Raymond DUPRAT, André MOUTON
INTESPACE

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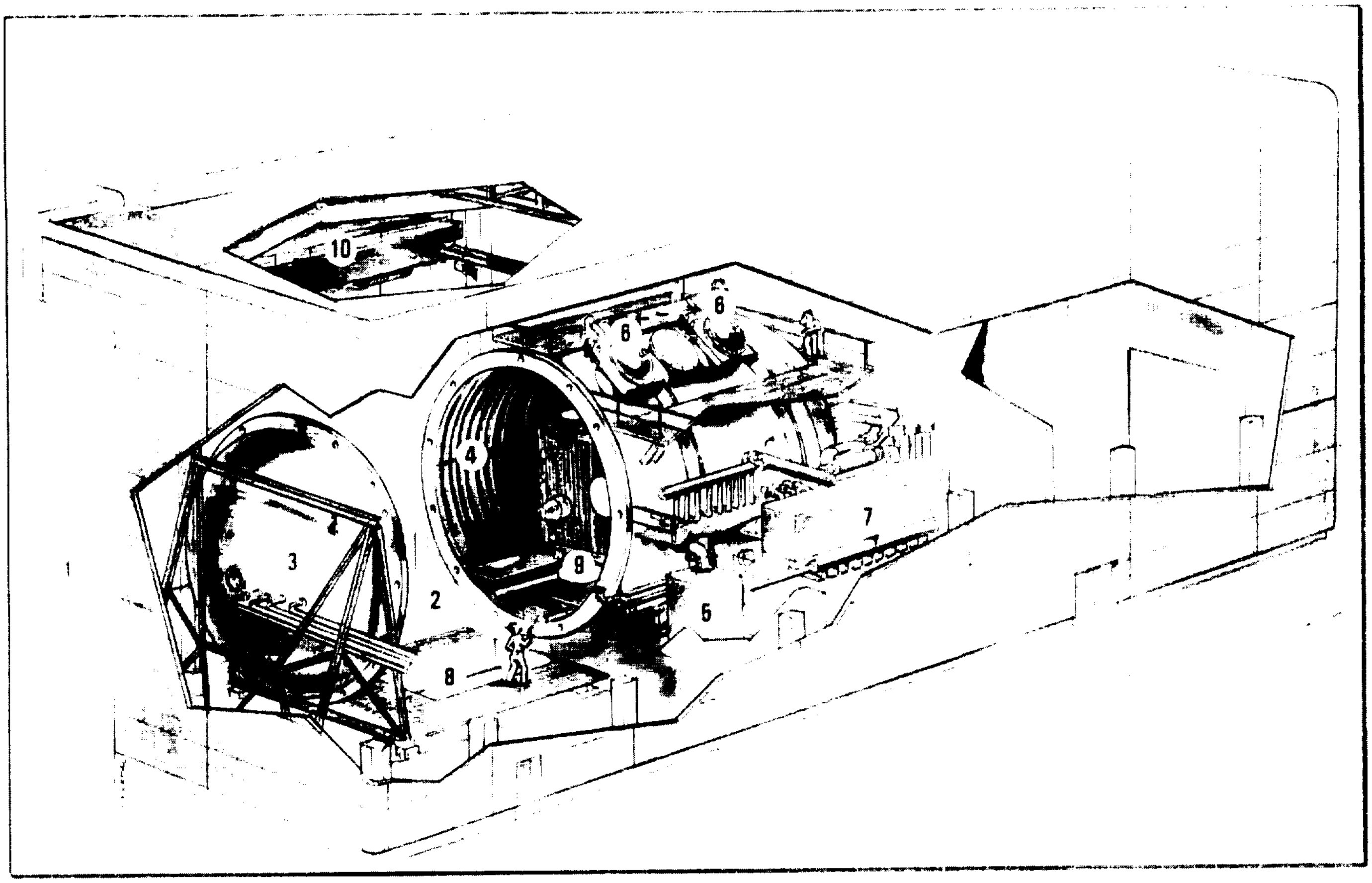


1-	Entrance Airlock	5-	Primary Pumps	8-	Lifting Device
2-	Preparation Area Class 100.00	6-	Cryogenic Pumps	9-	Platform
3-	Vacuum Chamber		Turbomolecular Pumps	10-	Travelling Crane
4-	Radiating screens	7-	Thermal Generator		

ABSTRACT

The development of an European satellite market over the last 10 years, the industrialization of space applications and the new requirements from satellite prime contractors have led INTESPACE to increasing the test center's environmental testing capacities and notably through the addition of a new thermal-vacuum test facility of impressive dimensions referred to as the SIMMER.

The SIMMER is a simulator specifically created for the purpose of conducting acceptance tests of satellites and of large structures of the double launching ARIANE IV or half ARIANE V classes.

The chamber is 8.3 meters long with a diameter of 10 meters.

The conceptual design of a chamber in the horizontal plane and at floor level is in a view to simplify test preparation and to permit final electrical checks of the spacecraft in its actual test configuration prior to the closing of the chamber.

The characteristics of the SIMMER complies with the requirements being currently defined in terms of thermal-vacuum tests :
- thermal regulation (temperatures cycling between 100 K and 360 K),
- clean vacuum (10^{-6} mbar),
- 600 measurement channels,
- 100 000 cleanliness class.

The SIMMER is located in INTESPACE's space vehicle test complex in which a large variety of environmental test facilities are made available for having a whole test program completed under one and a same roof.

1 - INTRODUCTION

Set up in Toulouse in 1969, INTESPACE has developed a wide range of facilities to fully match the test requirements as defined for launch vehicles.

The effective use of the modular Ariane IV launcher put into service in 1988 plus the ever-increasing competition on the global marketplace have led INTESPACE to developing new resources for the testing of satellites in view of qualification and acceptance. At the same period of time INTESPACE had to get involved in the testing of payloads as will be carried by the next-generation, heavy-lift ARIANE V launch vehicles.

The new test facility SIMMER for thermal vacuum testing was designed and manufactured as per the following criteria :

- Optimization of the chamber to conduct thermal vacuum acceptance tests for new families and/or recurrent models of satellites.
- Test configuration capabilities for Ariane IV- and Ariane V-launched satellites.
- Optimization of the test campaign durations and notably of the preparation, handling and test phases.
- Integration in the test configuration of a satellite of previously-defined functional connections.
- Verification of the proper functioning of a satellite under extreme environmental conditions (low and high temperatures) and this at different stages of its lifetime.
- Accommodation of the operations and integration staff members, installation of the equipment, facilities and determination of the areas needed for satellite testing and the series of operational checks.
- Extension capabilities for future enhancements of the chamber.

The simulator is housed in a building equipped with all the equipment and areas necessary to carry out testing operations (i.e. offices, OCOE and SCOE areas, preparation area in a clean room of class 100 000, storage area, and the like).

The simulator is linked via a specific airlock to the other facilities being available under one and a same roof for the purpose of performing qualification and acceptance tests.

INTESPACE Space Test Center	
Qualification	**Acceptance**
Integration and Test Preparation Area Experimenters' area Spacecraft checkout area High bay clean room	**Integration and Test Preparation Area** Experimenters' area Spacecraft checkout area High bay clean room
Tests : Vibrations : 300 kN multi shaker Acoustics : 1100 m³ chamber Thermal balance : 7m Ø x 9 m chamber plus 3,8 m Ø solar simulator EMI/EMC : 16 x 10 x 11 m shielded anechoic chamber Mass properties : 4 tons combined facility	**Tests :** Acoustics : 1100 m³ chamber **Thermal vacuum : 10 m Ø x 8.3 m thermal vacuum chamber** Mass properties : 4 tons combined facility

2 - MARKETING CONSIDERATIONS

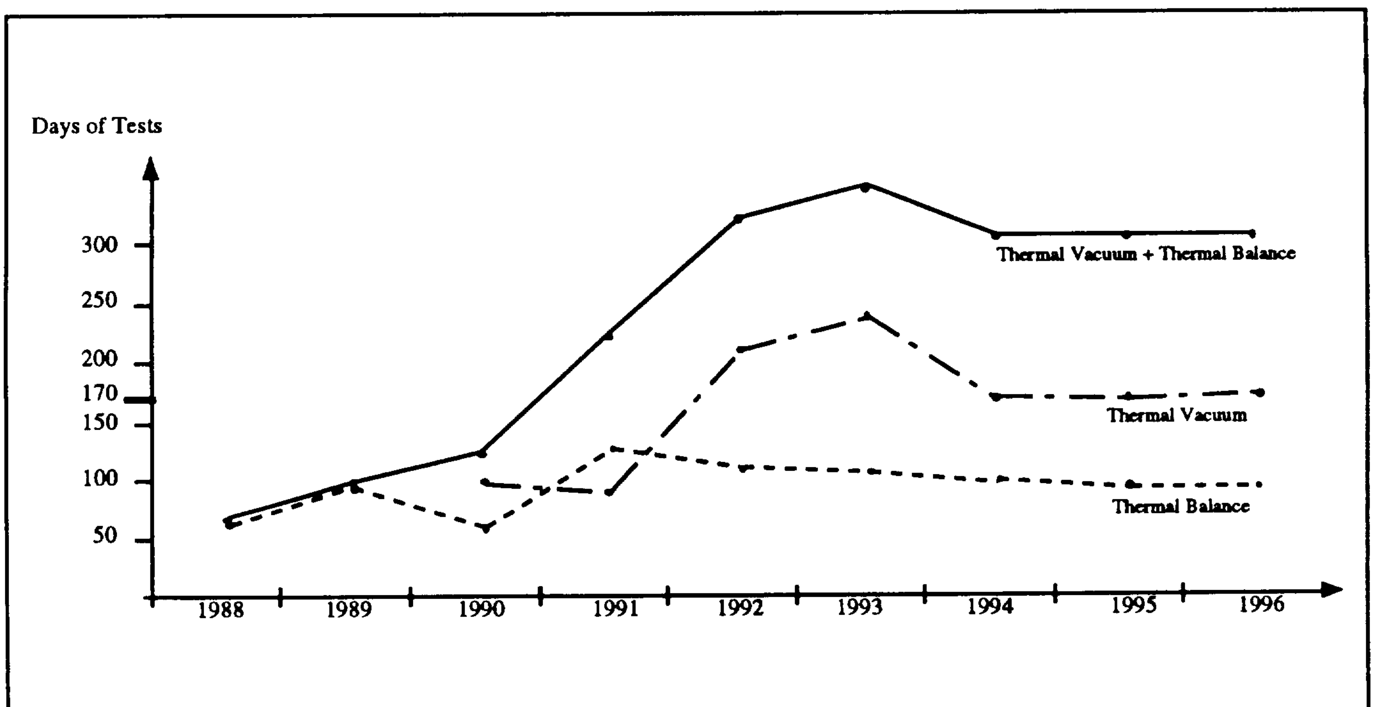
The curve presented below gives a clear indication of the market niches INTESPACE is in a position to gain and of the major industrial partners for which the company works today.

This curve evidences a growing demand for tests of the thermal vacuum type and a relative stability of the need for thermal balance tests.

The forecasts predicted from 1994 onwards are based on the market growth that the studies conducted by Arianespace and Euroconsult and by other industrials lead to expect, as well as on the ascertained loyaulty of INTESPACE's major European customers.

All these indications converge towards predicting a substantially boosted demand.

It is to be noted that an optimized test facility with an operational capability of 200 days (preparation, test, removal) in terms of thermal vacuum tests shows a most satisfactory workload. In contrast, a simulator used for its maximized thermal balance performance (with solar simulation) lets from 40 to 60% of its capability unused each year, that is 70 to 100 days.



3 - FACILITY's MAIN CHARACTERISTICS

3.1. Preparation Area

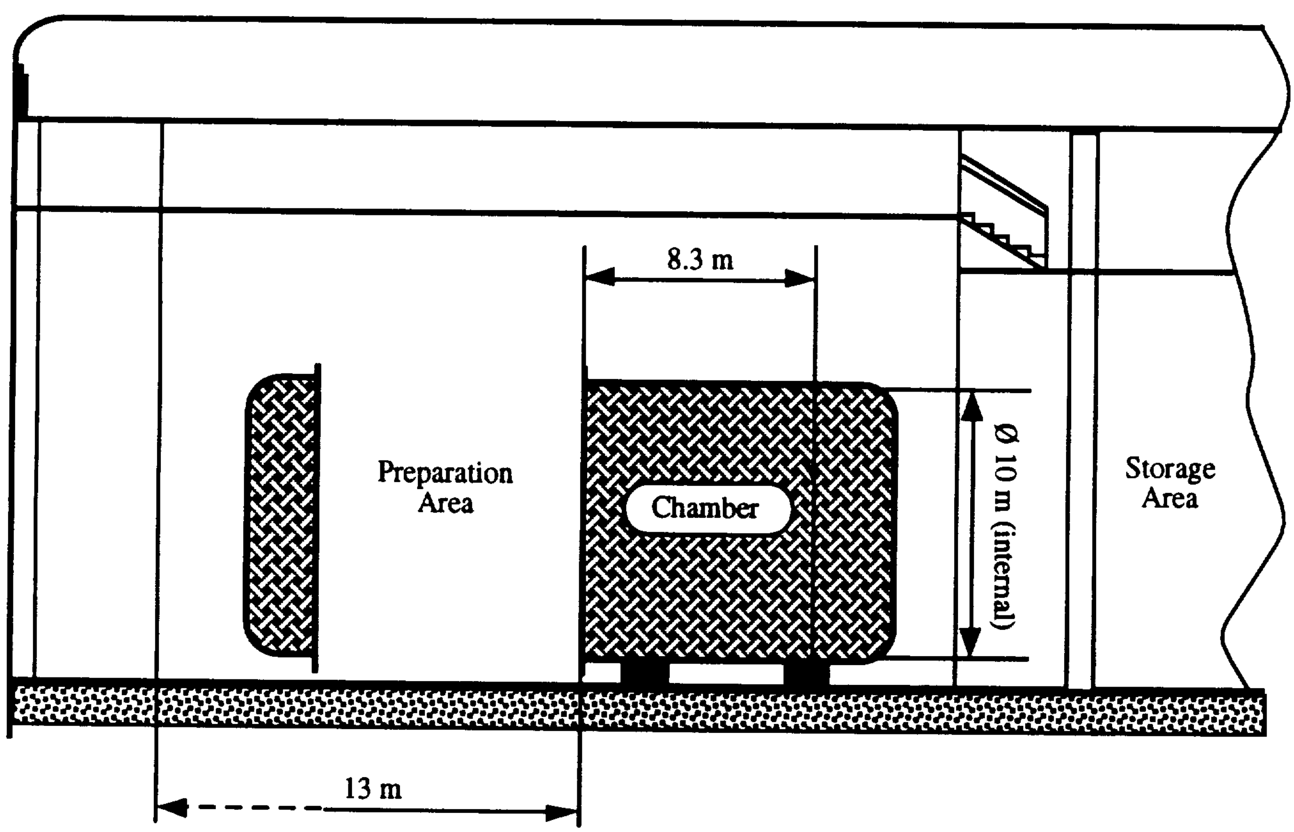
The preparation area is used to conduct the following operations :

- Preparation and servicing of the specimen prior to the test.
- Transfer of the specimen to the integration trolley.
- Insertion of the specimen into the test facility.
- Displacement and storage of the chamber's front door.
- Storage of the means of access to the specimen during the tests.

This area shall be maintained as a clean room of class 100 000. An overhead traveling crane of 7t is kept in this area.

Surface : 374 m^2 - Effective height : 13 m under the overhead traveling crane's hook.

3.2 Chamber



Schematic View of the Chamber

The chamber consists of a cylinder in the horizontal plane closed by two spherical bulkheads, that is :

- The front bulkhead, in the clean area, is used as an access door to enter the chamber and is moved away on an automotive trolley.
- The aft bulkhead, in the grey area, is permanently attached and provides capabilities for additional cylindrical rings to be fixed, permitting thereby later extensions of the simulator.

Overall dimensions :
- diameter : 10 meters
- length : 8.30 meters

A number of removable feedthroughs are distributed over the simulator so as to have the data from the specimen (electrical feedthroughs, thermocouples, ...) and/or from the simulator itself to be properly transmitted (vacuum gauges, temperature measurements). A series of windows are evenly distributed over the chamber to permit visual monitoring of the specimen when being tested.

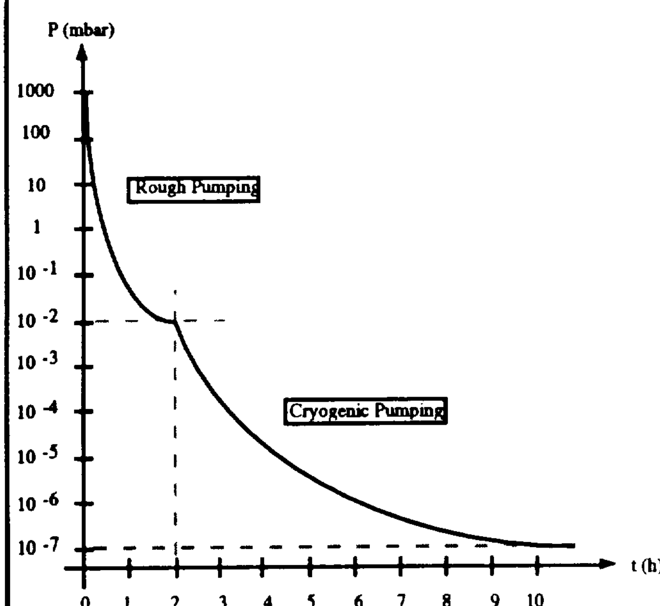
Two rails are mounted on both sides of the lower part of the simulator for the trolley carrying the specimen to be rolled inside.

A fixed beam is secured to the upper part of the simulator along the vertical axis. This beam is capable of sustaining a load of up to 7 tons.

In addition, the chamber is equipped with an inner lighting system, a ventilation system and with a number of servicing platforms to access the satellites and the electrical feedthroughs.

3.3 Pumping System

- Rough pumping : two parallel pumping chains with a total flow rate of 12000 $m^3.h^{-1}$.
- Cryogenic pumping : two 15 K pumps including shut-off valves and delivering a flow rate of 100 000 $l.s^{-1}$ at 10^{-6}mbar.
- Turbomolecular pumping : one pump including shut-off valves and with a flow rate of 5000 $l.s^{-1}$ at 10^{-6}mbar.
  The turbomolecular pump is also used for leak detection with Helium .
- Cryogenic shroud : one cryogenic shroud of 16 m^2 filled with LN2 being used for the pumping of outgassing flows.
- Operating pressure : $P < 4.10^{-6}$ mbar.
- Elapsed time from atmospheric pressure to operating pressure : 6 hours.
- Recovery time from operating pressure to atmospheric pressure : 1h 30 (min.) or 8 hours (nominal).



Pressure Profile

3.4 Thermal Shrouds

The shrouds are made of stainless steel and have an inner diameter of 9 meters.

- Emissivity > 0.85 (at ambient temperature).
- Absorptivity > 0.95 (at ambient temperature).

Under the gaseous nitrogen configuration, the system offers the following performance capabilities :

- Temperature range : 100 K to 360 K (temperatures regulated with gaseous nitrogen).
- Regulation drift : 1 K/h.
- Regulation accuracy : ± 3K over the whole range.
- Temperature uniformity for the thermal shrouds : 10 K (stabilized temperature).

With a view to achieve temperature uniformity, the shrouds are partitioned into 17 zones, each having its own flow control loop.

- Variation speed (up or down) : 60 K/h.
- Power capacity : 25 kW.

Liquid nitrogen(optional) :

When filled with pressurized liquid nitrogen, the system's power capacity is 150 kW.

3.5 Platform

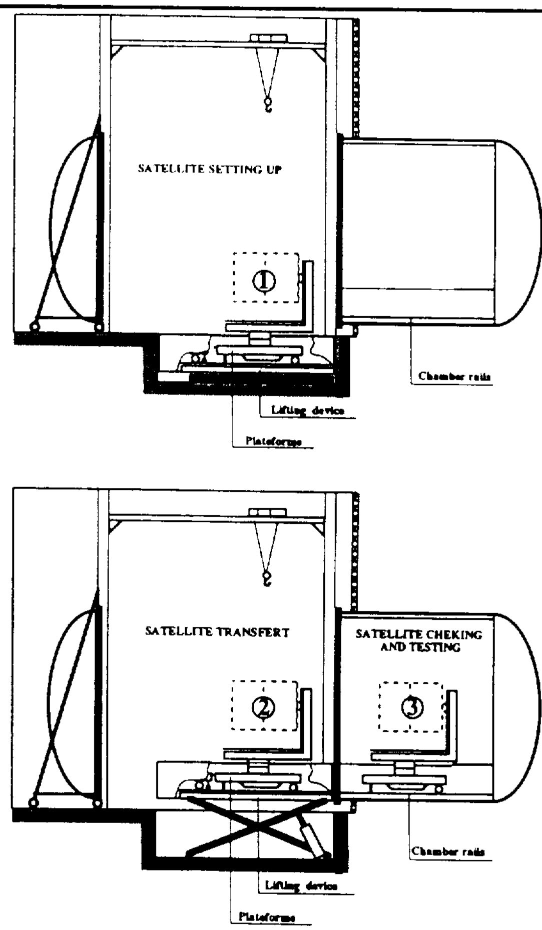
In the process of being tested, the specimen is placed inside the simulator on a platform (see schematic diagram) possibly equipped with a horizontality table and a specific leveling arm. In order to have the specimen placed inside the simulator, the platform is first installed on a lifting device and the specimen mounted on the platform. The lifting device raises the platform rails at the same level that the rails integral with the chamber so as to have the platform rolled inside the chamber.

The principal characteristics of the platform are as follows :

Specimen mass :

- vertical axis : 4000 kg
- horizontal axis : 2500 kg
- cog : 2 m above the interface plane
- interface plane horizontality (to be adjusted during the test) :
  - . accuracy : 0.5 mm/m
  - . range : ± 30 mm/m.

The platform is covered with thermal shrouds so as to ensure temperature homogeneity inside the chamber.



Platform Principle

3.6 Integrated Control and Measurements System

In conjunction with this new simulator, the necessity for improvement of the thermal measurements systems has been appearing with the following objectives :

- Use of modular acquisition means so as to satisfy the need for adapting the measurements capacities to customers' requests.

- Use of new generation computing means to meet various needs such as :

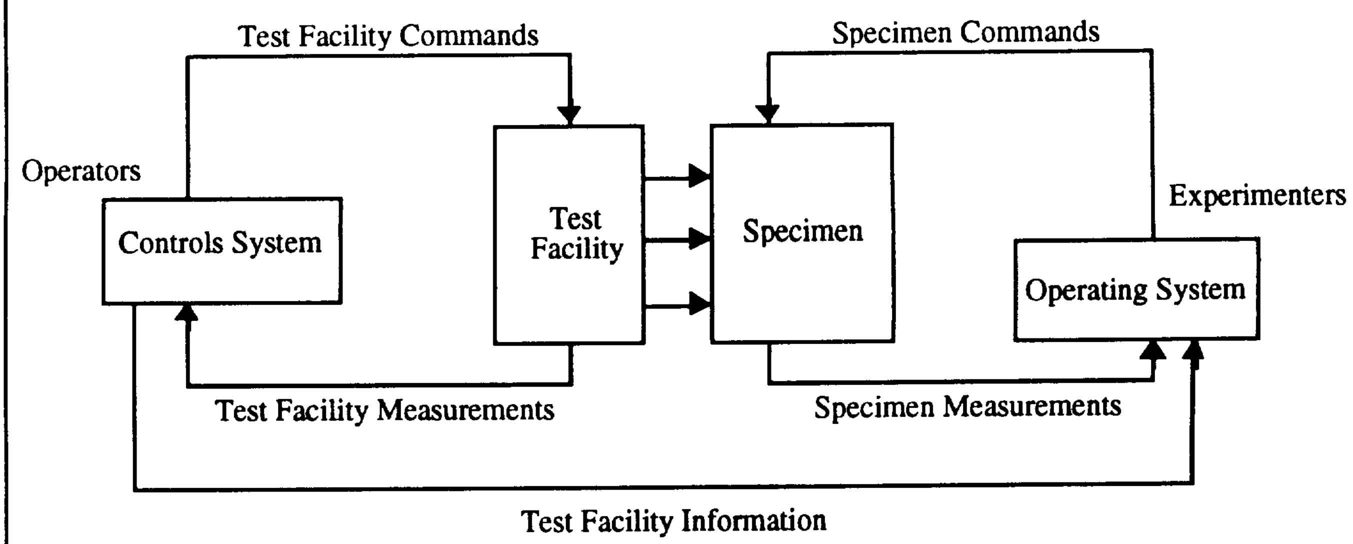
  • improved performance capabilities,
  • improved reliability,
  • reduced maintenance costs,
  • maximized test facilities /equipment park.

- Use of standards as an operational system and man-machine interface so as to minimize software maintenance and to reduce training.

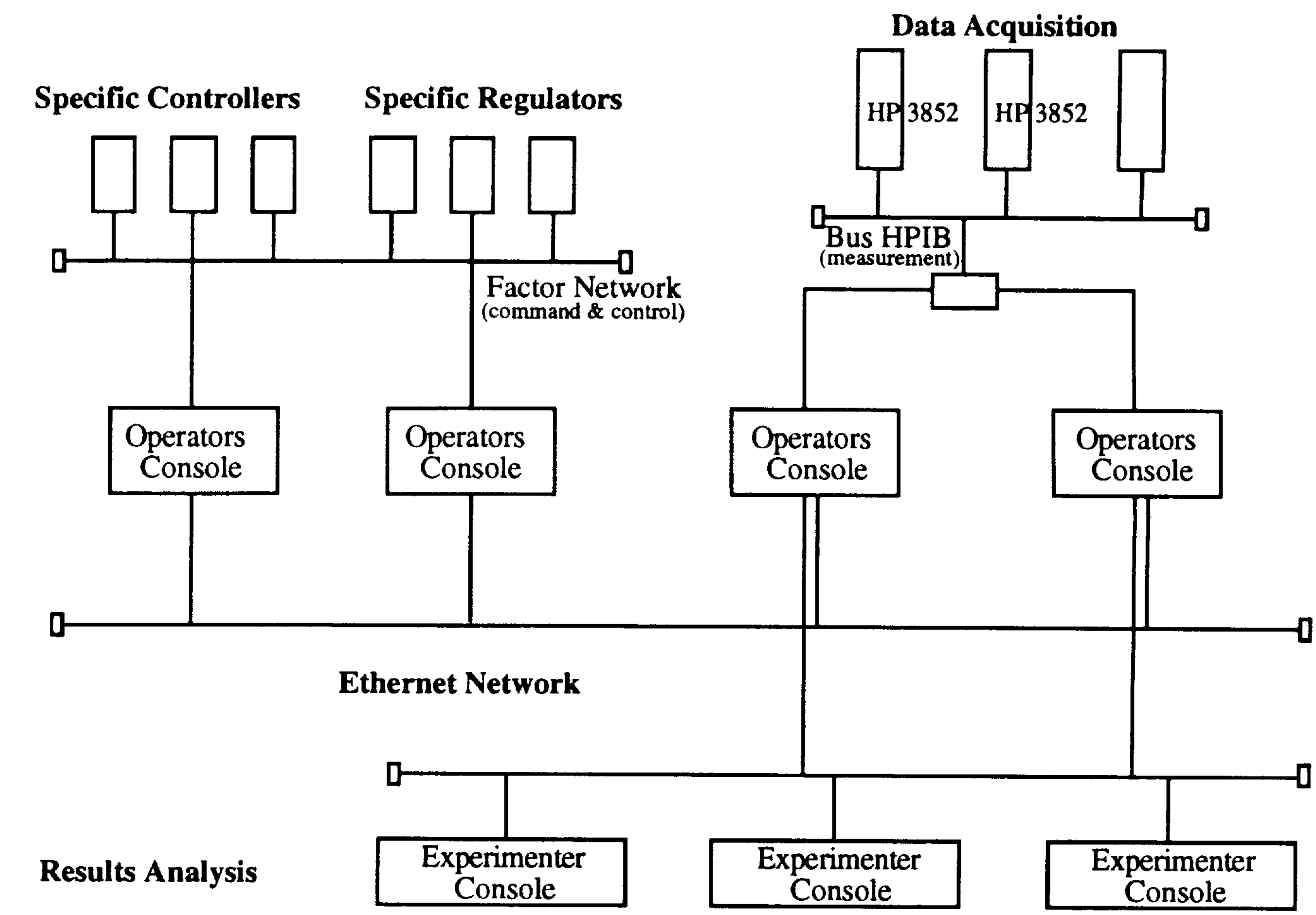
- Having the computing means made available to the customers for test preparation so as to reduce the duration of this phase, to verify the data inputs, and to reduce the test costs.

- Having the software for management and analysis of the test results made available for real-time operation. This, in order to improve the test effectiveness and thus, to reduce its overall cost.

All the technological choices retained as associated with the defined requirements has led to considering a new concept for an integrated test facility based upon the observed operating philosophy of the thermal vacuum test facility.



Operating Philosophy of the Thermal-Vacuum Test Facilities



Block Diagram of the Control and Measurement System

At data acquisition level are present either programmable automatic systems or regulators or else, acquisition systems HP 3852. Also note the two dedicated buses, one for command and control -i.e. Factor network- and the other being specific to measurements -i.e. bus HP-IB. At monitoring level, there are the operator consoles. These consoles are linked one to another via the monitoring Ethernet network. Thanks to this network, the consoles are standardized and thus provide for redundancy among themselves. Finally, at operations level, there are the experimenter consoles linked to the measurements operator consoles and also one to another via the Ethernet network for results analysis.

4 - CONCEPTUAL DESIGN

The new test facility has been designed in response to the basic objective of limiting operation costs. To this end, the overall conceptual design to be satisfied has been defined as follows :

- Restriction of the mission assigned to the simulator to thermal-vacuum tests of satellites for the purpose of acceptance only.
- Connection of the simulator to other test facilities under one and a same roof.
- Choice of proven technical solutions.
- Ensuring mechanical and electrical compatibility with the other existing thermal vacuum facilities.
- Ensuring operations flexibility and, more specifically, for pre-test setup operations of the specimen to be tested.
- Reduction of the time required for the pumping down process.

The following is a detailed description of the technical choices which have been prevailing at the time of the construction of the SIMMER facility.

4.1 The Chamber

- The concept of a chamber in the horizontal position permits accessibility to the satellite by the experimenters as per the determined test configuration for the purpose of functional checks prior to and following the test.
- The minimization of the section of the simulator in the clean area means a reduced surface of the clean area and is thus reflected through investments and operations savings made in terms of air-conditioning and required power.
- The clean area is connected to the other areas of the integration and test complex. For this reason, the satellite secured on the integration trolley can be easily transferred from one test facility to another.
- The initial location of the upper beam and of the horizontal rails for rolling the trolley permit simple solutions to be considered for setting up the mechanical installations needed for the tests (i.e. mounting of anechoic loads, unloading devices, ...).
- The overall layout of the building plus its manufacturing specificity permit possible extensions of the simulator from its rear section to be considered.
- The "experimenters" room located in the first floor of the building contains the control stations of the satellite. The windows placed on the partition between the experimenters room and the test facility area open onto the feedthrough plates placed on the chamber and are one meter distant from the feedthroughs. The cablings are thus reduced to a minimum.

4.2 The Pumping System

The solutions retained are the result of considerations on the operation costs and ease-of-use of the facility.

- The solution consisting of two parallel primary pumping systems of smaller dimensions has been preferred to the installation of a single larger primary pumping system. In case of a failure, the test is not interrupted during the time needed for repairing.

- The turbomolecular pump has been dimensioned so as to pump light gas. This pump is however also used during two basic phases of the life of the test facility :
  . For decontamination of the simulator, for which two auxiliary pumping means only are used, that is the turbomolecular pump and the LN2-filled cryogenic shroud.
  . For leak detection on the simulator, the pumping speed of the turbomolecular pump generates a brief response time from the moment of the virtual detection of a leak and the moment of its recording on the leak detector.

- The cryogenic shroud consists of a non-expensive and yet highly effective pump for the outgassing products from the specimens being tested. For satellites of the SPOT dimensions for example, a significant amount of outgassing flows are released at the beginning of the test. The later are water vapors but also outgassing products such as paintings (e.g. toluene), pottings, cablings, honeycombed structures-induced leakages, wave guide, and the like. The cryogenic shroud pumps these flows and thereby prevents contamination of the cryogenic pumps.

4.3 The Thermal System

- *Gaseous nitrogen circulating in the radiative shrouds :*

  The gaseous nitrogen option has been retained versus the liquid nitrogen circulation on account of the advantage in terms adaptability to meet specific test requirements. Note that the essential role assigned to the simulator is to perform acceptance tests for satellites, that is, to reproduce on the equipment the extreme temperatures as encountered in flight and not to verify the thermal subsystem of the satellite.

- *Extensibility :*

  The specified power of 25 kW is largely overdimensioned. The energy dissipated by a satellite is approximately 3 kW. A noticeable margin is thus available permitting thereby to take into account dissipative test devices (internal anechoic loads, temperature-maintained wave guides) and additional simulators (stimulis, IR grids, etc. ...).

  The simulator shrouds, the input and output collectors, the regulation valves are so dimensioned as to supply the simulator with circulating liquid nitrogen through the addition of a specific generator. In this case, a power of 150 kW can be absorbed, thus allowing a new type of simulation process.

4.4 The Platform

A specific trolley provides the interface between the specimen and the simulator. The liftting platform on which is installed the specimen facilitates the loading of the satellite and its positioning inside the simulator.

During the preparation or the post-test phase, the platform is used to position the satellite at floor level in the preparation hall and to facilitate experimenters access to the specimen.

4.5 The Control and Measurement System

To control and monitor this facility a new concept has been developped : an integrated measuring-control and monitoring system.

This new concept is based on :

- A computer network using UNIX operating system and X-WINDOWS as operator interface.
- A process supervisor software which controls the test facility, the process measurements and test article measurements.
- A dedicated software for test data analysis connected with a data base feeded on-line by the supervisor. This software has the capability for the operator to have access to whatever measurement channel to do visualization, computations or comparisons. All these actions are updated as long as the acquisition is activated and can be made with previous measureements saved in the data base (i.e. measurement on other test articles.

This new concept allows :

- An improvment of the characteristics of the control and monitoring system by a clear division of the various functions.
- A standard operator interface for the softwares, so a reducted training and a least specialization of operator.
- A feasibility of delocalization of control room, due to the computer network therefore a possible cost reduction.
- An improvment of reliability due to standard software and hardware.
- A new capability for test team : on-line visualization and data analysis of measurement.

5 - CONCLUSION

The SIMMER embodies the voluntarist strategic choice made by INTESPACE to position the company on the commercial market of application satellites.

The simulator represents a long-term investment viewed to be operated over a period of more than 30 years and as a complement to INTESPACE's integrated test center.

Availability- and operation costs-related considerations have guided all the technological choices.

The SIMMER offers to INTESPACE's European and worldwide customers a highly effective and competitive solution as regards thermal tests for acceptance of medium and large satellites.