



# MSL: 10 MONTHS OF OPERATIONS AT JPL AND FIMOC, THE FRENCH OPERATIONS CENTER FOR CHEMCAM AND SAM

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- The MSL Mission and the ChemCam instrument
- Preparation of "90 sols" (commissioning)
- The 90 first sols of operations
- Operations at FIMOC
- Long-term monitoring of consumables



# MARS SCIENCE LABORATORY



- **ChemCam** : Chemistry camera :
  - Laser-Induced Breakdown Spectrometer (LIBS)
  - Remote Micro-Imager (RMI)
- **APXS** : Alpha Particle X-ray Spectrometer
- MAHLI : Mars Hand Lens Imager
- **ChemMin**: Chemistry & Mineralogy
  - X-Ray Diffraction
  - X-Ray Fluorescence
- **SAM** : Sample Analysis at Mars
  - Quadrupole Mass Spectrometer (QMS)
  - Gas Chromatograph (GC)
  - Tunable Laser Spectrometer (TLS).
- **RAD**: Radiation Assessment Detector
- **REMS** : Rover Environmental Monitoring Station
- **DAN** : Dynamic Albedo of Neutrons
- **MARDI** : Mars Descent Imager





# **MARS SCIENCE LABORATORY**



- Laser-Induced Breakdown Spectrometer (LIBS)
- Remote Micro-Imager (RMI)



Mast Unit



Calibration targets

Body Unit







- 2011: first remote tests
- Flight Schools in parallel with ORTs
- ORT-7, ORT-11 et ORT-14 very EDL-oriented (landing, CAP-1)
- ORT-8 and ORT-13: nominal training

## **GETTING READY FOR 90 SOLS**





- Required a lot of testing on the Engineering Model, especially for interactions between the different subsystems (ressources, laser collisions, etc.)
- A simulator of the instrument is onboard the EM rover
- Preparation of instrument procedures and training packages

# **THE FIRST 90 SOLS**



# First 4 sols (= days) activities, prior to any science observation:

- Turn on ChemCam few minutes after landing, first measurements with Mast stowed (sequences already onboard)
- Check the health of the instrument
- Provide a Go to mission for Mast deployment, by checking pyros firing
- First calibration activities
- Strong mission priority on outreach activities (Panoramas)







# **THE FIRST 90 SOLS**

# MARS SCIENCE · LABORATORY ·

#### 1 sol = 1 day on Mars

First sols happened to be very close to ORTs => excellent training



First RMI on Mars (sol 12)







## THE ORGANISATION OF OPERATIONS







## THE ORGANISATION OF OPERATIONS



- One uplink of activity plan per martian day
- 1 to 3 uplink opportunities from rover to orbiter (MRO, Odyssey)

cnes

• Roughly 400Mbits of available downlink per sol

### THE JPL MEETING ROOM

ARS SCIENC LABORATORY



# **REMOTE OPERATIONS AT FIMOC**

CCNES

- First remote operational shift on MSL by ChemCam ePDL from FIMOC at sol 75
- Transition from working 7/7 on martian time to 5/7 on US time (5pm to 4am in France)
- Share of operations with LANL, one week each
- Handover telecons on Mondays
- Mixing Engineers and Scientists (users) at FIMOC

# **OPERATIONAL PROCESS: DOWNLINK**



# Tactical

- Downloading and analysis of ChemCam data
- Must provide an assessment of instrument health
- A non-nominal state prevents from using the instrument

# • Strategic

- Long-term assessment of key parameters: temperatures, voltages, optical power, etc...
- Long-term assessment of consumables: number of laser shots, autofocuses, motor steps,...
- Instrument anomalies analysis



# **OPERATIONAL PROCESS: UPLINK**

ChemCam used for **remote science**, allowing to

save time and ressources for contact science





### **SCIENCE ACTIVITIES**

360° Mosaic with Cameras

Identification of targets

Remote science with ChemCam (2-7m)

Contact science

Target defined by scientists, with associated **coordinates** and **distance** 

# **CHEMCAM ACTIVITIES**



#### So what do we REALLY do with our laser on Mars?

#### We do some rasters (1x5, 1x10, 3x3, etc.), trying to hit calcium veins





Veins of hydrated calcium sulfates Sediments with basaltic composition

We take hi-resolution images of drill bit, cal target, rover parts





#### We clean dust





Cones

# **CHEMCAM ACTIVITIES**



25

We shoot at calibration targets...



... and do passive observations of the paint

And we can shoot inside the drill holes!



# **HIGH PRECISION POINTING**



Drill holes, from the mast (Navcam) Drill holes, 1 cm sampled & imaged by ChemCam + Laser pits 3 mm



We're aiming at a 1cm hole, 3m away



### **CHEMCAM ACTIVITIES**



#### When we really like a rock



### **BLIND TARGETING**



Cones

### **BLIND TARGETING (SINGLE POINT)**



# **TOOLS INTERNAL DEVELOPMENT**



### ARC (ruby + shell) :

#### Automatisation of Downlink reports

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#### CCAM Product Viewer (IDL) :

Analysis and visualization of received products Generation of html lists of expected, received and missing products



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#### ChemCam Mosaic Viewer (IDL) : Check the collision zone for all ChemCam laser shots



# LONG-TERM MONITORING OF CONSUMABLES

Parameters	Requirements	Up to Sol 368	% of lifetime
Number of hours ON for CCMU FM	1h/day for 2 years	44min/day	
Number of laser shots	3 millions	88250 Mean of 404 shots/day when Ccam is used	3%
Number of autofocuses	14000	936 Mean of 66sec/autofocus	6%
CWL diode (ON/OFF)	14000	940	6%
Number of shots in restricted zone	100000	0	
Total # of motor steps	N/A	15818227	

# ChemCam used 60% of times => very useful instrument for remote science



# CONCLUSION



COes

- Successful local operations at JPL during the commissioning phase
- Remote operations at night since november, alternating every week with LANL
- Various activities allowed by ChemCam, very useful instrument
- Long driving period ongoing

