Jason-1
Lessons Learned from Development and 1.5 year in orbit

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Jason-1 Satellite Manager
The JASON-1 Altimetry mission is dedicated to ocean and climate forecasting, in continuation to the successful TOPEX-POSEIDON satellite, launched in 1992.

The first discipline to benefit from these remarkably accurate tools is physical oceanography. This includes ocean circulation, multi-season to multi-year variability, mesoscale variability, changes in mean sea level, tides and sea state conditions.
JASON-1 Science

El Niño - 02 octobre 2002

SSALTO/DUACS – NRT MSLA – Merged Product
2002/10/02
T/P and Jason Satellites

TOPEX
2500 kg

Jason-1
489 kg
performances equivalent to T/P in flight
The JASON-1 Program

• NASA / CNES cooperation for development and operations
  – Balanced mission sharing
    • mission goals, constraints, funding, decisions, risks
  – High level agreement : Memorandum of Understanding
    • responsibility sharing precise definition
    • responsibilities almost reversed between TOPEX/POSEIDON & Jason

• Worldwide user community
  – 67 Investigator teams selected from more than 30 different countries
  – Strong interactions between project teams and the Science team
  – Project developed under the frame of international ocean and climate programs
Jason-1 challenges

- Toward operational oceanography
  - Operational requirements: Reliability, availability, data latency.
- Performances/accuracy
  - T/P in flight performances become the Jason science requirements.
- Protoflight platform for a new bus: PROTEUS
  - Small satellite to lower recurring costs
  - Commercial Of The Shelf (COTS) equipment
  - The first launch of a CNES Satellite on a Delta II launcher from the Vandenberg launch site, in a dual launch configuration.
- The establishment of new relationship between CNES and the Space Industry through partnership instead of standard contractual relations.
- Extensive use of benches for system validation and operation preparation.
- Complex ground system with transfer of satellite routine operation from CNES to JPL at the end of assessment phase.
- Aggressive schedule (First launch date objective: May 99).
Overall satellite context

- Jason-1 first application and use of the PROTEUS platform developed in partnership by Alcatel and CNES
- CNES had overall satellite responsibility
  - Payload instruments provided by CNES and JPL
- Satellite activities contracted by CNES to Alcatel
  - Preliminary Design Review June 97
  - CDR July 98
  - Satellite qualification review December 2000/April 2001
  - Operational Readiness Review May 2001
  - Pre ship review July 2001
  - Launch December 2001
- Satellite protoflight qualification approach
Three axis stabilized satellite
Approximately 3.4 m high
Total mass of 490 Kg (275 Kg for the platform and 175 Kg for the payload module including science instruments).
Two sets of solar panel of 9.5 m2 generates about 500 Watts.
Jason-1 is designed to last for an operational mission of 3 years and an extended mission of 2 years, all life limited elements being sized for at least 5 years.
Altimeter

Radiometer

Doris positionning system

Laser retroreflector

TRSR positionning system
Proteus Platform characteristics

**Orbit:** Any orbit altitude in 500-1500 Km range, inclination higher than 20 deg

**Launch Vehicles:** Compatible with all launch vehicle with fairing diameter >1.9

**Mass:** 275 Kg, 28 Kg hydrazine capacity

**Payload mass:** 100 to 300 Kg

**Reliability:** 0.889 at 3 years, 0.754 at 5 years

**Lifetime:** 3 to 5 years depending upon the orbit

**Power:** Bus maximum consumption = 300 W

**Payload power:** 200 W, up to 300 W on some orbits

**Pointing Attitude Restitution:** 0.05 deg (3 sigma) on each axis

**Data Storage:** 2 Gbits for payload

**Down link:** 722 kbits/s

**Up link:** 4 kbits/sec

**Unavailability:** 0.82 %
The PROTEUS Platform

- Star tracker *1
- +X panel
- +X
- magnetometer *2
- magnetometer *1
- Reaction wheel *3
- GPS receiver
- GPS preamplifier
- SADM *Y
- PCE
- -Y panel
- magnetorquer *3
- DHU
- hydrazine F/D valve
- helium F/D valve
- electrical I/F bracket
- +Y panel
- SADM +Y
- +Y
- Gyro *1
- Gyro *2
- Gyro *3
- electronic gyro (*3)
- -X propulsion panel
- +Z panel
- +Z
- DHU heatsink

Hydrazine tank
Reaction wheel *1
Battery
Battery power strap bracket
-Z panel
Battery heatsink
Magnetorquer *1
TTC transceiver *2
TTC transceiver *1
+Y panel
SADM +Y
+Y
Gyro *

17th AIAA/USU Conference on Small Satellites
Thierry LAFON
Proteus current and future applications

Calipso

Jason-2

Smos

Corot

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Thierry LAFON
In flight results:
Mass Memory, TMTC Link

- **Mass Memory**
  - on-board storage capability:
    - Housekeeping telemetry: ~6 days
    - Operational Science telemetry (data for OSDR generation): ~1.5 day
    - Science telemetry (data for IGDR generation): ~21 hours
    - Commands: ~7 days

- **TMTC Link:**
  - Very large margins for all the Earth Terminals
    - from 31 to 44 dB for the commands
    - from 18 to 27 dB for the telemetry
Satellite Budgets: Power, Energy, Thermal

- **Power**
  - 420 W max power consumption (consistent with predictions):
    - Mean flight value: 350 W + variations due to thermal control:
    - # 90 W margin w.r.t End Of Life battery capability

- **Battery**
  - Maximum Depth Of Discharge 16% obtained during the first Safe Hold Mode *(up to 80% acceptable)*. Very good performance due to good injection by the launcher, with low angular rates
  - About 15% DOD in Nominal mode

- **Thermal behavior**
  - Very stable temperatures: Payload Module orbital temperatures variations are limited to 1°C, beta related variations about 3-4°C
JASON1 Pointing Budget

- Short term errors
  - Levels for all the main contributors (SADM activation, GYR noises, STR noises) are as expected
  - No spike due to eclipse / sun transition
  - Minor spikes observed during STR tracking mode recovery
  - Overall performances (standard deviation) after GYR calibration (performed in January 2001)

⇒ half cone : 0.015 deg (3σ)
Star Tracker anomaly

- Increasing unavailability Due to loss of sensitivity
- Pointing accuracy degradation (still inside specifications)
- Likely due to STR internal pollution or radiation effect
- Increase of the detection threshold
- Stabilization of degradation (STR availability OK)
- Back up solution with ground filter using Mag, gyros, and altimeter (0.2° accuracy) has been developed
LESSONS LEARNED
Faster, better, cheaper?

- Use as much as possible electronic parts of "commercial" standard as opposed to usual "space" or "military" standard.
- Strongly "success oriented" schedule with important development and validation phase overlapping and parallel activities.
- Strong reliance on benches to validate the system and its operational behavior.
- Reduction of the number of system and element reviews as well as simplification and alleviation of their progress and minimization of the documentation.
- Maximum use of COT's (Commercial Off The shelf) equipments.
- Decrease of the number of redundancies.
- Limitation in the funding, both applied to development and operational cost.
Some lessons learned from development

• **Use of commercial electronic components**
  – Overall cost benefit not obvious due to:
    • New procurement rules to be used by contractors
    • Unknown behavior in space environment (harsh radiation environment of the Jason orbit).
    • Significant Impact of change of components in existing design

• **Extensive use of benches for validation**
  • Extensive software use made benches very complex and difficult to develop. Development delays underestimated
  • At the end, they proved to be a very efficient tool for test coverage and schedule gain.
BV1
Software validation

BV2
Functional validation
Some lessons learned from development

• Schedule management
  • Compromise between “motivation tool” and project management tool
  • Schedule pressure can lead to demotivation when goals are unrealistic,
  • Adequate margin provisions shall be kept, despite external pressure,
  • New development shall never been underestimated, especially when dealing with software activities (ex: benches)

• JASON -1 overall schedule achievement
  • 5 years from Phase B to Launch
  • 19 months delay due to:
    • 13 months of benches delays
    • 6 months due to solar array drive failure
  • To develop, validate a completely new product line and launch a first satellite in 5 years can be considered a good achievement.
Some lessons learned from development

- Decrease of the number of redundancies:
  - unacceptable impact on the reliability
  - payload sensors already redunded by design history
  - overall cost of the redundancies decreased by the « product line » effect.
  - Coherence between payload redundancy level and platform redundancy level

JASON-1 has a fully redundant design
Some lessons learned from development

• Reduction of the number of system and elementary reviews as well as simplification and alleviation of their progress:
  • review process adapted to fit within 3 working days,
  • implementation of a NASA “Red Team” Review Board for each major review, in parallel to the Standing Review Board,
  • The “Red Team” and Standing Review Board worked closely, with coherency checking of both teams conclusions;
Some lessons learned from development

• **Assembly, Integration and Test**

  • Careful validation of each GSE before starting any AIT activity,
  • Never postpone a test that can be performed at an earlier stage,
  • Provide some flexibility at the beginning of the payload integrated test to ease further system tests,
  • Minimize tests at the launch site, to avoid different behaviour in a different white room environment.
Some lessons learned from development

• *Careful preparation of operations*

  • Ground system qualification was about one year
  • Ground system validation started very early with simulators (RF suitcase)
  • Implementation of a comprehensive series of validation test and operational qualification
  • All systems validated and personnel trained carefully before Launch, addressing nominal and contingency operations.
Some lessons learned from development

**Complex organization management**
- Cooperation between agencies at mission level
- Partnership between CNES and ALCATEL for Product line development
- CNES prime contractor for satellite development
- CNES and NASA provided payload instruments
- Ground segment and operations shared by NASA and CNES.

- Adequate steering committees set in place at the beginning of the program to provide continuous monitoring of the program progress and take appropriate decisions when needed.
- People with good knowledge of the program, low turn-over
- Flexibility and availability suited to normal and critical situations
DEVELOPMENT SEQUENCE
PF Integration
1999
Mar, Apr, May,

Payload
Intégration
1999
Mar, Apr, May,
Acoustic
June 2nd

Sinus
Qual
May 29, 30th
SA Deployment
June 6th

Separation shock
June 7th
EMC RE/RS
July 7th...

...July 22nd

17th AIAA/USU Conference on Small Satellites
Thierry LAFON
Pre-TV  
July 23rd

End of TV  
...September 2nd

Global Leak  
October 2nd
Final Performances:

First Ground-Board Test
Flight Software loading
Health Checks
AOCS End to End tests (SHM)
Traffic tests (SHM)
Arrival at VAFB
July 2001

Final processing
Nov. 2001
JASON-1 Launch
December 7, 2001
**JASON-2 (OSTM)**

**Jason 2 / OSTM** : Formally decided - Start of Phase B Nov. 2003-
- cooperation extended to operational agencies : NOAA & EUMETSAT
- to be launched in late 2007
- Same Core Mission with new technology experiment : WSOA (Wide Swath Ocean Altimeter)