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Accurate Entry Guidance for a Mars Precision Landing

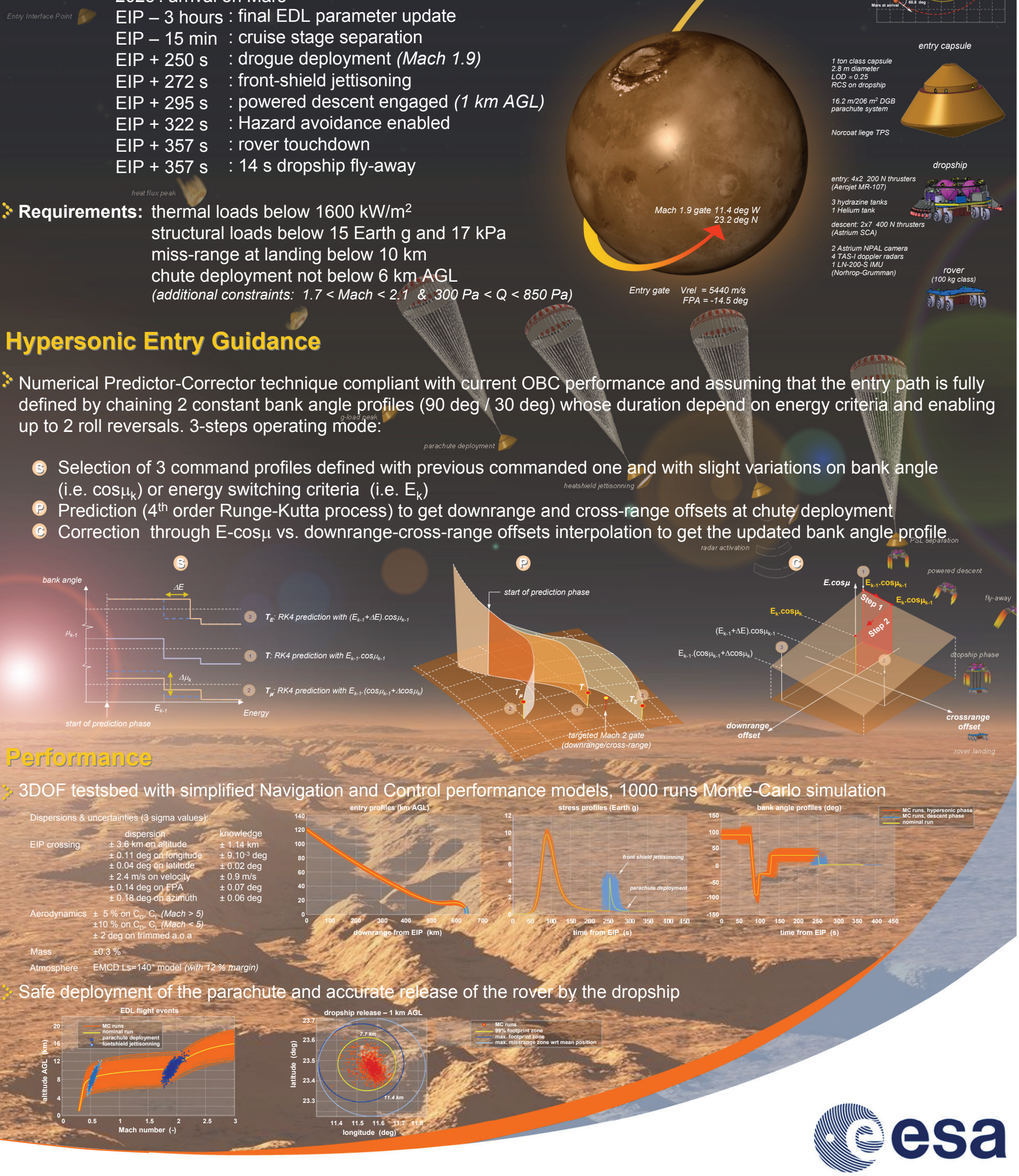
ESA Mars Robotic Exploration Preparation program: MPL mission

Objective: to land an autonomous rover with a 10 km accuracy using a Viking-shaped entry vehicle

Timeline

2023 : launch from Kourou CSG by a Soyuz-Fregat launcher
2025 : arrival on Mars
EIP – 3 hours : final EDL parameter update
EIP – 15 min : cruise stage separation
EIP + 250 s : drogue deployment *(Mach 1.9)*
EIP + 272 s : front-shield jettisoning
EIP + 295 s : powered descent engaged *(1 km AGL)*
EIP + 322 s : Hazard avoidance enabled
EIP + 357 s : rover touchdown
EIP + 357 s : 14 s dropship fly-away

Requirements: thermal loads below 1600 kW/m^2
structural loads below 15 Earth g and 17 kPa
miss-range at landing below 10 km
chute deployment not below 6 km AGL
(additional constraints: 1.7 < Mach < 2.1 & 300 Pa < Q < 850 Pa)



Hypersonic Entry Guidance

Numerical Predictor-Corrector technique compliant with current OBC performance and assuming that the entry path is fully defined by chaining 2 constant bank angle profiles (90 deg / 30 deg) whose duration depend on energy criteria and enabling up to 2 roll reversals. 3-steps operating mode:

- **S** Selection of 3 command profiles defined with previous commanded one and with slight variations on bank angle (i.e. $\cos\mu_k$) or energy switching criteria (i.e. E_k)
- **P** Prediction (4th order Runge-Kutta process) to get downrange and cross-range offsets at chute deployment
- **C** Correction through E-$\cos\mu$ vs. downrange-cross-range offsets interpolation to get the updated bank angle profile

Performance

3DOF testsbed with simplified Navigation and Control performance models, 1000 runs Monte-Carlo simulation

Dispersions & uncertainties (3 sigma values):

	dispersion	knowledge
EIP crossing	± 3.6 km on altitude	± 1.14 km
	± 0.11 deg on longitude	± 9.10^{-3} deg
	± 0.04 deg on latitude	± 0.02 deg
	± 2.4 m/s on velocity	± 0.9 m/s
	± 0.14 deg on FPA	± 0.07 deg
	± 0.18 deg on azimuth	± 0.06 deg
Aerodynamics	± 5 % on C_D, C_L *(Mach > 5)*	
	±10 % on C_D, C_L *(Mach < 5)*	
	± 2 deg on trimmed a.o.a	
Mass	±0.3 %	
Atmosphere	EMCD Ls=140° model *(with 12 % margin)*	

Safe deployment of the parachute and accurate release of the rover by the dropship

All the space you need

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