early 1980s. The next section describes the SEE system: programming principles, organization, functions, etc. The last section discusses the program as used primarily to analyze flight test data, with additional examples of implementation by the Design Office. The conclusion reviews the present situation and notes improvements planned for the near future.

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[1] *SEE: Système d'Exploitation d'Essais*

2 - CONTEXT

2.1 Description of Measurement Acquisition System

AIRBORNE TEST SYSTEM

The Marignane Flight Test department currently uses two separate data acquisition systems (Figure 1).

- The first is a digital pulse-coded modulation (PCM) system used to log quasi-static parameters including aircraft flight parameters (control and attitude data) and engine parameters (rpm, fuel consumption, etc.) with a capacity of 80 to 100 variables at a mean sampling rate of 16 to 32 points per second.
- The second is an analog system specifically adapted to helicopter requirements. It is used to measure dynamic parameter data at higher frequencies (0.1-100 Hz) such as stress loading of stationary or rotating components and vibration levels. The signals are acquired by frequency-division multiplexing, with 8 multiplexed carriers each including 12 parameters for a total of 96.

The data signals from both systems are recorded on magnetic tape together with the time code and audio signals and a synchronization pulse corresponding to the main rotor azimuthal position. The telemetry system provides for inflight monitoring of the complete PCM signal together with 14 of the most significant analog parameters for CRT display purposes.

This setup is used primarily for basic aircraft development work (vibrations, flight characteristics, performance data, etc.).

The implementation of digital systems (self-contained navigation, fly-by-wire control, etc.) has considerably increased the volume of data, and requires new measurement acquisition systems now under development (DANIEL PCM and CATINA computer).

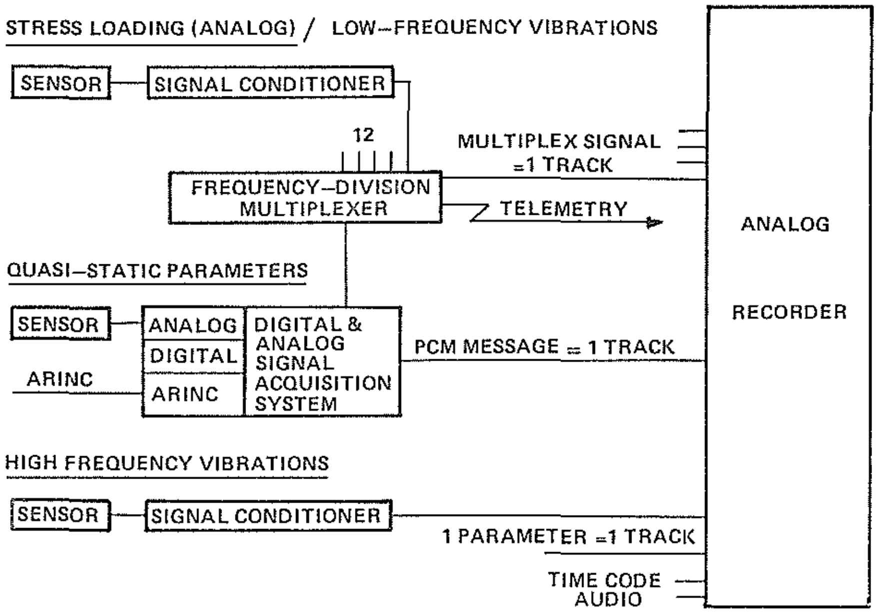


Figure 1 Airborne test system

DATA ANALYSIS SYSTEM

Data analysis, like data acquisition, comprises two separate systems:

- Quasi-static parameters are analyzed using a Gould SEL 3297 computer (Figure 2).
- A Hewlett-Packard 350 computer is also used to process dynamic measurement signals (Figure 3).

The two systems generate either time-referenced graphic plots or data files containing the results of performance, handling qualities or vibration tests. The files are then recovered by Sun workstations or by the IBM 3090 mainframe computer over an Ethernet local area network for processing with SEE.

The telemetry system provides for limited real-time processing, e.g. spectrum analysis, PCM and dynamic parameter-versus-time charts and data acquisition.

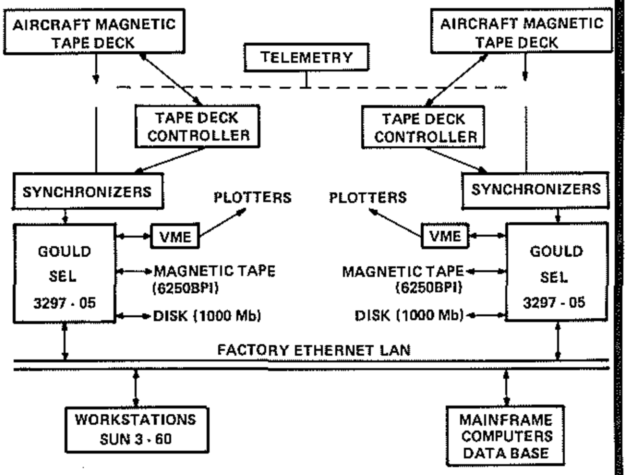


Figure 2 Quasi-static test analysis procedure

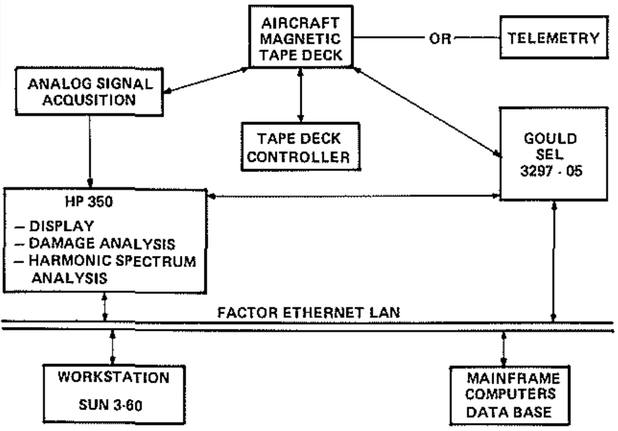


Figure 3 Dynamic test analysis procedure

2.2 Situation in 1985

Before SEE was developed, flight test results were processed and analyzed virtually by hand. Except for the parameter time-series charts printed directly by the Gould system to analyze transient and steady-state phenomena, the test results were only available as parameter lists (parameters in physical units and some calculated values). Numerical tables were manually prepared from the printed lists to allow data sorting and classification, and graphic views were prepared manually.

This long and tedious work prevented test flights from being evaluated in detail and left little time for analysis. The deadlines inherent in flight testing prevented any comparison of the test findings with calculated results, and made implementation of mathematical models impossible.

3 - DESCRIPTION

3.1 Objectives

The goal in 1985 was to develop a computer tool capable of providing a complete picture of the available test results, and to make available a maximum of data from the tests.

Basic data base management functions had to be provided for data collection (transfer, processing, transformations) and organization (sorting, classification, indexing).

The most important objectives, however, involved data analysis and interpretation: functions indispensable for displaying, analyzing and collating data included graphic capabilities, generation of statistics, numerical processing and multilinear regressions. These functions had to be compatible with all types of flight, wind-tunnel or laboratory tests.

The user interface was based on an interactive menu system, but provision was also included for developing specific tools that accessed these functions directly from specialized programs, for example to generate calculations automatically and compare them with test results.

The objective was thus to develop a general-purpose interactive data management and interpretation system with provision for customized add-in options.

3.2 Specifications

SEE was initially developed for a VM environment on the IBM 3090 mainframe system used by the Aérospatiale Helicopter Division. The system includes 650 modules with some 30 000 instructions, and makes full use of the structured programming potential of ANSI-compatible FORTRAN 77.

Each of the 650 modules corresponds to a specific function, and is naturally integrated into a functional library. Figure 4 is a schematic representation of the library architecture: processing and analysis programs are based on the general function libraries (procedures, arithmetic, vector, matrix and character routines) and the graphics utility libraries (chart generation and management, basic plotting commands).

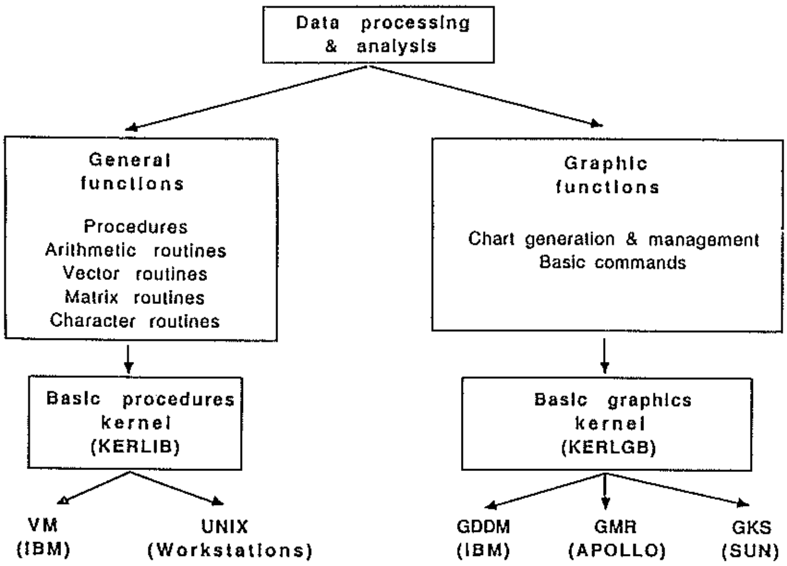


Figure 4 General SEE system architecture

The documentation comprises 650 help screens (20 000 lines) directly accessible from the terminal. Each of the SEE modules was documented to encourage their utilization in developing general applications.

In order to ensure software portability, system-related functions were implemented in two kernels: the "procedures" kernel includes basic procedures such as file editing or file list generation; the "graphics" kernel includes graphics primitives such as point plotting or label generation. On the IBM 3090 system, the procedures kernel is based on VM functionalities and the graphics kernel on the IBM GDDM graphic library. A UNIX-based version of the procedures kernel ensures software portability to other environments, for which the graphics kernel is based on the system manufacturers' libraries: GKS for Sun workstations and GMR for Apollo.

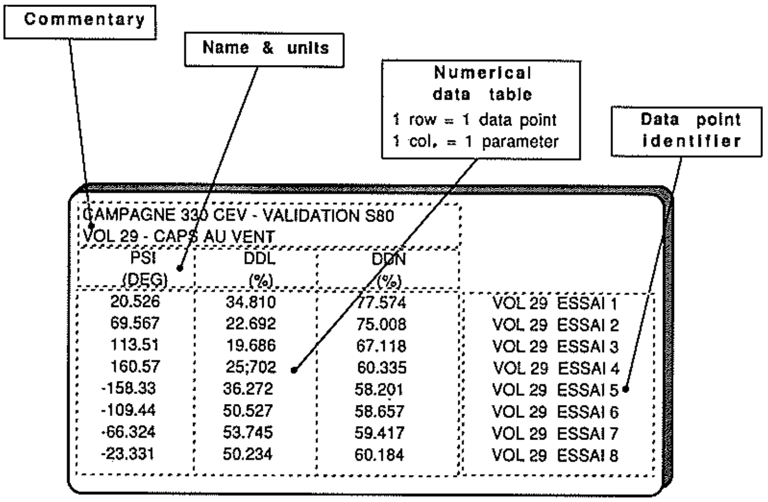
The SEE development methodology thus led not only to an effective test analysis system, but also a programmer's toolbox. The result has been increased productivity in developing scientific applications, ensuring software portability and enhancing the unity and coordination of calculation and test interpretation procedures.

3.3 Data

SEE is capable of accepting any type of data that can be presented in tabular form, in which each column corresponds to a parameter and each line to a calculated or measured data point. Comments and the list of parameter names and units are appended to the table; in some cases a comment identifying the origin or category of the data point can be assigned to each line in the table.

When SEE is used directly, the data must be supplied in a SEE file with a specified format; an example is shown in Figure 5. The file identifier includes the name and type: the name indicates the data source (aircraft, test reference, etc.) and the type specifies the nature of the data (time series, test configuration, etc.). The data management utilities integrated in SEE are used to organize the files in logical groups, and to produce catalogs listing the files with their commentaries.

SEE processing modules often generate new data that can be stored in SEE disk files for subsequent processing by other modules. This system allows any number of combinations: for example, generation of calculated results, processing and disk backup, followed by comparison of the disk file with other test or calculation results, etc. This open-ended process simplifies links between SEE and other applications. Moreover, the standard file format considerably enhances data exchanges between engineering and test departments.



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CAMPAGNE 330 CEV - VALIDATION S80
VOL 29 - CAPS AU VENT
    PSI        DDL        DDN
   (DEG)       (%)        (%)
   20.526     34.810     77.574       VOL 29  ESSAI 1
   69.567     22.692     75.008       VOL 29  ESSAI 2
   113.51     19.686     67.118       VOL 29  ESSAI 3
   160.57     25;702     60.335       VOL 29  ESSAI 4
  -158.33     36.272     58.201       VOL 29  ESSAI 5
  -109.44     50.527     58.657       VOL 29  ESSAI 6
  -66.324     53.745     59.417       VOL 29  ESSAI 7
  -23.331     50.234     60.184       VOL 29  ESSAI 8
```

Figure 5 SEE data format

3.4 Functions

SEE was designed for data analysis; this assumes that preliminary processing (selection of time ranges, conversion into physical units, organization in tabular form, averaging, etc.) is done at an earlier stage in the procedure.

The test centers at Marignane supply most test results in SEE file format. The results of tests conducted outside Aérospatiale may be provided as rough time-series measurement data on magnetic tape, however. SEE therefore includes utilities for reading in tape files, averaging and spectrum analysis. Nevertheless, these utilities are rarely used, and it is always preferable for these functions to be performed under the responsibility of the test centers using their own facilities.

The essential tools in SEE are the functions used to display and process data contained in SEE files (Figure 6). These functions are briefly described below, and specific examples are discussed in Section 4.

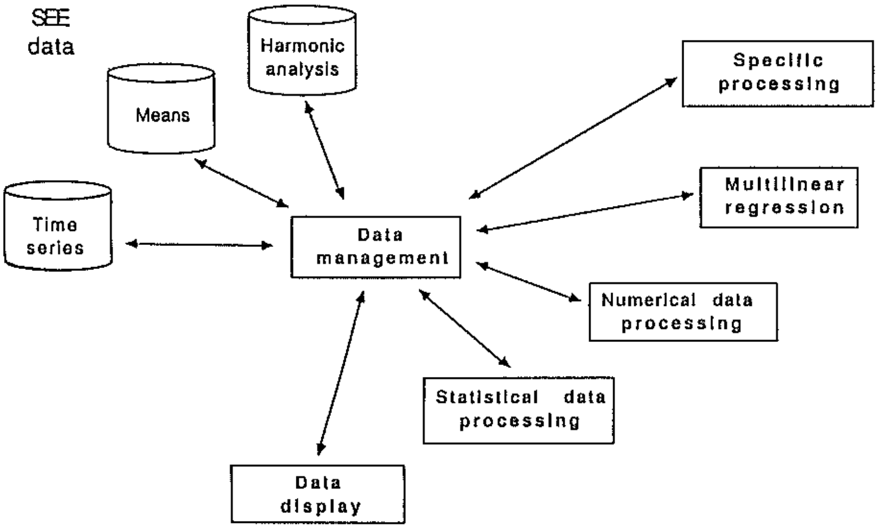


Figure 6 SEE functions

DATA MANAGEMENT

SEE files can be searched and classified according to their identifiers (name and type). File lists also include the commentaries describing their contents.

File editing tools are also included: copy, add or delete lines or variables, consolidate data from multiple files, etc.

DATA DISPLAY

After the files and variables are selected, the data from one or more SEE files can be displayed in tabular or graphic form. Interactive commands allow variables to be graphed in a variety of ways, including multilayer and multiline displays with up to 28 graphs on a single view, etc. Many options are available: graphic presentation, scaling, curve and point plotting, captions, splines, polar coordinates, etc.

STATISTICAL DATA

The major statistical functions are available in SEE to check and analyze test results: basic functions (extremes, medians, means, standard deviations, etc.), histogram plotted together with the distribution function and normal law, correlations and eigen values, Henry line and normality test, run up and down tests.

Main component analysis (MCA) is also available: synthetic graphic plots reveal the structure of the variables (correlation circle) and the distribution of individual points on a privileged plane that displays a maximum of the data in the table.

The availability of these statistical tools, notably MCA, has encouraged their use, and has proved indispensable for systematic and synthetic analysis of measurement data. Work is now in progress to extend these possibilities.

NUMERICAL DATA PROCESSING

A wide range of functions is available: sorting points on keyword identifiers; searching families of values with high point densities for a specified variable, then sorting the corresponding points; sorting points for which certain variables are within specified ranges; sorting on a single variable; unit conversions; etc.

The user can interactively define transformations affecting all or part of a data table to obtain complex selection parameters easily without programming, even when not included in the initial archival definition. This possibility is used to generate the initial model for multilinear regression.

Standard numerical routines (filters, Fourier analysis, etc.) were developed by the relevant departments (vibrations, aerodynamics, etc.). Work is now being done to ensure full integration of these tools in SEE.

MULTILINEAR REGRESSION

Multilinear regressions are used to fit a mathematical model to actual observation data. The model consists of a linear combination of elementary terms. Using SEE, an a priori model can be generated interactively, the optimum regression can be determined, the results analyzed, questionable and significant points identified, and various graphic representations generated to check the result.

This procedure meets two categories of needs: parameter modeling for subsequent entry into a calculation routine, or smoothing to obtain synthetic graphic representations (to reveal the influence of a specific parameter, to produce nomographs, etc.).

4 - EXAMPLES

4.1 Flight Test Department

SEE has solved the problems raised by manual interpretation of flight test results by providing users with suitable tools. This is largely due to the fact that SEE was developed by the users themselves, who built in the flexibility necessary to meet changing requirements.

An example is the SEE file format itself, which is simply a computerized version of the data charts once prepared manually (Figures 7 and 8).

The SEE functions illustrated below were direct outgrowths of the analysis needs expressed by the Flight Test Department, to automate manual processing while integrating more sophisticated techniques.

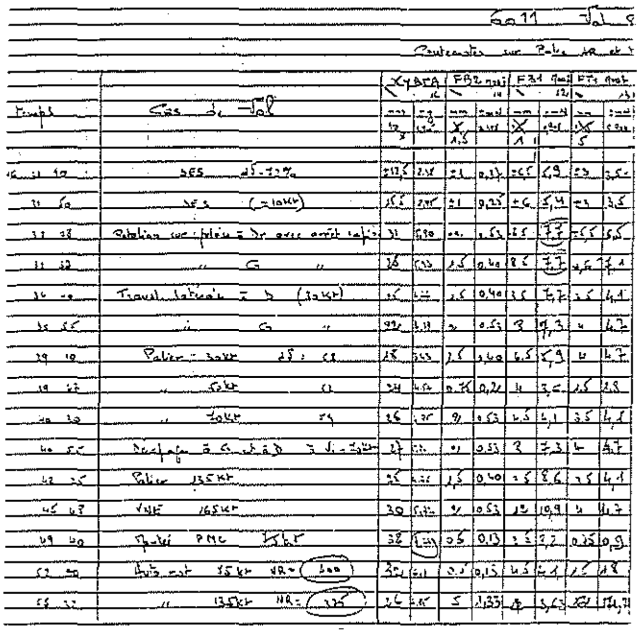
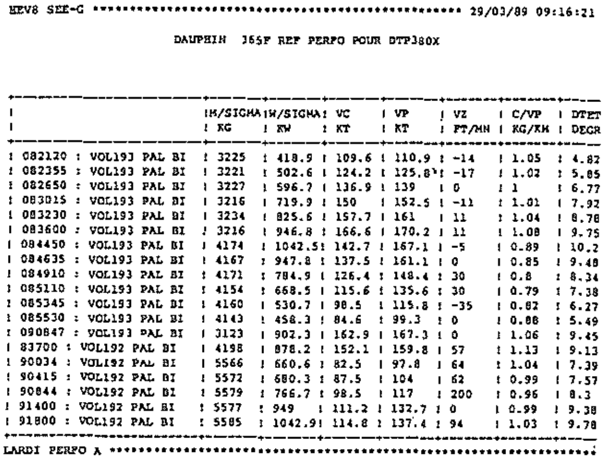


Figure 7 Typical manual test data chart



HEV8 SEE-G ** 29/03/89 09:16:21

DAUPHIN 365F REF PERFO POUR DTP380X

		M/SIGMA KG	W/SIGMA KW	VC KT	VP KT	VZ FT/MN	C/VP KG/KM	DTET DEGR
082120	VOL193 PAL BI	3225	418.9	109.6	110.9	-14	1.05	4.82
082355	VOL193 PAL BI	3221	502.6	124.2	125.8	-17	1.02	5.85
082650	VOL193 PAL BI	3227	596.7	136.9	139	0	1	6.77
083015	VOL193 PAL BI	3216	719.9	150	152.5	-11	1.01	7.92
083230	VOL193 PAL BI	3234	825.6	157.7	161	11	1.04	8.78
083600	VOL193 PAL BI	3216	946.8	166.6	170.2	11	1.08	9.75
084450	VOL193 PAL BI	4174	1042.5	142.7	167.1	-5	0.89	10.2
084635	VOL193 PAL BI	4167	947.8	137.5	161.1	0	0.85	9.48
084910	VOL193 PAL BI	4171	784.9	126.4	148.4	30	0.8	8.34
085110	VOL193 PAL BI	4154	668.5	115.6	135.6	30	0.79	7.38
085345	VOL193 PAL BI	4160	530.7	98.5	115.8	-35	0.82	6.27
085530	VOL193 PAL BI	4143	458.3	84.6	99.3	0	0.88	5.49
090847	VOL193 PAL BI	3123	902.3	162.9	167.3	0	1.06	9.45
83700	VOL192 PAL BI	4198	878.2	152.1	159.8	57	1.13	9.13
90034	VOL192 PAL BI	5566	660.6	82.5	97.8	64	1.04	7.39
90415	VOL192 PAL BI	5572	680.3	87.5	104	62	0.99	7.57
90844	VOL192 PAL BI	5579	766.7	98.5	117	200	0.96	8.3
91400	VOL192 PAL BI	5577	949	111.2	132.7	0	0.99	9.38
91800	VOL192 PAL BI	5585	1042.9	114.8	137.4	94	1.03	9.78

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Figure 8 Data chart produced by SEE

MEASUREMENT QUALIFICATION

The post-processing step, which covers validation of measurement data, was once a purely visual procedure.

Today, this phase still uses graphic plots, which remain the basic engineering analysis tool, allowing variation curves to be displayed and compared. With SEE, however, qualification also involves statistical functions: an averaged parameter data file (stabilized tests) is analyzed by determining the extremes, means and standard deviations, and plotting the corresponding histograms.

For time-series tests these functions are completed by others that allow specific regions to be defined on the graphic plots and aberrant points to be eliminated.

PERFORMANCE RATINGS

SEE was modified for performance evaluation purposes to accept files in which each line corresponds to the average flight parameter values for a stabilized flight segment. This was achieved mainly by implementing a number of sorting functions:

- Keyword sorts allow different flight configurations (hover, level flight, climb, etc.) to be examined separately. As in the manual charts, each line of a SEE file includes a keyword describing the corresponding test point. Work is in progress to implement automatic sorting of flight configurations based only on the numerical parameter values using artificial intelligence techniques (SPECTRIA), but the extended aircraft flight envelope makes it extremely complex to develop this type of sort function.
- Numerical sorts are used to select test points meeting certain criteria (weight or altitude range, etc.).
- Group sorts are designed to determine iso-conditions for specific parameters (iso-weight, power, airspeed, etc.) within specified tolerance limits.
- Classification: files can be classified by increasing order of a given parameter value.

After sorting, all types of graphics can be generated.

Multilinear regression is another tool used to fit a performance analysis model to measured test data: the necessary power diagram recorded in hover, level flight or climb. The optimum model is determined by a preliminary variance analysis before proceeding with the regression. The results can be displayed graphically together with the measurement points (Figure 9). This tool is extensively used by other programs: one of them, for example, produces Flight Manual performance rating charts (Figure 10) from the flight test measurements and the results of multilinear regression.

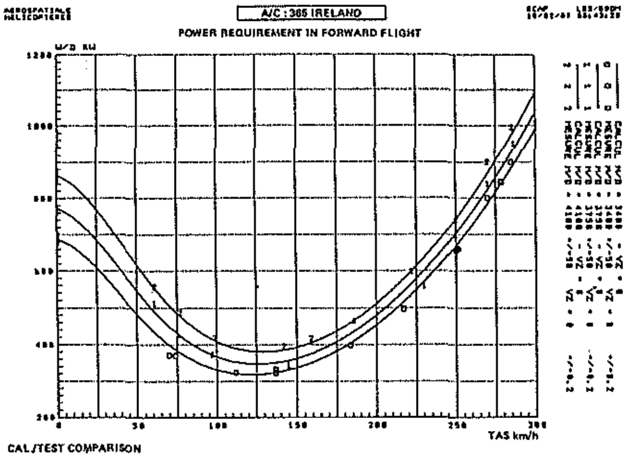


Figure 9 Performance modeling

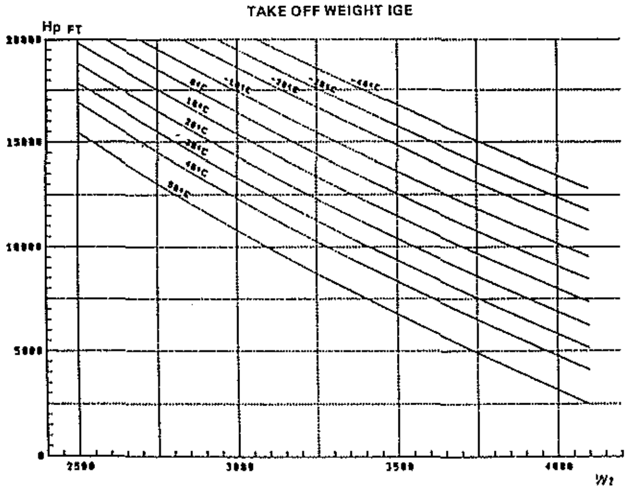


Figure 10 Flight Manual performance chart

HANDLING QUALITIES

Helicopter flight handling qualities are investigated using the SEE utilities: for dynamic tests, for comparison and adjustment of calculation models, or for static tests to plot the standard curves (longitudinal and lateral stability, dihedral effects, etc.).

Figure 11 is an example of the graphic plots obtained for an exceptional maneuver: acrobatic flight with a PANTHER.

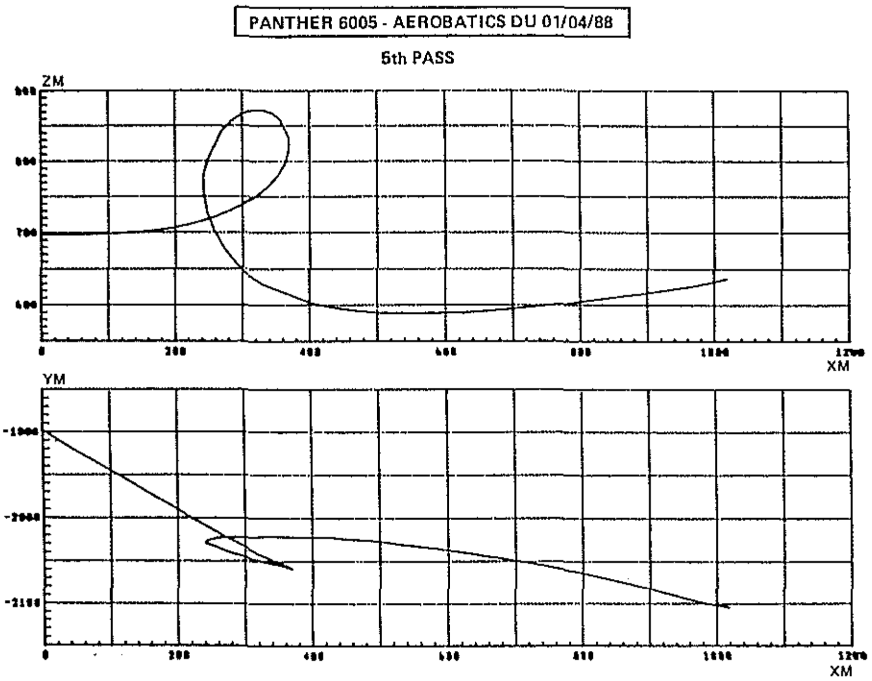


Figure 11 Flight characteristics

AUTOMATIC FLIGHT CONTROL SYSTEM DEVELOPMENT

SEE is used in AFCS development work primarily to compare flight test and simulation results.

A dedicated program was written using SEE modules to determine the accuracy of self-contained navigation systems, and to qualify the accuracy of the systems installed on production aircraft (Figure 12).

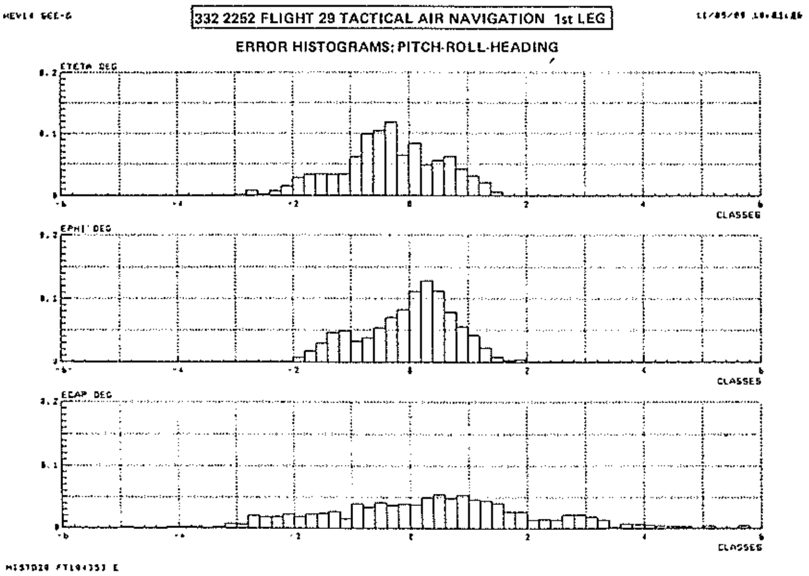


Figure 12

Qualification of navigation system accuracy

DYNAMIC ANALYSIS

SEE has proved to be the most suitable tool for helicopter vibrational analysis. Vibrations are the fundamental problem in helicopter design, with excitation frequencies generated by the main and tail rotors.

Investigation of the phenomenon is based on harmonic analysis of measured signals by the Gould-HP system; the analysis results are then processed under SEE:

- Graphic representation of the excitation and response harmonics; comparison of vibration levels obtained for different flight configurations or aircraft modifications (Figure 13).

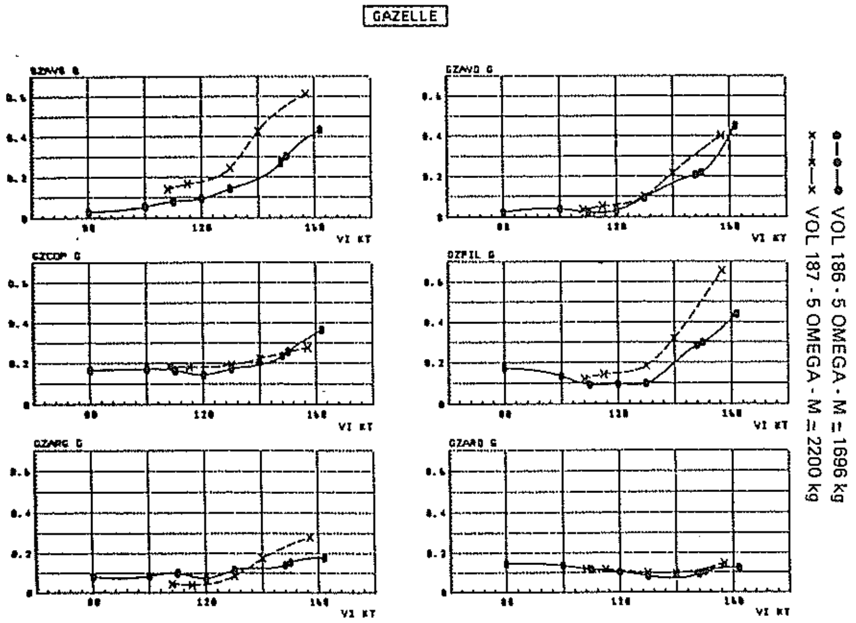


Figure 13

Dynamic response curves

- Calculation of the excitation torque load set (loads and moments sustained by the rotor head) using the general transformation module – a veritable interactive programming module allowing any operation on file parameters, and the creation of new parameters.
- Reconstitution of the original signals from the harmonic analysis results to qualify the measurement procedure (Figure 14).

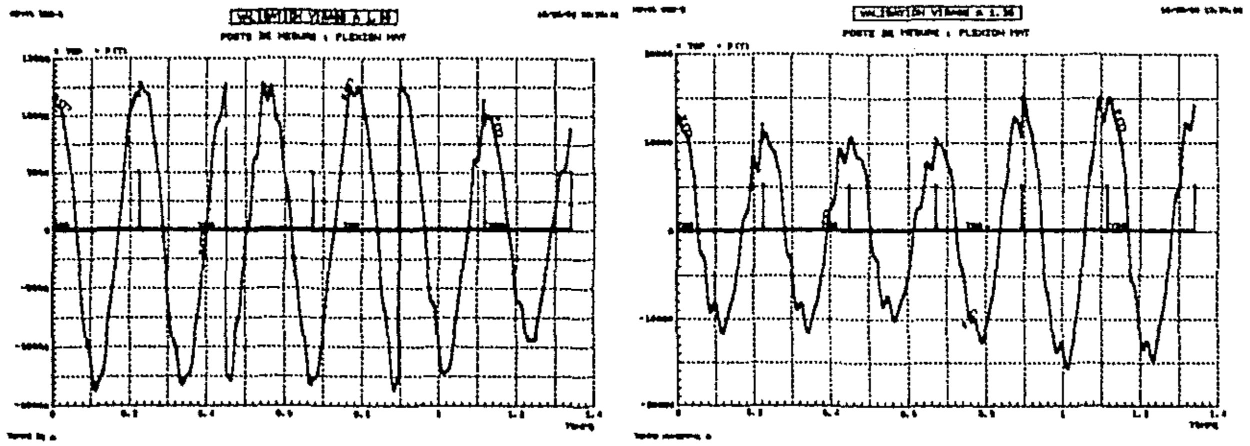
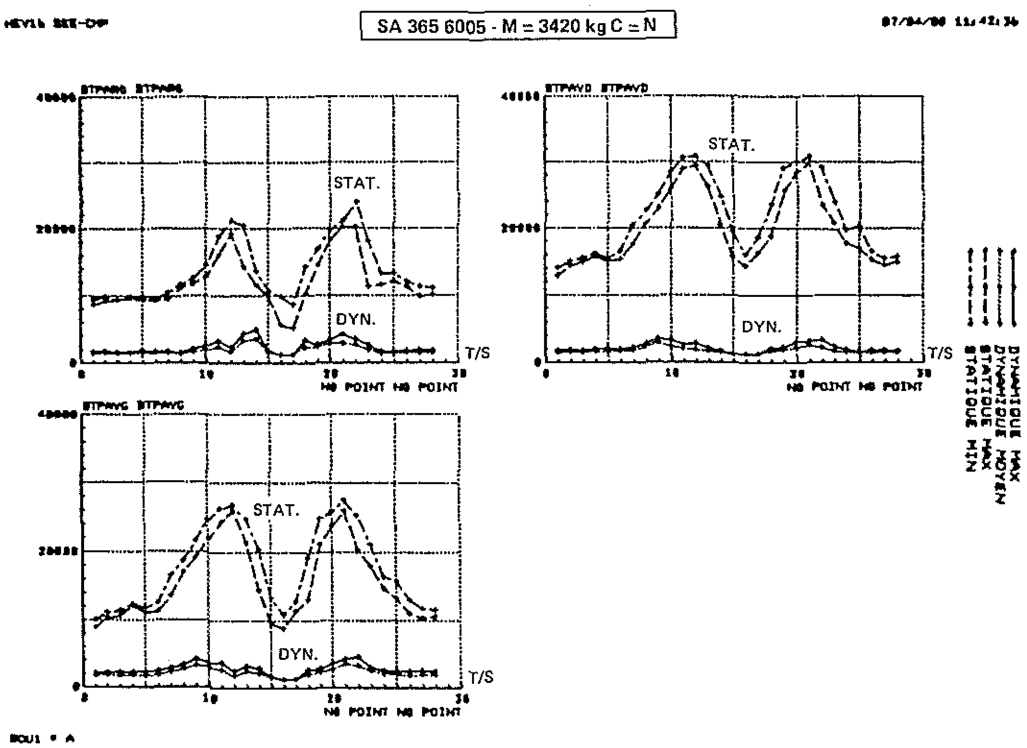


Figure 14 Original and reconstituted signals

- Spectrum analysis to investigate nonharmonic phenomena affecting rotor operating conditions (ground resonance, air resonance, flutter).
- Analysis of the damage peak counting records to calculate the service lives of parts submitted to vibratory fatigue. The peaks are counted by the Gould-HP system; SEE is then used for statistical analysis, to determine the maximum static and dynamic levels, and to determine the effects of aircraft weight, airspeed, load factors, etc. (Figure 15).



STARTING TIME : 9h 08' 17"

FIRST LOOP

Figure 15 Damage analysis

4.2 Design Office

Nearly a hundred people use the SEE system daily in the Design Office for an extremely wide range of applications covering fields as different as aerodynamics, vibration analysis, power transmission and component dimensioning. For all these applications, the most frequently used SEE utilities are the graphic features, basic statistical functions and multilinear regression analysis.

The following examples illustrate a range of SEE utilizations, and highlight the adaptability of the package: wind tunnel conditions (rotor tests at Modane), processing large volumes of complex data (blade pressure measurements), integration of calculation models (S80), implementation of automatic monitoring processes (vibrations) or analysis of calculated results (component dimensioning).

ROTOR TESTING AT MODANE

In 1988, Aérospatiale conducted a series of rotor tests in the S1 wind tunnel operated by ONERA at Modane. The test objective was to compare the performance and vibration behavior of blades with different tip fairings.

In order to minimize the wind tunnel utilization time, Aérospatiale decided to develop a dynamic test control system for virtually real-time validation and interpretation of the test results. A modified "real-time" version of SEE was therefore developed in a relatively short time (2 weeks) to run on an Apollo workstation on line with the Modane data acquisition system (HP 1000 and VAX series minicomputers). The modified version was used for the following purposes:

- Rotor performance without blades was modeled by multilinear regression to allow subsequent rotor head corrections.
- Measurement data was monitored in real time, and data consistency was verified using multiple graphic plots.
- SEE files were generated to archive the test results covering harmonic analysis and performance measurements.

SEE was then used to assess the results of the wind tunnel tests by generating graphs to illustrate the test report (Figure 16), and by comparing calculation and test results for the R85 rotor (Figure 17). The test results in SEE file format now constitute a valuable data base that is extremely useful for analysis and development of calculation programs.

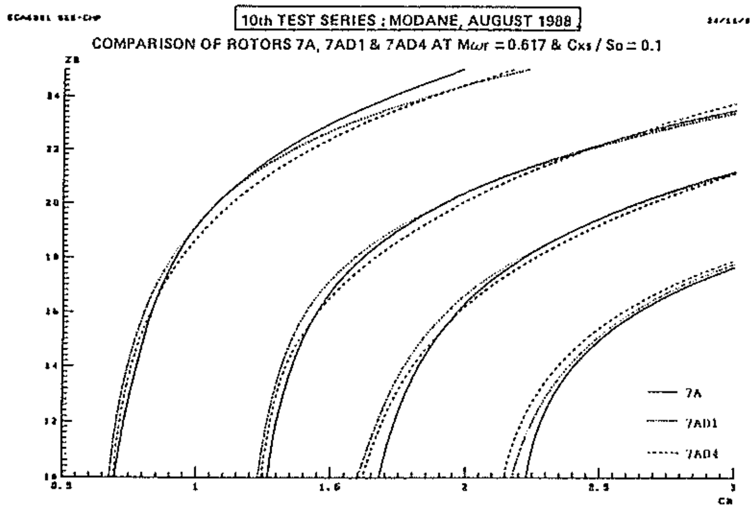


Figure 16 Rotor comparisons

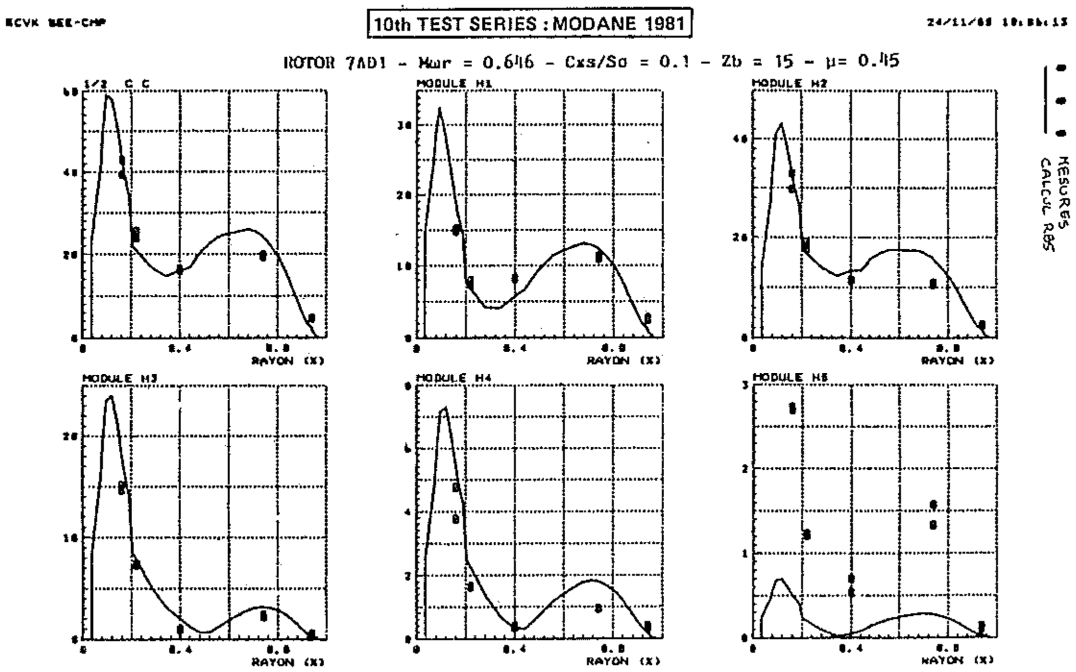


Figure 17 Comparison of experimental and calculated results for R85 rotor

IN-FLIGHT ROTOR PRESSURE AND STRESS MEASUREMENTS

Several flight test runs were conducted with an experimental SA 349 Gazelle helicopter to compile a test data base in order to qualify rotor aerodynamic calculation models. The rotor blades were modified to allow stress and pressure measurements along several blade sections, using a higher harmonic control system to generate rotor pitch excitation signals.

Some 200 flight configurations were tested, covering various altitudes and airspeeds and many types of controls. For each configuration, the first 10 harmonics of the 80 available stress and pressure measurements were analyzed through 8 rotor revolutions, for a total of over 1.4 million values.

A large number of graphic procedures were implemented with SEE to investigate parameter variations according to the cyclic control input phase, rotor behavior in response to a specific type of control input, comparison with calculation results, etc. (Figure 18).

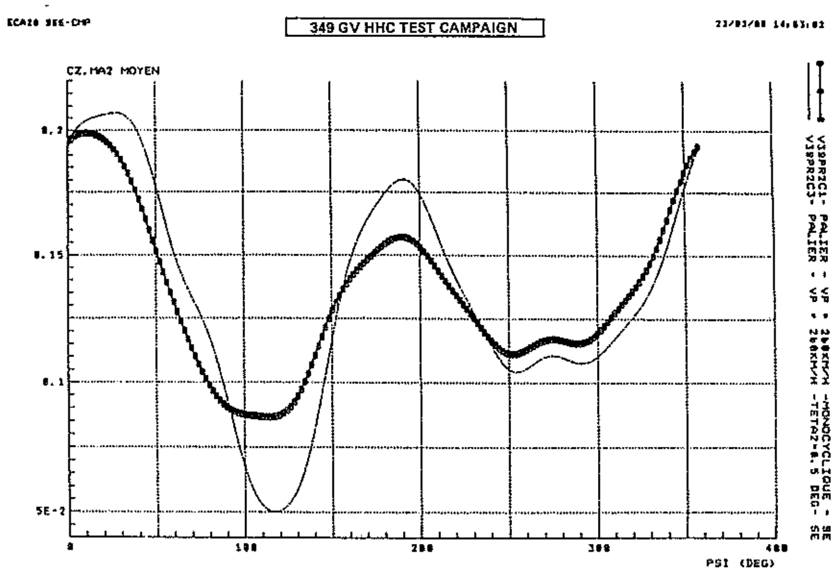


Figure 18
Influence of control input
on rotor thrust

QUALIFICATION OF THE S80 SIMULATION MODEL

S80 is a helicopter flight simulation model developed by Aérospatiale since 1980, and used to investigate handling qualities, evaluate inflight loading and develop navigation systems (AFCS, FBW, etc.).

The data management functions, calculation interactivity and graphic generation features are based on the SEE package. A procedure linking SEE and S80 also ensures that S80 data input is generated automatically from control and flight condition measurements read from SEE files. Test and simulation results can then be compared directly on the same graph: examples are shown in Figures 19 and 20.

This technique is extremely valuable to the engineer responsible for developing and refining the model, and can quickly assess the effects of changes in the model.

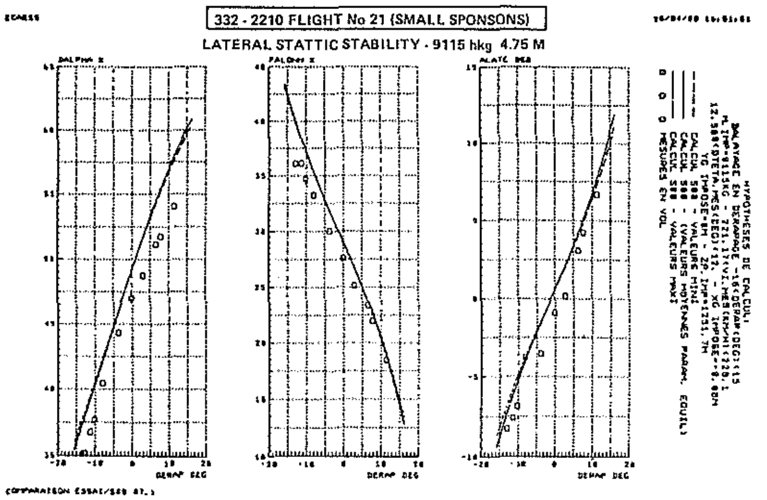


Figure 19 S80 equilibrium values

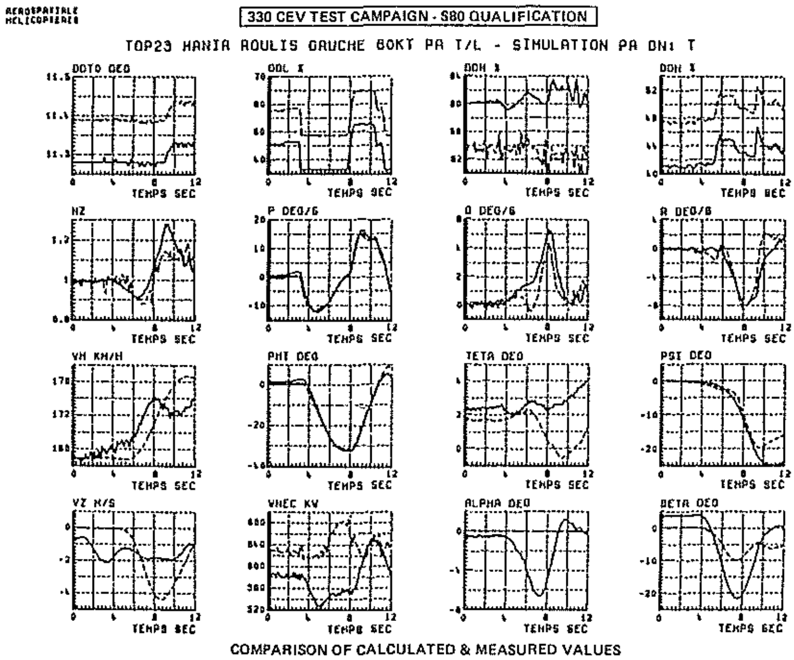


Figure 20 S80 time series

VIBRATION ANALYSIS

As part of a vibration monitoring program for transmission system components, Aérospatiale has implemented a processing and diagnostic method based on acceleration measurements. With a limited number of sensors mounted on the casing, the problem is to identify a component, and to generate an indicative parameter to determine abnormal behavior with respect to a reference population.

As shown schematically in Figure 21, this procedure uses SEE graphic utilities to display mean values and analyze harmonic data for definition or monitoring purposes, with statistical analysis to detect defects.

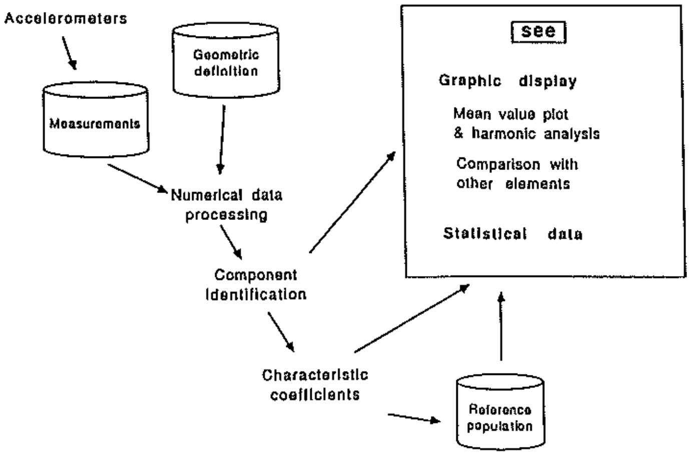


Figure 21 Transmission system vibration monitoring

COMPONENT DIMENSIONING

This novel application uses SEE to analyze the results of stress calculations for the extreme contours of a part. As outlined in Figure 22, CADAM files containing the geometric dimensions are input with a specified load configuration; meshing is performed automatically (GRATIS) prior to finite-element calculation (SAMCEF) and digitizing to obtain the evolution of elongation or stress loads along one or more specified contour lines.

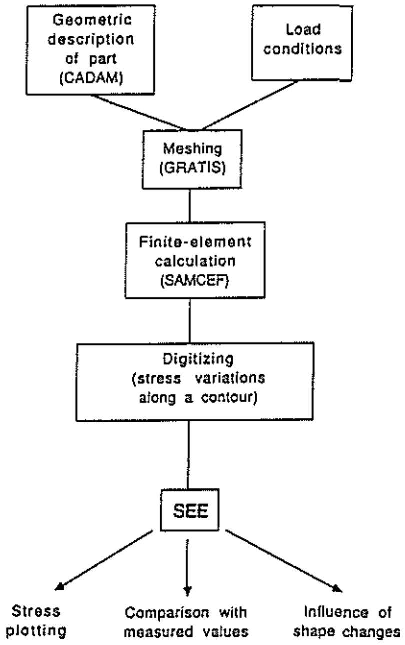


Figure 22 Component dimensioning

SEE displays the general shape of these stress variations, which can be compared with measurement points; multiple superimposed graphs reveal the effects of component design changes (Figure 23). As with test applications, this automatic processing sequence significantly cuts the calculation time, multiplies the possibilities for analysis, and ensures greater reliability.

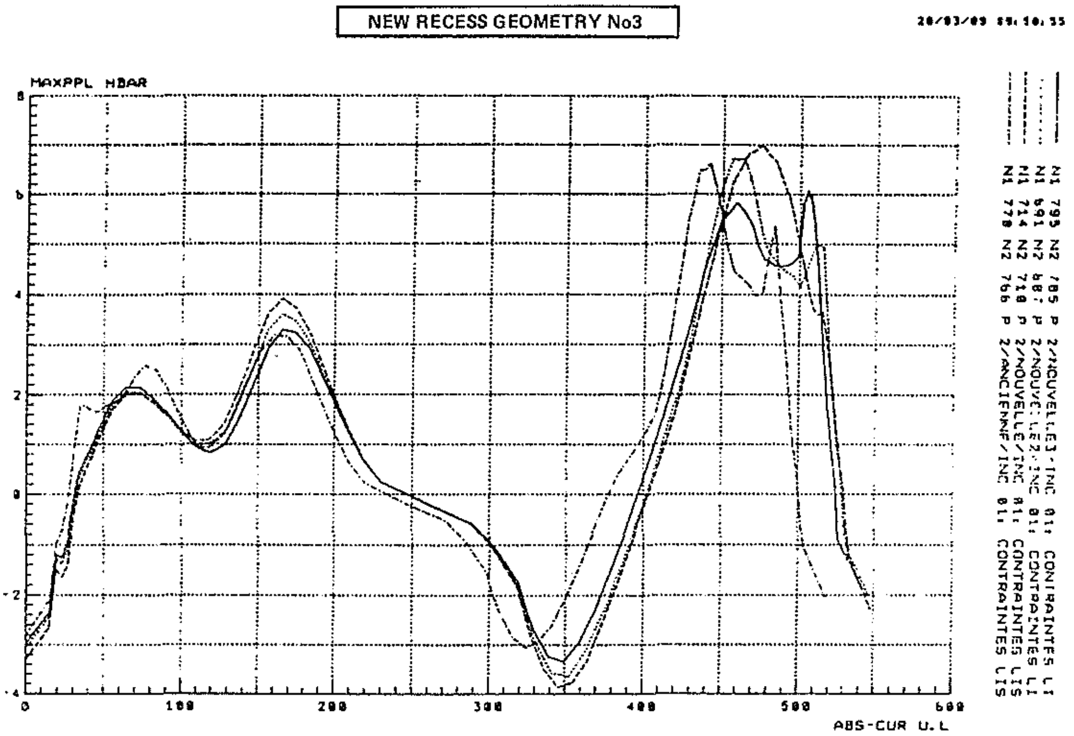


Figure 23 Stress evolution along a contour line

5 - CONCLUSIONS

The SEE system was designed and developed by its end-users, and corresponds perfectly to the needs of the Helicopter Division for processing and interpretation of test and calculation results. Most scientific applications now call on SEE functionalities.

The Flight Test Department generates most of the measurement data, and has integrated SEE into its measurement procedures. The performance gain was immediately perceptible: in 1989, it is estimated that 50 to 70% of the test results are usable, compared with only about 10% in 1980. With considerably more data available, the test center is better able to orient subsequent tests, improve measurement reliability and shorten the time lag required to provide data to the users. All data is archived in SEE file format to ensure maximum flexibility in use and to constitute an invaluable experimental data base that enhances the long-term effectiveness of the tests themselves.

In the Design Office, SEE ensures more effective use of feedback from testing, minimizes the risk of error and allows calculation methods to be refined.

SEE has been the incentive behind increased cohesion among users that encourages communication of data and ideas: many SEE features were originally created to meet specific needs, and were then generalized for maximum benefit. The standard data file format has largely increased data exchanges within the testing and engineering departments.

Beyond the software package itself, SEE has thus promoted valuable relations that have notably improved productivity. Two projects are now under development to increase and extend the potential of this test analysis system:

- A test management system will be used for documentary data base management, creating relational links between SEE files, the test conditions and the aircraft configuration.
- A dedicated analysis package for system tests will be capable of manipulating and processing discrete, logical or asynchronous data, constituting a useful extension to SEE in this important area.

Marignane has thus been able to mobilize technical, human and computer resources around a tangible project for the purpose of creating a single comprehensive experimental data base accessible to all users. Powerful computer facilities were smoothly coordinated to ensure better resource allocation and greater productivity in measurement activities. This represents an important asset that will be extremely beneficial for the significant projects of the next decade: the HAP Franco-German combat helicopter and the NH90 European transport helicopter.