Technology Splinter

Strategy for Powered Descent
No throttleable engines in Europe (very few in the world)
Costly development program for a new throttleable engine in Europe
Pulse Width Modulation (PWM) mode for Bi-prop engines to be proven
Europe needs to decide to either develop the engines needed for future missions or to further test the pulse modulation mode of operation together with the complicated control systems.

Power/Heat Generation
Future exploration missions will need advanced power systems
Current solar power generation is not sufficient in all cases (long duration operation in eclipse/darkness)
Use of Nuclear power and heat generation needs to be addressed in Europe. Currently only USA and Russia have devices available. Procedures and certification for handling during AIV as well as launch operations needs to be addressed.
Power beaming technology and tethers

Deployment of Instruments
Several science packages will rely on a large number of sensor packages being distributed over a larger area of the planetary surface. Technologies are needed to distribute these. However specific technologies will differ depending on the exact scientific package requirements leading to different deployment technologies.

Descent and Landing
GNC for Accurate Soft Landing and Hazard Avoidance
A lot of work has been done for visual hazard detection to be used for safe soft landing on planetary surfaces in Europe. Further development of this technology is needed. This involves both the imigage processing and control algorithm development as well as the development of the image acquisition hardware (LIDAR or visual cameras).
Landing strategy
Landing legs and touchdown monitoring development

ISRU Technology
All large scale exploration architectures rely on ISRU to enhance the robustness by providing resources in situ greatly reducing the need for costly logistics. However currently the knowledge of what resources might be available, in what quantities and what state, is not sufficient to be able to define the best technologies for resource extraction and processing.

Aerothermodynamics and RVD for Earth return missions in the future

Robotics/Mechanisms
Mole technology for subsurface analysis and sampling
Robotic support will be needed for first ISRU demonstrations (Beagle 2, DEXARM derived)

Mission Analysis
Better determination of Lunar orbital parameters and lunar gravitational field for better trajectory definition (SMART-1, US Missions??)
Better determination of lunar topography
Landing strategy (optimised trajectory without hovering vs. EuroMoon type trajectory with human intervention)

Structures
Multi purpose S/C bus (orbiter and lander) which can be used for several missions. Attention must be paid to the controllability of the S/C during decent and the overall configuration.

Communications
Possible issue of using RF on the back side of the moon
Need for good comms link during descent and operation

Mission Roadmap (missions, P/L and technology development)
- Reduce risk with an evolutionary approach
- Several "low cost" missions
- Each mission to have clear European objectives (both science and tech demo) which fit into an overall long term plan
- Complementary to International missions but may provide independent science and tech demo for critical items
- Cooperation with other International Partners for science (e.g. SMART-1 instrument on Chinese mission)
- Data exchange agreements between all participants in lunar exploration

Lander Mission Elements
- Objectives (Tech demo: landing, preparation for exploration, Science: Geochemical, ice, outreach function)
- P/L (biological habitat (100kg), demo of radio astronomy P/L, deployment of navigation beacon/seismic sensors)
- Orbit, duration, landing location, all defined by specific mission objectives (interaction between science and tech demo)
- Lander Station Element,
- Rover Element (requirements), additional probes, vertical mobility,
  - should investigate what could be done with more small rovers compared to a single larger rover
- Orbiter and relay stations

Actions to promote Lunar Exploration
- Communicate clear European objectives and benefits for Moon Exploration (science and exploration)
- Apollo has not answered all questions
- Why did Euromoon not fly?
- Present the Moon as a stepping stone to Mars, further define the Aurora Exploration roadmap w.r.t. lunar activities

Workshop Declaration
European Lunar Lander would be a logical step within the Exploration roadmap leading to operational experience on the Moon which is an important part on the way to humans on Mars. A first stepping stone.