Direction des **S**ystèmes **O**rbitaux
Sous-Direction **E**tudes Systèmes et **D**éveloppements
Division **Ma**rs Premier

2007 ORBITER

PRELIMINARY DEVELOPMENT PLAN

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ABSTRACT

This document presents the different phases of the 2007 Orbiter development, the philosophy of engineering, models and testing, the deliverables from NASA and CNES and the overall schedule.

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Table of contents

Appendix 1: schedule

List of tables and figures

TBC and TBD lists

TBC:

TBD:

Acronyms

Acronym	Signification
AOCS	Attitude and Orbit Control System
BM	Bus Management
CFE	Customer Furnished Equipment
CLA	Coupled Launch Analyses
CNES	Centre National d'Etudes Spatiales
EGSE	Electrical Ground Support Equipment
FDIR	Failure Detection Isolation Recovery
FUMO	FUnctional MOdel
GSE	Ground Support Equipment
MIM	Mechanical Interface Model
MOI	Mars Orbit Insertion
NASA	National Aeronautics and Space Administration
OBIS	Orbiter Bus Interface Simulator
OBSO	Orbiter, Bench, System, Operation
OBT	On Board Time
OFM	Orbiter Functional Model
OS	Orbiting Sample
PFM	Proto-Flight Model
RSC	Rendezvous Sample Capture
SCATS	Sample Capture and Transfer System
SDB	System Data Base
SM	Spare Model
SPL	Science PayLoads
SSM	Solid State Memory
STM	Structural and Thermal Model
STPM	"Orbiter" Structural Thermal and Pyrotechnic Model
TBC	To Be Confirmed
TBD	To Be Defined
TC	TeleCommand
TM	TeleMetry

1 SUBJECT

The scope of this document is to define a basic approach to develop the "Mars Premier" 2007 Orbiter.

That covers the different phases from the design to the integration and tests.

The mission, planned for 2007 has for mains objectives:

- to carry and release the four NetLander probes and then support them as a telemetry relay,
- to demonstrate the Mars Sample Return rendez-vous in Martian orbit.
- In addition the orbiter will carry some scientific payloads.

The 2007 orbiter will be launched by an ARIANE 5 launcher.

For this mission, certain elements will be supplied by CNES or NASA under CNES interface. They are called Customer Furnished Equipment (CFE).

Due to the context of co-operation between NASA and CNES and the several Customer Undertakings in term of engineering inputs and Customer Furnished Equipment (CFE), a particular attention shall be paid to milestones where mutual deliveries are necessary.

2 ORBITER PRESENTATION (FLIGHT SYSTEM)

2.1 GENERAL

The 2007 Orbiter is mainly composed of:

- a two-stages bus and equipment units related to the mission,
- the four NetLander probes attached on the first stage of the bus,
- the RSC (Rendezvous Sample Capture) including the Rendezvous sensors, the Capture Cone and possibly the Transfer System (**TBC**),
- Several scientific payloads (2 ; **TBC**),
- an UHF package dedicated to telemetry relay in Martian orbit (including NEIGE experiment).

2.2 ORBITER BUS

The bus has two stages, the first one being mainly the carrier of the four NetLander probes.

The second stage is the main stage and carries the major equipment, including the main payload RSC supplied by NASA under CNES interface. All payloads and equipment units supplied by CNES to the prime contractor are called CFE (Customer Furnished Equipment). The CFE are:

- the UHF package and NEIGE experiment (supplied by NASA),
- the RSC payload (supplied by NASA),
- the scientific payloads.

3 INTERFACES

The interfaces to be addressed are between:

- the Orbiter and the Netlanders, covered by a CNES/CNES ICD,
- the Orbiter and the RSC, covered by a CNES/NASA ICD,
- the Orbiter and the UHF package (ELECTRA), covered by a CNES/NASA ICD,
- the Orbiter and the NEIGE experiment covered by a CNES/NASA ICD,
- the Orbiter and each Science payload, covered by a CNES/ (**TBD**) ICD,
- the Orbiter and the Launcher, covered by a CNES/ARIANESPACE ICD
- the Orbiter and the Ground Segment, covered by a CNES and NASA ICD's.

4 RESPONSIBILITIES

CNES is responsible for the development of the complete Orbiter, from the design to the Final Acceptance and Flight Readiness.

CNES is responsible for the development of all CFE and shall deliver them to the orbiter Prime Contractor, after a complete Qualification and acceptance.

NASA is responsible for the development of the RSC and some equipment units and shall deliver them to CNES for a final integration in the Orbiter, after a complete Qualification and Acceptance at NASA level.

NASA and CNES shall be jointly responsible for testing and demonstrating the compliance between Orbiter ICD and the Ground Segment.

5 TARGET AND DEVELOPMENT PHASES

5.1 2007 ORBITER MASTER SCHEDULE

All dates and duration indicated in the here after table are (**TBC**) by the prime contractor.

Phases	Main activities	Duration (months)	Start	Complete
Compl. study	**Preliminary design (feasibility)**	**2**	**02-2002**	**04-2002**
B	**Preliminary design**	**12**	**10-2002**	**10-2003**
	PDR review	-	-	10-2003
C	**Consolidated Design**	**20**	**10-2003**	**06-2005**
	CDR review	-	-	06-2005
D	**FM fabrication and procurement**	**20**	**06-2005**	**03-2007**
	Orbiter PFM AIT	14	12-2005	02-2007
	Orbiter PFM Acceptance review		-	03-2007
	Margin	3	-	-
	Launch campaign	3	06-2007	09-2007
	Orbiter PFM delivery	-	-	09-2007

Table 5.1-1 : Orbiter master schedule

The Flight Model of the Orbiter shall be delivered on launch pad after the final acceptance review. A preliminary acceptance review shall be issued at the end of Orbiter PFM tests.

5.2 PHASES AND REVIEWS

5.2.1 Definition and preliminary design phases

*There are 2 main phases:

Complementary study :

During this two months phase, the industry will be involved. Two industrial studies will be performed in parallel. The objective of that phase is to improve the definition of the Orbiter and interfaces. This set of requirements shall be the baseline inputs for the Final Request For Proposal.

Bidding Phase

The bidding phase will take place from May 2002 to September 2002. The Prime Contractor will be selected during this phase.

Phase B :

This phase shall be conducted by the selected Prime Contractor who shall improve the level of definition of the Orbiter and then, shall start the preliminary design activities in coordination with some sub-contractors. The ICD's may be updated but always under the Change Control Process which guarantees a mutual agreement between NASA and CNES after an exhaustive assessment of the different impacts (cost and schedule). That phase ends with a Preliminary Design Review (PDR) at the Orbiter level and possibly some PDR'S at equipment level.

5.2.2 Design, Fabrication and Procurement phases

Phase C:

During that phase, the design of the Orbiter is completed and validated by Analysis and Tests with Development Models and Test Beds. The process shall be different for each equipment and shall be function of its state : recurrent and qualified, recurrent but with a delta-qualification to be done, existing to be modified, to be designed from scratch. At the end of this phase, the different Critical Design Reviews (CDR's) shall take place (equipment units and Orbiter levels). These reviews shall be mandatory (deviations to that rule may be assessed case by case) to authorise any fabrication or procurement of Flight Hardware. The exceptions are the structure and the thermal control. The manufacturing of the protoflight structure will be anticipated during phase C to build up a Structural Model (with dummy equipment units) which will be tested at qualification level. This model will then be equipped with the Thermal Control sub-system for thermal validation test.

Phase D:

This phase is dedicated to :

- the fabrication and procurement of all the Flight Hardware,
- the integration of the Orbiter Proto-Flight,
- the Flight Software
- and then all the process of qualification to environment up to the final Acceptance and delivery.

Launch Campaign:

The launch campaign duration to be taken into account is 60 working days (~ 3 months).

6 PHILOSOPHY OF ENGINEERING

6.1 MECHANICAL & THERMAL ENGINEERING

Mechanical

During the complementary study (after the renunciation of aerocapture), a first analysis at Orbiter level shall be done in order to determine the sizing loads for the different element of the structure. For the interfaces: preliminary mechanical environment of ESA ECSS-E10-03 Shall be applied for Netlander, RSC, Science Payloads and other CFE. These requirements shall be used for the initial design of these elements. A mathematical model corresponding to the preliminary design of these elements shall be delivered to the ORBITER Prime Contractor 6 months before the PDR (at least).

During the phase B, the analysis at Orbiter level is consolidated by some analysis at lower level (RSC, tanks and Electronic Modules…). Then, the models of Netlander, RSC, Science Payloads and others CFE will be assembled with a phase B mathematical model developed by the ORBITER Prime Contractor, who performs the necessary analyses to establish the preliminary design justification file. An update of Netlander, RSC, Science Payloads and other CFE specifications will be released during phase B based on the results of these analyses. A CLA with Ariane 5 should be performed. The objective of that CLA, based on preliminary design, will be to consolidate specifications.

During the phase C, the elements of the structure are manufactured and tested. A second CLA, using the final design NASTRAN model, could be perform at this level to consolidate notchings for Orbiter STPM tests (**TBC**).

On Orbiter STPM structure, models of other equipment units shall be integrated (Orbiter STPM Test campaign) and shaked at qualification levels. A model of CFE (STM model) will be delivered by CNES. The results are used to correct and/or tune the Orbiter mathematical model (which is used then to verify the environment of each equipment) and to identify, if necessary, the need of some secondary notchings. This verification is co-ordinated with a new-coupled analysis with the launcher. This final CLA is dedicated to consolidate notchings to be applied for Orbiter PFM tests. A fit-check test is foreseen between the PFM structure and a RSC mechanical interface model, at the beginning of phase C.

The phase D analyses shall be dedicated to PFM test predictions and mathematical model correlation.

Finally, during the Acceptance Tests, the PFM (completely integrated) shall be vibrated (sine and acoustic) at proto-flight levels (qualification level, acceptance duration).

Interface control

Preliminary geometrical ICDs shall be issued at the end of the complementary study (after the renunciation of aerocapture) for all CFE (allowable volume and interface points locations). These ICDs shall be refined during phase B, when configuration monitoring will begin.

A particular attention shall be paid on the mass, inertia and CoG properties of payload, passenger and equipment properties throughout the development.

Thermal

The approach will be similar to mechanical engineering :

The STM thermal balance test will be used to verify the overall thermal control, to tune the Orbiter thermal model and to consolidate flight temperature prediction at equipment level.

Sun simulation could be not necessary if hot spots are avoided by Orbiter geometry (concave surfaces).

Finally, the qualification is stated by a Thermal Vacuum test with the completely integrated Orbiter (PFM).

6.2 MECHANISMS ENGINEERING

Mechanisms and actuators shall be qualified before implementation on STPM Orbiter. Pyrotechnical actuators shall be fired at STPM level

6.3 PROPULSION ENGINEERING

The propulsion sub-system will have a classical development phase including PDR and CDR.

The qualification of individual equipment item (propellant tanks, thrusters, …) will take place before CDR of propulsion system.

Sub system tests will be focused on hydraulic purpose (pressure drop, waterhammer ….) on a representative mock up .

Participation to the STPM orbiter is the first connection between propulsion system and orbiter. It will allow checking thermal and mechanical loads on the propulsion equipment items. This model, which will be flight representative for piping routing, will also be used to prepare and valid integration procedures (connections, welding, cleanliness…) and calibration of the feed system.

6.4 ELECTRICAL ENGINEERING

The Power Budget is updated all along the development phases and particularly after the different reviews at equipment level (PDR, CDR) and is checked with regard to the Power Supply sizing and the different protections (fuses, limiters, circuit breakers).

During the phase B, some analyses are performed concerning:

- the electrical behaviour of power and data bus,
- the robustness of the architecture,
- some EMI/EMC predictions,
- the radiation by sector of the Orbiter,
- the antenna diagrams.

For the antenna diagrams, some tests shall be performed also with a RF-mock-up.

During the phase C, some pre-qualification electrical tests are done, using Engineering Models of equipment, in the test-bed so-called OFM (Orbiter Functional Model) (see also § 9 and 10). So, CNES shall provide the Prime Contractor with Engineering Models of the CFE, including some spares.

6.5 RENDEZVOUS AND AOCS ENGINEERING

The Rendezvous is globally under the NASA responsibility. However, the interfaces with the Orbiter are so complex, particularly for the Attitude & Orbit Control System, that some joint engineering has to be performed.

During the phase A, a baseline of sharing has been agreed between NASA and CNES:

- CNES (via the prime contractor) is responsible of the absolute navigation and of the piloting & control,
- NASA is responsible of the relative navigation and of the guidance.

During the phase B, the strategy and algorithms shall be developed, using intensively digital simulations. They shall be tested intensively in *a rendezvous (& AOCS) simulator*, which shall be at that time mainly software-based. This simulator/test-bed shall be set-up on both sides of the ocean and an exchange of data (navigation, guidance and control models) shall be done, accordingly to respective responsibilities. A using of common tools (such as Mathlab) shall make the exchanges easier.

During the phase C, a pre-validation is performed with one or two other test-beds, with progressively more and more hardware-in-the-loop. These two test-beds are :

- The AOCS/Rendezvous test-bed (see also § 11),

- The Spacecraft test-bed (OFM), which is close to an Electrical & functional Model but the integration of equipment in a right structure/topology.

  The performances are validated by step:

- at the equipment level, mostly for sensors and actuators,
- at the rendezvous test-bed level, for the algorithms and associated software (navigation, guidance and control), probably in parallel in France and USA,
- at the Spacecraft test-bed level, for the complete system in closed-loop but with a simulated environment,
- at the PFM level during some partial performance tests.

6.6 SOFTWARE ENGINEERING

During the phase A, the study of the Software Development Environment (SDE) shall be started and shall be consolidated during the phase B.

During the phase B, the preliminary design shall be performed. The rendezvous part shall be performed by the US side with a strong interface over the ocean (see previous §).

During the phase C, the detailed design shall be performed and the CDR review shall authorise the coding and testing over the phase D.

The different test beds for the Software are:

- debuggers and open-loop test tool in the Software Development Environment (Unit Testing),
- the Software test-bed including medium-fidelity simulations for closed-loop testing,
- the rendezvous/AOCS test-bed,
- the Spacecraft test-bed used as a System test-bed with none or some hardware-in-the-loop,
- the Operational System test-bed (BSO) for the Ground Segment.

6.7 COMMAND/CONTROL AND OPERATIONS ENGINEERING

During the phase A, a concept of Command and Control of the Orbiter shall be defined ("operability", modes, autonomy, FDIR, etc…), in co-ordination with the Ground System.

During the phase B, the Plan of Measures and Commands and the ICD with the Ground System (in co-ordination with Software Engineering) are set up and presented at the Equipment PDR's and Orbiter PDR reviews.

During the phase C, a preliminary version of the Operations and User’s Manual is written and delivered at the CDR review to the Ground System.

During the phase D, the coupling of Software and Hardware on both the « OFM» and the PFM models shall verify via only the « natural » links (Telemetry and Telecommand):

- all the "observability" and "commandability" of the spacecraft,
- all the Mode Diagram (modes and transients between modes), including the contingencies (FDIR) .

6.8 PLANETARY PROTECTION ENGINEERING

During phase A, planetary protection requirements impacts shall be assessed in order to define the associated validation plan.

In addition to cleanliness plan, planetary protection plan shall be early defined and associated budget established.

During phase C or earlier in phase B some technological and process assessment/validation shall be performed in order to consolidate plan and budget.

7 PHILOSOPHY OF MODELS

The basic approach is as follows:

- *Spacecraft OFM (Orbiter Functional Model)* : an electrical and functional verification is performed with models of equipment simply connected on the OFM. These models are breadboards or engineering models and must be electrically representative of the flight models. Some simulators will be used for performance measurements and environmental simulations. The real topology is not respected. Numerical simulators could temporally replace engineering Models.

- *STPM* (Structural Thermal and Pyrotechnic Model) : a Structural Thermal and Pyrotechnical Model of the ORBITER will be build up. It will consist in a structure fully representative of the PFM, equipped with fully representative thermal control hardware. A typical constitution of the ORBITER STPM could be as follows:

-

Sub-system	Model
Structure 2nd stage	PFM (*)
Structure 1st stage	PFM (*)
RSC	STM
Netlander probes	1 STM + 3 MIM's
Other CFE (incl. Science Payloads)	STM or Dummies (**)
Antennas	**TBD**
Solar Array	**TBD**
Avionics equipment and sensors	**TBD**
Propulsion	**TBD**

Table 7-1 : Orbiter STPM

Dummies (or MIM) = Mock-ups which have to be representative in terms of mass, CoG, thermal dissipation, thermal and mechanical interface, and - for larger items – structural dynamic behaviour below 150 Hz.

(*) After the STPM test campaign, this hardware shall be upgraded to be used for the ORBITER PFM (static test shall be defined to avoid structure oversizing)

(**) STM or Dummies function of the complexity of elements.

- *PFM* : (Proto-Flight Model)

The final functional, electrical & environment qualification is performed with the PFM.

So, the Orbiter for 2007 mission is a Proto-Flight Model and is called PFM. That means:

- the qualification to the environment (mechanical & thermal) shall be performed with the same structure than for the flight. At the beginning of the protoflight mechanical and environment test campaign, the PFM shall be in its final flight configuration. If one of this item is not present during PFM tests, it should be replaced by a fully representative QM or STM.

- the qualification to EMI/EMC at the Orbiter level shall be performed (only) with the fully integrated PFM model. Of course, all equipment shall have been qualified individually to EMI/EMC with a large margin w.r.t the Orbiter level.

8 PHILOSOPHY OF VALIDATION

8.1 GENERAL

The verification program is dedicated to ascertain, from model philosophy, that the flight hardware and software delivered to launch will be capable to fulfil successfully the assigned mission objectives.
The verification process will start early in the development phase to demonstrate by analysis and evaluation the expected performance, the design feasibility and the compliance to requirements. The approach to be followed for the verification of the orbiter design against the specified performance requirements will be governed at prime level by a single document, which is the Verification Plan. *A preliminary verification plan (main requirements) is requested (mandatory) at the beginning of phase B.*

8.2 VERIFICATION APPROACH

The verification program covers all on-ground tasks up to the final flight acceptance review of the PFM.
The orbiter industrial Prime Contractor shall have the full responsibility for all verification activities from units to system as far as the orbiter is concerned. Responsibility for the overall flight system end to end verification will be shared with CNES because of the significant role of customer furnished items, which are NetLander, RSC and science payload, and customer furnished expertise for some critical mission aspects and phases (rendez-vous).

The verification program deals with all aspects of the flight hardware and software, the mechanical and electrical ground support equipment and any associated equipment required fulfilling the verification program objectives. This program shall consider the design risks, the availability and accuracy of analytical tools, the availability and capability of facilities, the test method and implementation cost, the schedule, and the confidence in the verification approach.

The verification activities will meet the following objectives:

- ensure a consistent approach to development qualification/acceptance from unit level to orbiter flight system,
- provide to CNES full visibility with regard to the compliance of the delivered hardware and software with the specified requirements,
- introduce the verification concept at the early design stage in order to ensure consistent specifications at any levels,
- select at an early stage of the program the most cost effective approach,
- optimize the design and use of GSE
- systematic "traceability" off all requirements at each verification level,
- Identification of impacts at the various levels in case of change of requirements or criticality during lower level verification,
- Integration into the higher level of the lower level verification data.

9 PHILOSOPHY OF TESTS

9.1 GENERAL

We may identify three groups of tests, whatever the level is (equipment, assembly/module, or Orbiter) :

Performance Tests:

The purpose is to check the different performances (including functional) of the equipment with respect to the specifications. This kind of test is generally realised with a reduced and adapted (on-board) software and a partially simulated environment.

Software and System Tests:

The purpose is to check the real flight software and associated interfaces (hardware, Ground System), in a simulated environment but with scenarios close to the real operations, as well as to perform some global performance tests.

Environment Tests:

The purpose is to check the ability to withstand with the flight environment: shaking, thermal and thermal vacuum, EMI/EMC and Electrical compatibility (including Radio-Frequency).

9.2 STPM / PFM FOCUS

On the STPM:

Mechanical tests:

- mathematical model updating
- validation of the primary and secondary structures and of the main structural links, at qualification level, (with respect to the stiffness, quasi-static and sine requirements),
- confirmation of the requirements of the mains elements (Structure, Netlander probes, RSC, solar array, etc. with respect to the stiffness, quasi-static and sine requirements),
- confirmation of equipment units environmental specifications,
- measurement (or direct extrapolation) of shoch levels at all equipment units interfaces for differents pyroshock actuations. The objective will be to verify all interface shock level and to buid the Orbiter internal SRS transfer function matrices.

Thermal Tests :

- validation of thermal control performances and technologies,
- validation and updating of the mathematical prediction models,
- characterisation of radiative properties.

On PFM:

Mechanical tests:

- proto-qualification of the ORBITER at system level (qualification level, acceptance duration).

Thermal tests:

- validation of system functional performances in the operational thermal environment, and of the absence of performance degradation after excursions in the non operational thermal environment,
- Consolidate mathematical thermal model in a characteristic case (**TBD**).

A typical test matrix is described in the following tables:

System level	Thermal balance in vacuum	Thermal vacuum (functional cycles)	Modal	Sine	Random	Acoustic	Internal shocks	Launcher shock	Physical meas.
STPM ORBITER	X (2)		X	Q	--	Q (1)	X	X	X
PFM ORBITER	X	X	X	PQ (3)	--	PQ	X	-X	X

Sub-system level (assumption = PFM type development)	Thermal balance in vacuum	Thermal vacuum (fonctional cycles)	Modal	Sine	Random	Acoustic	Internal shocks	Launch shock	Physical meas.
RSC PFM	X	X	X	PQ	PQ	PQ (4)	X (5)	-- (5)	X
Science PL/Other CFE PFM	X	X	--	PQ	PQ	--	**TBD (5)**	**TBD (5)**	X
Netlander QM	X	X		Q	Q		X		X
Netlander FM		X		A		**TBD**	--		X

Table 9.2-1 : STPM / PFM tests matrix

A	acceptance test
Q	qualification test
X	to be performed
--	not required
Q	Qualification tests
PQ	Proto-qualification (qualification levels, acceptance duration)
TBD	to be determined

(1) If needed to improve acoustic response predictions. In which case a good "representativity" of equipment dummy interfaces on STM is mandatory.

(2) At STPM level, this test will only include a sun simulation if it is judged mandatory from a technical point of view.

(3) Primary notching based on QSL interface force criteria at flight level. For local responses, CLA predictions * 1.25 shall be reached.

(4) Acoustic test may only be necessary on RSC sled (**TBC**).

(5) a SRS envelope shall be defined taking into account internal and launch shocks.

10 PHILOSOPHY OF INTEGRATION

10.1 The ITP (Integration Test Plan)

Based on Performance Verification Plan, the Prime Contractor shall define in the ITP of all Orbiter models (STPM, OFM, PFM), the objectives and the common content of:

- Integration tasks,
- Each main test (reference, EMC, TV, etc.),
- Module test requirements & Test Requirements common contents.

Nota :

- Generic integration tasks could be defined in a separate "Generic integration plan",
- Module test requirements & Test Requirements common content could be defined in separate documents.
- ITP document shall be approved by CNES.

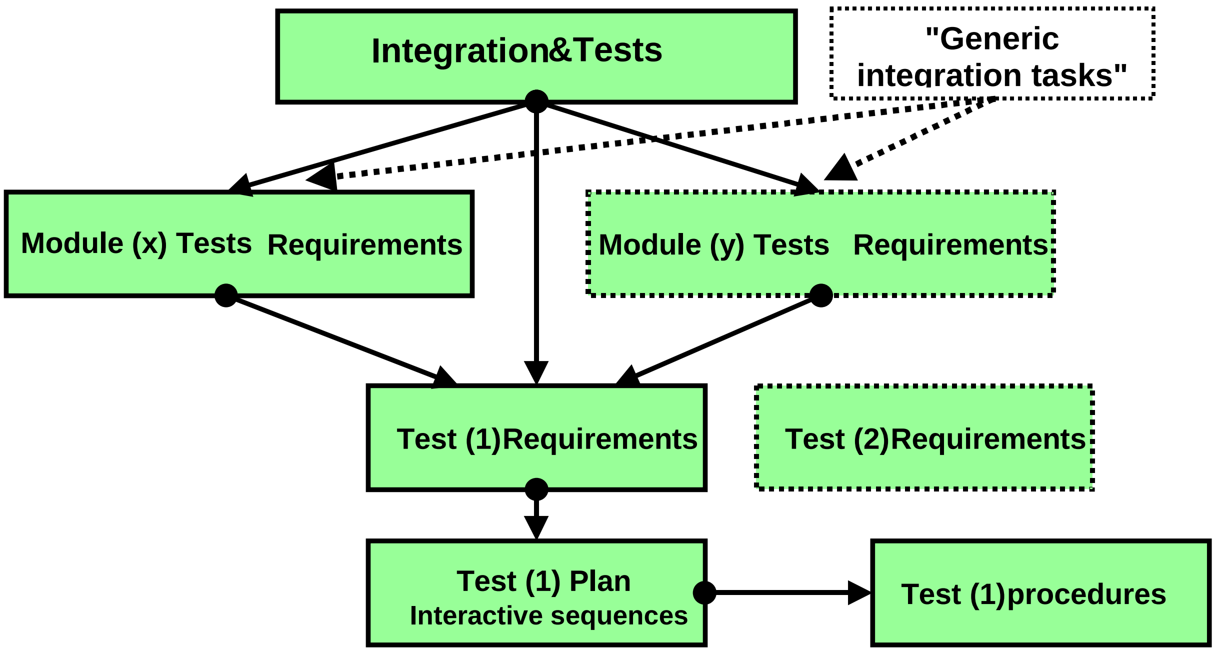

Figure 10-1: philosophy of integration

10.2 THE MTR (Module Test Requirements)

The content of MTR could be:

- for each task of ITP (each AIT sequence : integration, reference test, EMC, etc.) :the matrix of elementary tests to be performed,

- for each elementary test (ex : power consumption, performance, etc.), the definition of the test sequence : test objectives, command to be sent, TM to be checked , results presentation (graphics, trend analysis, etc.), simulators to be used, GSE, etc.

Note:

- CFE's MTR shall be provided by CNES,

- MTR documents shall be accepted by CNES.

10.3 THE TR (Test Requirements)

Based on ITP & MTR documents, Test Requirements documents shall be issued for each main test (phase C)

The content of TR could be a matrix of applicable tests of each module associated with the interactive sequence to be run (tests to be run in parallel, etc.).

Note:

- in order to minimise test duration, some elementary tests shall be associated in a global sequence (ex : power consumption, etc.),

- these documents shall be issued by the prime contractor and accepted by CNES.

10.4 KEY TESTS AT ORBITER LEVEL

Bio-contamination :

Planetary protection requirements shall be applied and verified during AIT activities. General rules could be early defined in the AIT development overview such as clean room environment, bioshield, main cleaning, etc.

The mains constraints for AIT, coming from planetary protection, are :

- First stage: as this stage will not crash on planet MARS (**TBC**), "forward-contamination" requirements are only applicable to what is necessary to avoid the cross-contamination between the first stage and the Netlanders.

- Mission stage: this stage is supposed to meet the crash probability requirement. So, bio-decontamination could be limited to release hardware and system intended to impact MARS surface. However, the potential cross-contamination between Mission and first modules shall be taken into account and overall equipment units and MLI external surfaces bio-cleaning could be necessary.

Integration : (equipment units, sub-assemblies)

Objectives:

- visual check of equipment or modules after transportation,
- mechanical and electrical fitting up of equipment or modules,
- check mechanical ICD(both side),
- check electrical ICD (using breakbox for C&I, grounding, polarity, etc.),
- functional tests and check of system database (inrush current, power consumption, TM transfer function, limits, etc.),
- check AIT software compatibility (first integration).

Reference Tests :

Objectives:

- check global functional/performances of the Orbiter as a reference before environmental tests,
- check global functional/performances of the Orbiter after environmental tests and prior to launch,
- all configurations shall be tested (Nominal, Redundancy, cross connections),
- ground simulators shall be used for sensors or specific functions.

« health » Tests :

Objectives:

- check global working (functional only) of the Orbiter as a reference before, between or after environmental tests,
- quick check (less than 2 days) using high level command and telemetry for functional check
- typical sequence could be an "autotest" of power consumption (using telemetry), main functional modes and « health test » of modules.

Alignment measurement :

Objectives:

- check global mechanical stability of the Orbiter as a reference before, between or after environmental tests,
- perform alignment and co-alignment measurement needed at module level and/or at Orbiter system level.

Environment Tests :

- EMC,
- Thermal Vacuum,
- Vibration.

10.5 RESPONSABILITIES SHARE FOR CFE AIT ACTIVITIES

CNES is responsible for delivery of all CFE. CNES shall provide:

- Equipment units (table 13-1).
- Transport and storage containers,
- Equipment units ICD.
- Acceptance Data Package and Log Book (End Item Data Package).
- User's manual.
- Handling and storage manual.
- Dedicated EGSE, MGSE, Bio-GSE (if necessary), simulators (if necessary) and associated user's manual and procedures.
- Module Tests Requirements (common content defined by the Prime Contractor, requirements accepted by the Prime Contractor).
- If necessary, procedures run at equipment level as help.

Tests using dedicated EGSE:

All functional/performance tests (if needed) performed on CFE using only dedicated EGSE shall be performed by CNES (or CFE responsible) under CNES responsibility and procedure. The Prime Contractor will provide space and electrical power in clean room or test station room for EGSE and operators.

Integration: (STPM, OFM, PFM)

The Prime Contractor is responsible of all AIT procedures and performs mechanical and electrical integration of all CFE in accordance with requirements. During these activities a permanent support of CFE representative and/or CNES shall be provided to the Prime Contractor.

Performance and environmental tests: (OFM, PFM)

The Prime Contractor shall co-ordinate all performance tests activities and write associated procedure and test sequence at Orbiter level. CNES and/or CFE responsible will provide: procedure and operators for dedicated EGSE, simulators, and etc. and real-time expertise. The Prime Contractor will provide tests activities reports. CNES will provide tests performances reports (or contributions to a global performance report: OFM) and contributions to Test Review Board.

Health tests: (OFM, PFM)

The Prime Contractor could be authorised to perform CFE health test without any CNES support. (**TBC** for each CFE).

System tests with the Ground: (PFM)

CNES will be responsible for all system tests (Technical and Operational Qualification). The Prime Contractor shall provide support as required and write associated procedure (Orbiter configuration set-up).

Non Conformance Report: (STPM, OFM, PFM)

The Prime Contractor will issue all NCR during AIT activities. CNES will provide support and expertise for NCR treatment and closure. (See Product Assurance requirements).

11 TESTBEDS AND GSE

11.1 IDENTIFICATION

The major identified test-beds and benches are:

- the rendezvous & AOCS test-bed: the rendezvous part shall be provided by NASA and the complement for AOCS purpose by CNES. It shall be located in the prime contractor premises and this test-bed shall be partially or totally (rendezvous purpose) duplicated in Pasadena.
- the Software test-bed , which may have two parts:
  - First, embedded in the Software Development Environment for Unit testing,
  - Second, with medium-fidelity simulations for closed-loop testing (see the so-called Baby Bed from NASA).
- the Spacecraft Test-bed which is the System Bench,
- the Operational System Bench (OBSO) for the Ground System.

The two main EGSE are those for the Spacecraft Test-bed and the one for the integration and test of the PFM model.

11.2 COMMONALITIES

The test-beds and Ground Support Equipment shall have a lot of common functions and commonalties:

- command and Control (Telemetry and "Telecommand", Test Sequencer),
- software simulators (environment, flight dynamics, interfaces, …),
- front-ends for HW-in-the-loop,
- stimulators (for sensors),
- image processing (camera),
- storage and processing of data,
- …

The schedule of activities shall determine the number of equipment to duplicate or to be used on a time-sharing basis.

12 PRIME CONTRACTOR DELIVERABLES

The table here after indicates the main items to be delivered by the Orbiter prime contractor. Delivery dates are coming from MARS PREMIER system master schedule including system test and Ground System development.

Phase	*Item*	*Delivery date*
B	Temperature at CFE interfaces.	t0 phase B
B	Reduced radiative and thermal mathematical models for CFE interfaces (RSC, **TBC** for SPL)	t0 phase B +3 months
B	Orbiter 1553 Bus Interface Simulator (OBIS) (1553 hardware + bus protocol)	PDR
C	Orbiter/RSC Interface Numerical Simulator	08-2004
C	System Data Base (SDB_draft)	10-2004
D	OBSO_V1 including LV1 software and SDB_1	04-2005
D	OBSO_V2 including LV2 software and SDB_2	03-2006
D	OBSO_V3 including LV3 software and SDB_3	11-2006
D	X-band suitcase	07-2005

Table 12-1: Prime contractor deliverables

Software version (as an example):

- LV0: basic functions such as TC/TM/FDIR/OBT/SSM,
- LV1: LV0+1553 BM (Bus Management), Platform Modes Management, SPL Management,
- LV2: LV1+ AOCS and RSC rendezvous Management,
- LV3: final version.

13 CNES CFE DELIVERABLES

Delivery dates indicated in here after tables shall be taken into account in Orbiter development schedule with, at least, 20 days margin.

Phase	Orbiter Model	*Item*	*Delivery date*
B		CFE specifications and ICDs (Change Control)	t0 phase B
B		Rendezvous strategy and algorithms (Change Control)	t0 phase B
B		Orbiter / RSC ICD (Change Control)	PDR - 6 months
B		CFE Nastran & Thermal Model	PDR -6 months
C	STPM	RSC & Science payloads STM	09-2004
C	OFM OBSO	RSC & Science payloads Numerical Simulator	08-2004
C		Rendezvous software	See table 13-2
C	OFM	RSC & Science payloads EM	03-2005
D	PFM	RSC & Science payloads FM	01-2006
D		RSC & Science payloads SM	01-2006
C	STPM	UHF- Pack (including NEIGE) STM	09-2004
C	OFM OBSO	UHF- Pack (including NEIGE) Numerical Simulator	06-2004
C	OFM	UHF- Pack (including NEIGE) EM	03-2005
C	OBSO	UHF-Pack (including NEIGE) FUMO	03-2005
D	PFM	UHF- Pack (including NEIGE) FM	11-2005
D		UHF- Pack (including NEIGE) FM	On the shelf
C	OFM	NetLander Flight System Numerical Simulator	08-2004
C	STPM	NetLander Cruise S/A STM + 3 MIMs + NRTU STM	09-2004
C	OFM	Netlander NRTU & SurfM EM	01-2005

C	OFM	3 Netlander Functional models (FUMO)	01-2005
D	PFM	NRTU PFM	02-2006
D	PFM	NetLander Cruise S/A FM 1, FM2, FM3, FM4	05-2006
D		Netlander NRTU SM	08-2006
D		Netlander Cruise S/A SM (QM refurbished)	08-2006

Table 13-1: CFE deliverables

Build	***Item*** (All Flight Software releases will run on real-time testbed)	***Delivery date***
R 1.0	- Control algorithms software to perform closed-loop rendezvous with Lidar, RDF, and Cameras - Preliminary fault protection software covering a few major scenarios (e.g. passive abort) - Hardware Manager performing I/O with BB/EM of Lidar, RDF, and Cameras - Preliminary Flight S/W Executive, Mode Commander, Command Handler, Telemetry Mgr, Bus Mgr, Configuration Mgr	04-2004
R 2.0	- Final Control algorithms software to perform closed-loop rendezvous with Lidar, RDF, and Cameras - Fault protection software covering most fault scenarios - Flight S/W Executive, Mode Commander, Command Handler, Telemetry Mgr, Bus Mgr, Configuration Mgr, Hardware Mgr	02-2005
R 3.0	- Updated final Control algorithms software to perform closed-loop rendezvous with Lidar, RDF, and Cameras - Final Fault protection software - Final Flight S/W Executive, Mode Commander, Command Handler, Telemetry Mgr, Bus Mgr, Configuration Mgr, Hardware Mgr	08-2005
R 4.0	- Updated final Flight software, Control algorithms software, and Fault Protection software	04-2006

Table 13-2: RSC software deliverables

APPENDIX 1 :SCHEDULE

Nom de la tâche	Durée	Début	Fin
Program Review	**1175 jours**	**14/10/02**	**11/09/07**
T0 (Phase B)	0 jour	14/10/02	14/10/02
PDR	0 jour	28/10/03	28/10/03
SIR	0 jour	20/01/04	20/01/04
CDR	0 jour	23/06/05	23/06/05
PFM Acceptance Revue	0 jour	05/03/07	05/03/07
PFM FAR (TBD)	0 jour	22/05/07	22/05/07
PFM Delivery	0 jour	11/09/07	11/09/07
Program Phases	**1263 jours**	**03/12/01**	**05/03/07**
Mise à plat	***212 jours***	**03/12/01**	**07/10/02**
Préparation Spécs Comp. Study	40 jours	03/12/01	29/01/02
Mise en place industrielle Comp. Study	20 jours	30/01/02	26/02/02
Ccomplementary Study	40 jours	27/02/02	24/04/02
Préparation A.O B/C/D	40 jours	27/02/02	24/04/02
Mise à jour des spécifications	10 jours	25/04/02	10/05/02
Envoi A.O	0 jour	10/05/02	10/05/02
Réponses A.O	40 jours	13/05/02	10/07/02
Evaluation A.O et choix	50 jours	11/07/02	19/09/02
Préparation & C.A	20 jours	10/09/02	07/10/02
Phase B	**245 jours**	**14/10/02**	**27/10/03**
Phase C	***400 jours***	**28/10/03**	**23/06/05**
Phase D	**401 jours**	**24/06/05**	**05/03/07**
OFM_Activities	**691 jours**	**29/10/03**	**22/09/06**
STPM_Activities	**139 jours**	**03/09/04**	**26/03/05**
PFM AIT Activities	**282 jours**	**12/12/05**	**16/02/07**
PFM Acceptance Review	0 jour	05/03/07	05/03/07
QO	10 jours	06/03/07	19/03/07
PFM FAR (TBD)	0 jour	22/05/07	22/05/07
Margin	**63 jours**	**16/02/07**	**22/05/07**
Pack and Ship	18 jours	22/05/07	20/06/07
PFM-Launch Campaign	**78 jours**	**20/06/07**	**29/09/07**
PFM1 orbiter Delivery	0 jour	11/09/07	11/09/07
Launch Campaign	60 jours	20/06/07	11/09/07
PFM1-Launch	0 jour	11/09/07	11/09/07
Launch period	21 jours	09/09/07	29/09/07