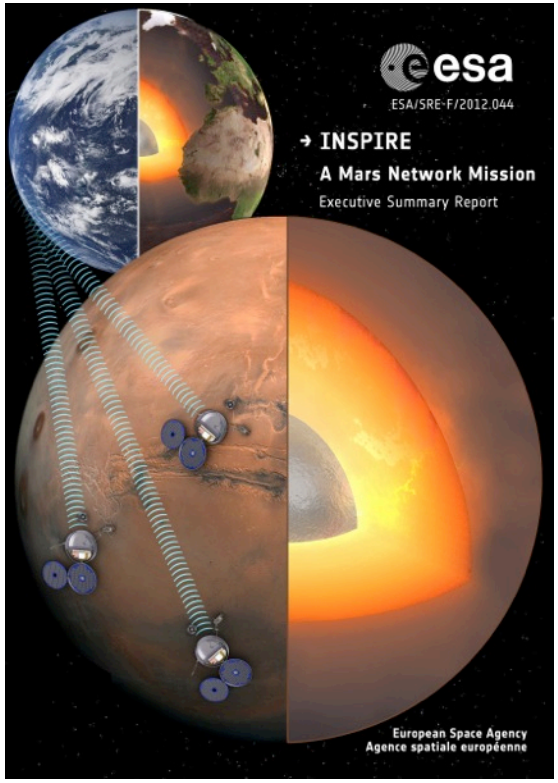
INSPIRE

A Mars Network Science Mission



INSPIRE pre-Phase A study team

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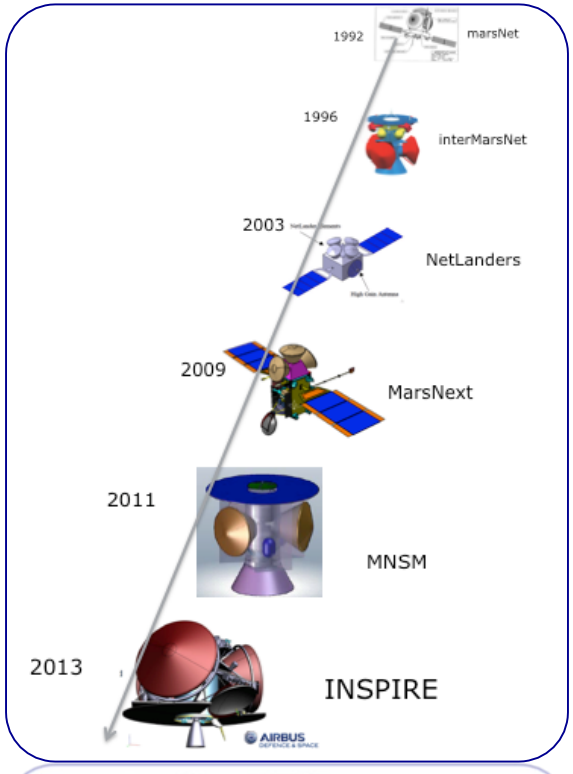
IPPW 11, Pasadena,

Introduction
Background

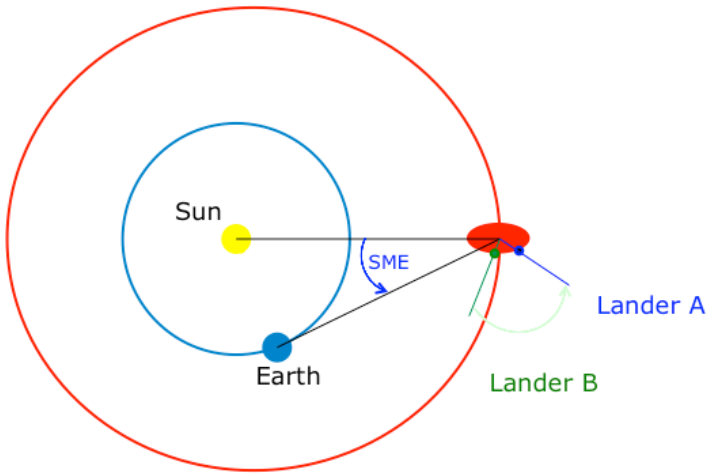
- ESA's **Mars Robotic Exploration Program** 'MREP' :
  - preparing future missions and associated technologies
  - Mars Sample Return (MSR) is the long term MREP objective
  - "Intermediate" Missions currently being studied within MREP for a launch in 2024-2028 : Phootprint & Inspire

- **INSPIRE** : a Mars Network Science Mission
  - The latest of a long series
  - Aim : to land 3 landers simultaneously on Mars for geophysics and atmospheric science during 1 Mars Year
  - Pre-phase A in 2013-14 with 2 industrial contracts : TAS-F and Airbus D&S F



Mission concept
Science Case

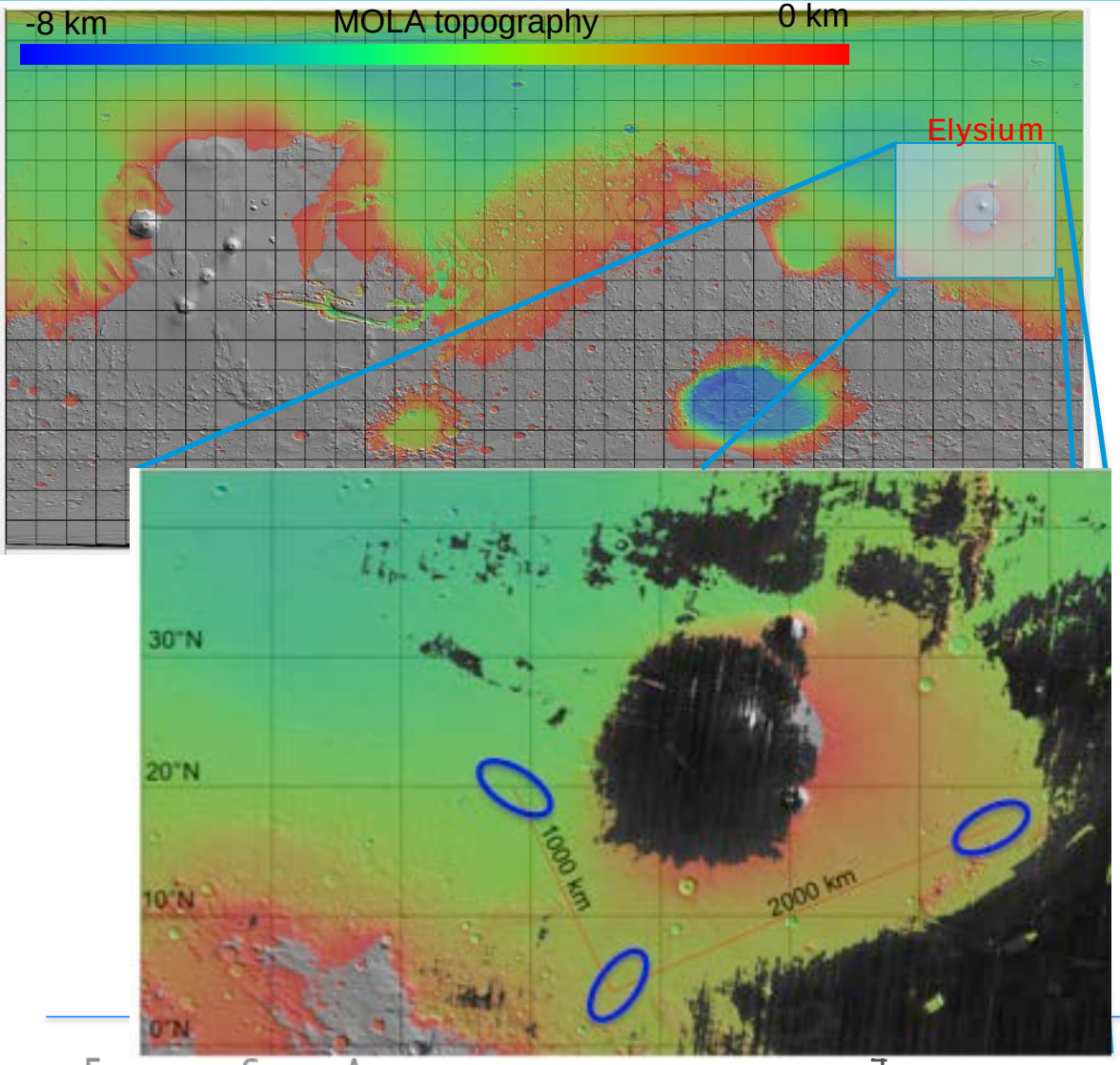
- **Science goals :**
  - A. characterize Mars interior (core, crust) through simultaneous geophysical measurements at multiple points on the surface (minimum 2).
  - B. Meteorological site characterization
  - C. Surface-atmosphere exchange (heat, dust, water)
- 1 Mars year surface operations (goal : 2 year)



	Mass [kg]	Science goal covered
RSE	0	*A*
SEIS	8.5	*A*
METEO package	3.0	*B*
HP3 (mole)	2.3	*C*
Camera	0.565	*A, B*
TOTAL	**14.4**	***kg***

- Payload is composed of 5 instruments, including SEIS (similar as for InsIght)
- SEIS and Mole require a dedicated deployment system (robotic arm)
- RSE : delta Doppler measurement between 2 landers, both being equipped with a CDMA X-band transponder.

Mission concept
Landing sites

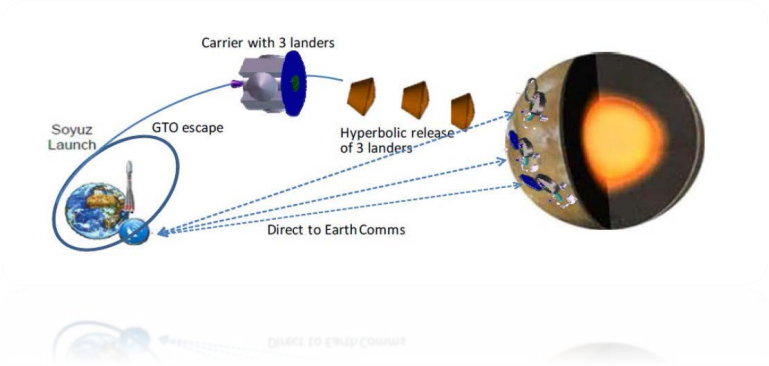


- No strong science requirements for Landing site selection except for RSE.
- Elysium area looks *Inspiring*
- Low elevation (below -2 km)
- High thermal inertia
- Relatively low average wind
- A priori compatible with expected landing ellipse (200 km radius)

Example of landing sites configuration ; in shaded areas : TES night time thermal inertia < 150 (Putzig, N. E., and M. T. Mellon, Icarus, 191, 68-94, 2007)

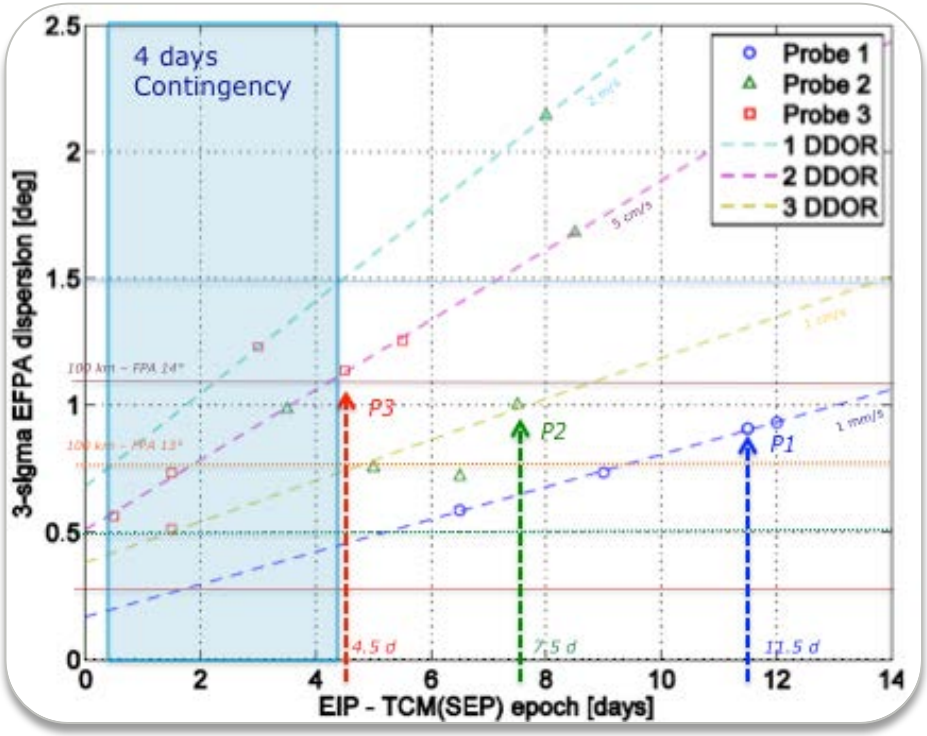
Mission concept
Overview

- Soyuz launch + GTO by using High Thrust Engine to minimize gravity losses (1.1 kN, in development under MREP program)
- Launch 2024 (2026) or 2025 (2027) with EGA
- 3-axis controlled carrier with 3 identical probes
- Sequential Release of the probes
- MER-like EDLS
- 1 Mars year surface operation.
- Key differences with previous “network missions” which drive INSPIRE : self-standing concept with mo orbiter assumed, No RHU, No RTG, Direct-to-Earth Communications .

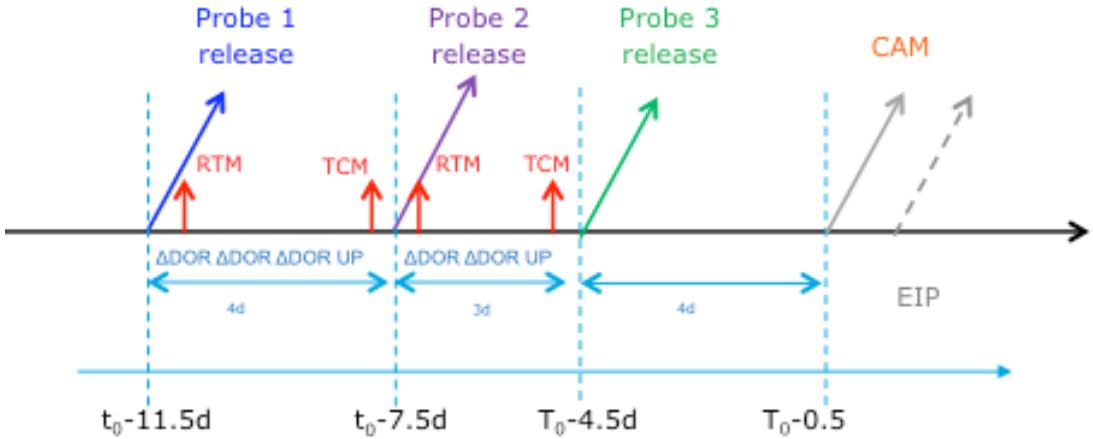


Mission concept
Probes Release Sequence

- Release sequence is **time and mission critical**
  - Robustness to one separation failure is required
  - Coasting : short enough to avoid oversizing probe power / thermal
  - Coasting : long enough to allow for sufficient DDOR measurements
- **Optimized release sequence** :
  - Includes 4 days Contingency
  - Autonomous TCM / release / RTM manœuvres
  - 1 day for manœuvre preparation and upload
  - Required number of DDOR is function of the date of release.



Mission concept
Probes Release Sequence



3 d DDOR
1 d processing

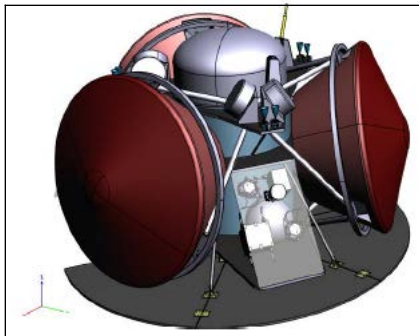
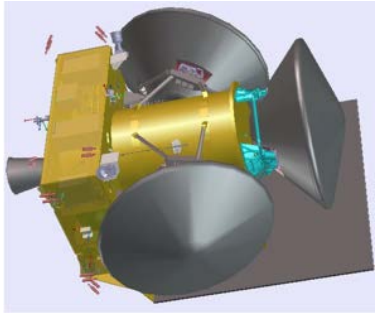
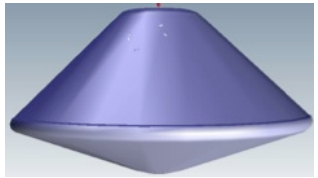
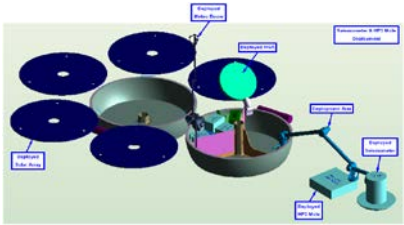
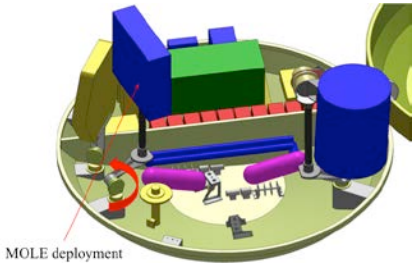
2 d DDOR
1 d processing

4d buffer =
1 d G/S
1 d Safe Mode
1 d DDOR
1 d processing

scenario	Release of Probe 1	Release of Probe 2	Release of Probe 3
Nominal	-11.5	-7.5	-4.5
Failed release of P1	-6.5	-3.5	-0.5
Failed release of P2	-11.5	-3.5	-0.5
Failed release of P3	-11.5	-7.5	-0.5
	Date of release wrt EIP in days		

5d buffer =
1 d G/S
1 d Safe Mode
2 d DDOR
1 d processing

Spacecraft design
Main features

	**Composite spaceacraft** Designed for Soyuz fairing 3-axis controlled X-band MGA / HGA NSP in the shadow of SA 600 kg dry mass for the carrier	
	Network Science Probe ExoMars frontshield shape MER-like entry 2m diameter 400 kg entry mass	
	**Network Science Lander** Dual X-band UHF transponder Steerable X-band HGA Robotic arms for payload deployment Dust Removal System 130 kg Landed mass	

Mission concept

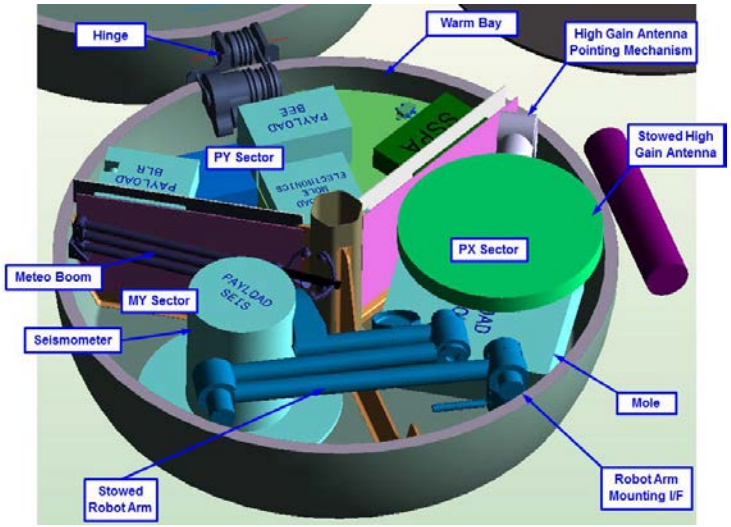
Entry, Descent and Landing system

1. Entry
2. T0: PDD fired – acceleration + delta t algorithm to ensure Mach 1.8 – 2.1 range
3. T0 + 20s front shield released
4. T0 + 40 lowering commences
   T0 + 55 Lowering completed
   h < 1500 m radar altimeter acquires surface - LVEC determines lateral wind
   h = 500 m RAD h determined based on descent velocity, RAD dt determined
5. h = 450 m airbags inflated
   TIRS mode and TIRS timing selected at RAD dt -1
   •Lateral wind
   •Backshell attitude and rates
6. RADS / TIRS fire
7. Riser cut when Vv = 0 at approximately 10 m above the surface.
8. Lander impacts surface and backshell flies away
9. Bouncing
10. Stationary on surface detected by accelerometer
11. Deflation and retraction

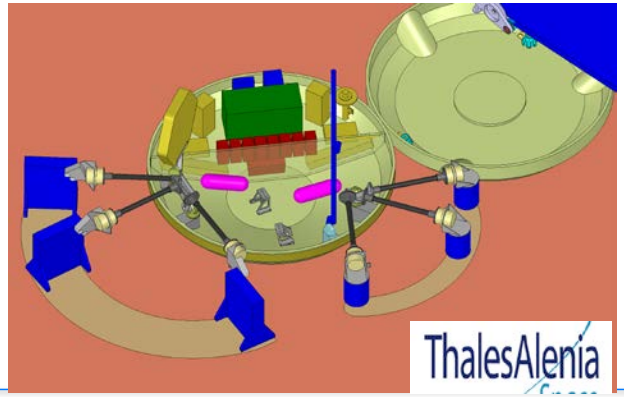
1. Front shield brakes probe from entry to ≈400 m/s at ≈12 km altitude
2. Parachute opens at mach 1.9 and brakes probe to ≈100 m/s
3. Airbags inflated at h=500m based on alti measurement
4. Vision-based lateral velocity estimation and control to cancel out lateral wind effect
5. RADS retro-rockets required to null-out remaining vertical velocity at h≈100m ; airbag absorbs the last 10 m.

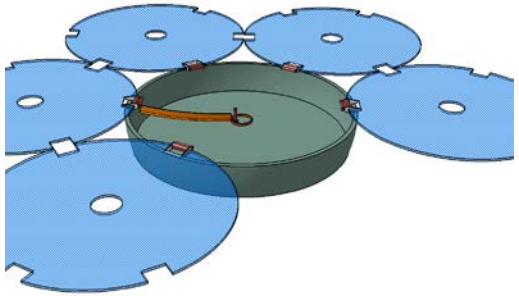
Spacecraft design
Network Science Lander

- Very compact design
  - 1.1 m diameter for the probe / 0.5 m high for a mass of 130 kg
- Warm bay to maintain eletronics warm enough
  - Designed to survive cold Mars environment : Ls=80, at 15 degree South, OD=2
- Specific mechanisms
  - Robotic arm for payload deployment
  - Dust Removal System



AIRBUS DEFENCE & SPACE





Summary
pre-phase A conclusions

- Pre-phase A has confirmed mission feasibility
- comfortable margins on Ariane 5 shared GTO / limited for Soyuz
- Most of critical technologies for INSPIRE already in development within MREP, e.g. HTAE, airbags
- Mission Drivers have been identified
  - DTE communication
  - Release sequence strategy drives the landing accuracy (200 km)
- Further optimization of lander design shall be pursued :
  - 1 kg landed mass per probe = 30 kg launch mass
  - Integration and miniaturisation of avionics has been identified as a realistic source of potential mass savings
- Questions ?

Combustion chamber test