3D-System-in-Package Distributed Rover Control Module featuring SpaceWire and CAN

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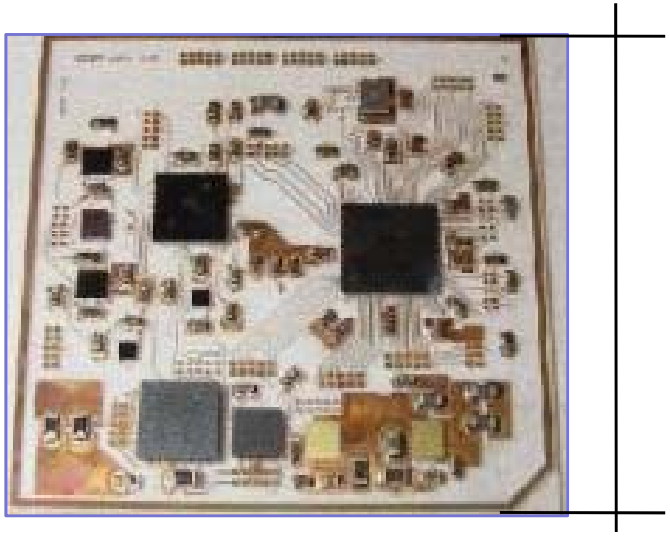
Recap from Previous Presentation on ÅAC 3D-SiP Subsystems

- ✓ 3D-SiP Remote Terminal Unit (RTU) together with Swedish Institute of Space Physics (IRFU)
- ✓ 3D-SiP Magnetic Attitude Control System (MACS) together with ZARM Technik

Mass: 3-4 gram
dep. on package



33 x 33 x 1

RTU

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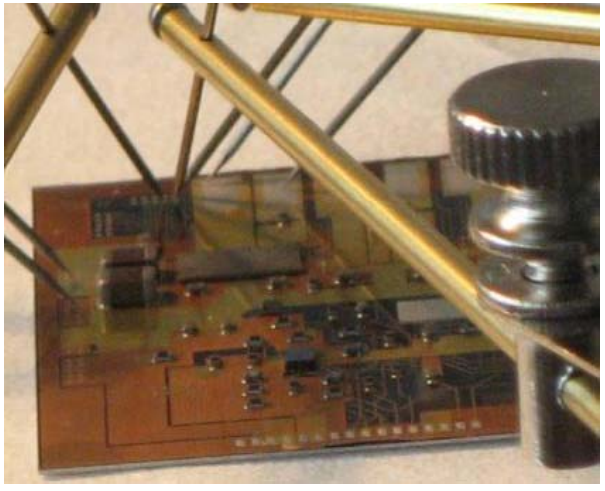


MACS

Short Background

- ✓ Rover complexity is increasing
  - More moving/rotating nodes
  - Higher feed-back in control loops
  - Massive increase in harness and wiring

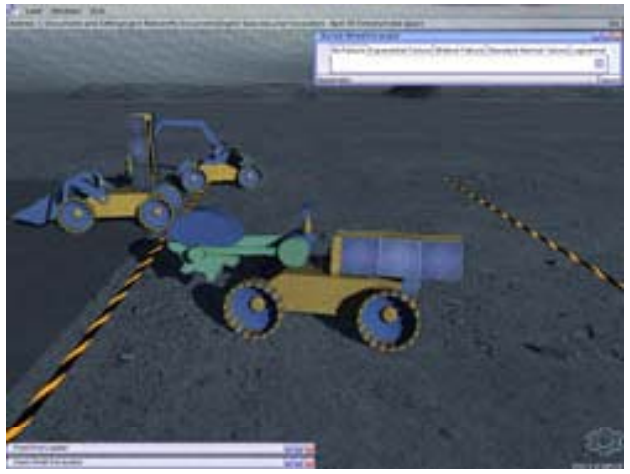


Image courtesy of NASA

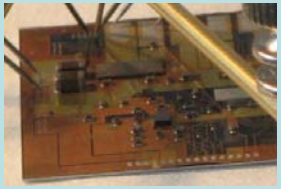
- ✓ Large increase expected in future robotic/rover missions
  - Reliable standard components necessary
  - Good opportunity to leverage development costs of 3D-SiP
  - Introduction of system-level redundancy
  - The radiation environment on Mars is relatively low. I.e. mil-spec. devices/chips can be used

- ✓ Interplanetary robotics is an area of interest for both government agencies and private companies

µRTSD - Development Definition and Roadmap

- Develop and quailfy a standardized component for motor control
- Micro **R**emote **T**erminal **S**ervo **D**river (µRTSD)

µRTSD Flight Hardware Roadmap



RTU/MACS adaptation and manufacturing of 10 units for Technology validation and testing.
TRL 6

Phase 1 – (1.5 year)

Phase 2 – Test and validation (months)

Phase 3 – QM (1 year)

µRTSD QM
TRL 7

Phase 4 – Test and validation (months)

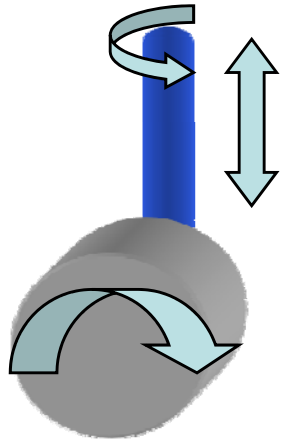
Phase 5 – FM (1 year)

µRTSD FM
TRL 8

FM in ~ 4 years including QA of new 3D-SiP technology. Ready for 2012

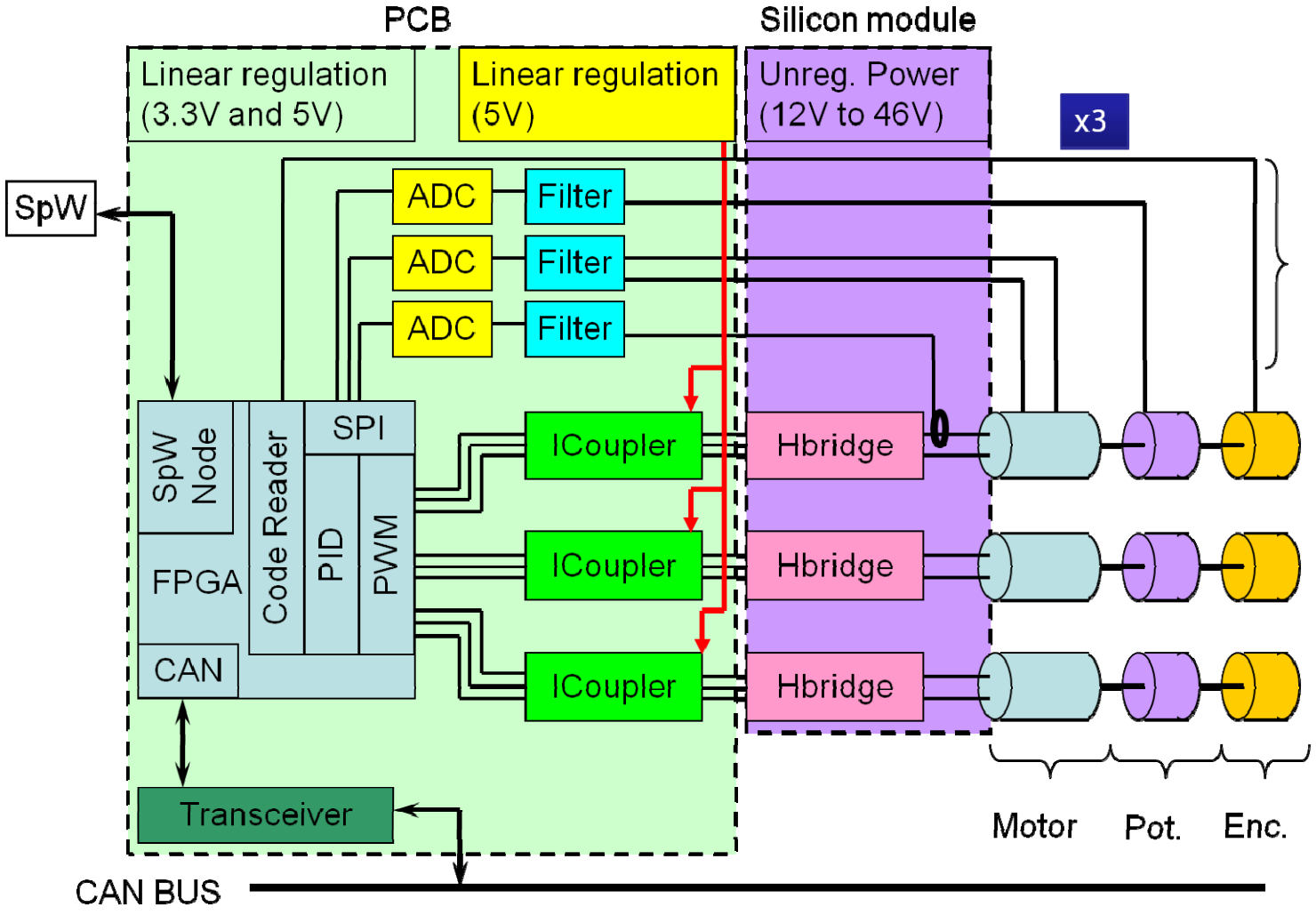
µRTSD – First Requirements

- Distributed design
- SpaceWire (Link/Router) connection
- Controller Area Network (CAN) connection
- Optional SpaceFiber for Gbit/s transfers
- Plug 'n play
- Up to 3 motors per µRTSD
- Up to 40 V motor voltage
- Up to 3 A motor current (120 W per motor, 360 W per µRTSD)
- Up to 200 kHz pulse-width-modulation (PWM) per motor
- Up to 14 bit x 1 Msample/s in feed-back from sensors
- Localized Kalman filtering
- Built in heater
- -160 to 150 degrees C in storage temperature
- -40 to 80 degrees C in operational temperature
- Maximum 50 x 50 x 3 mm^3 in volume



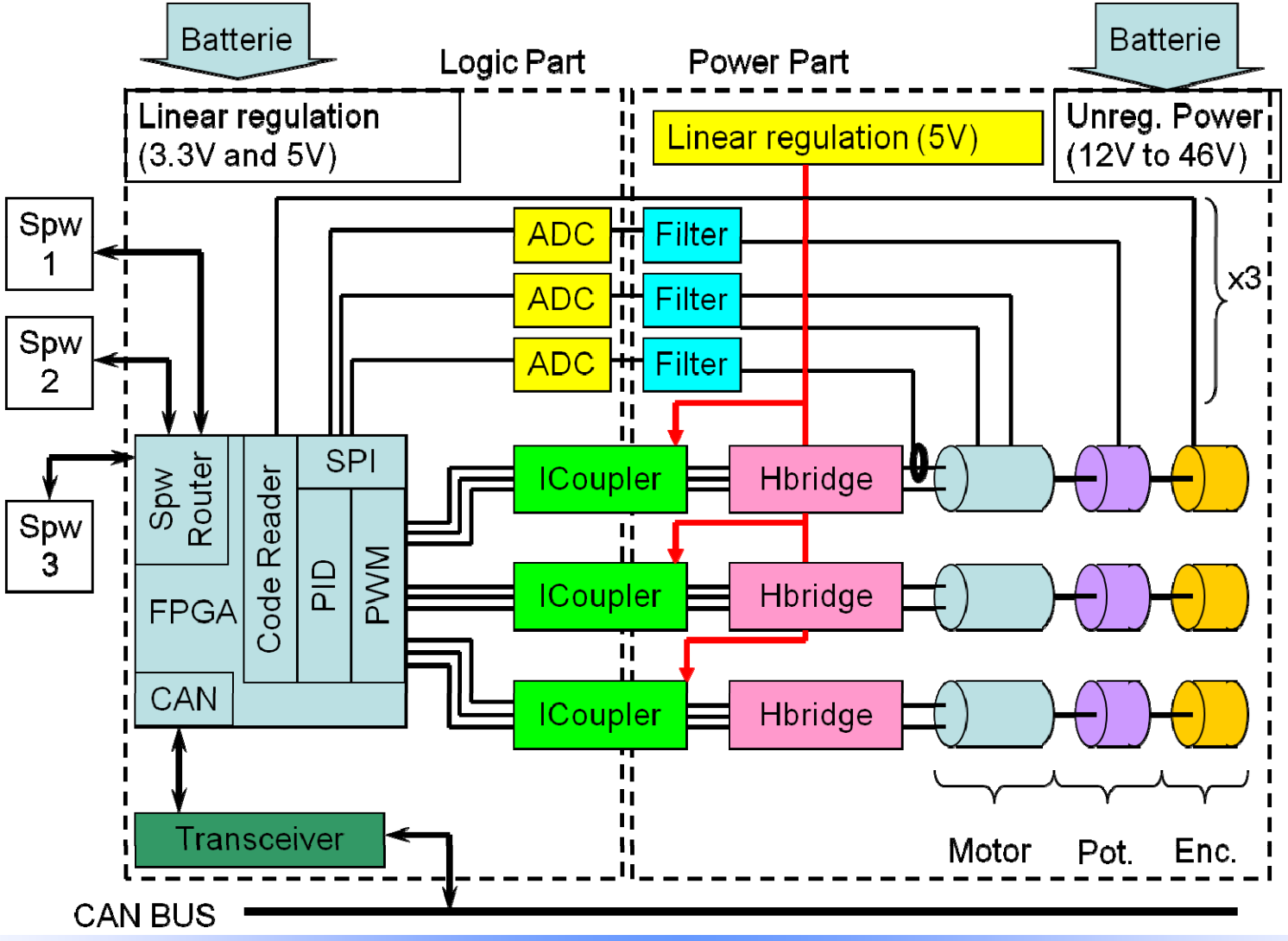
Phase 1 – Block Diagram

- Verification of critical parts (motor drivers). Heritage claimed from RTU for the digital parts. Important to find out if galvanic isolation is needed. Phase 1 includes option to bypass ICoupler.



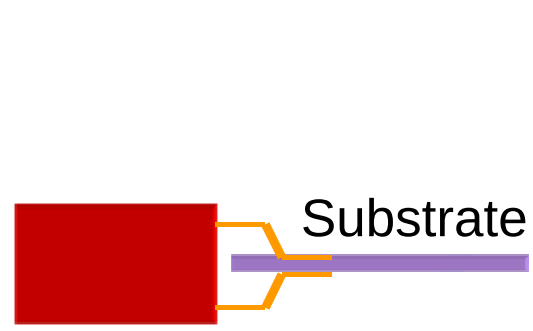
Phase 3 – Block Diagram

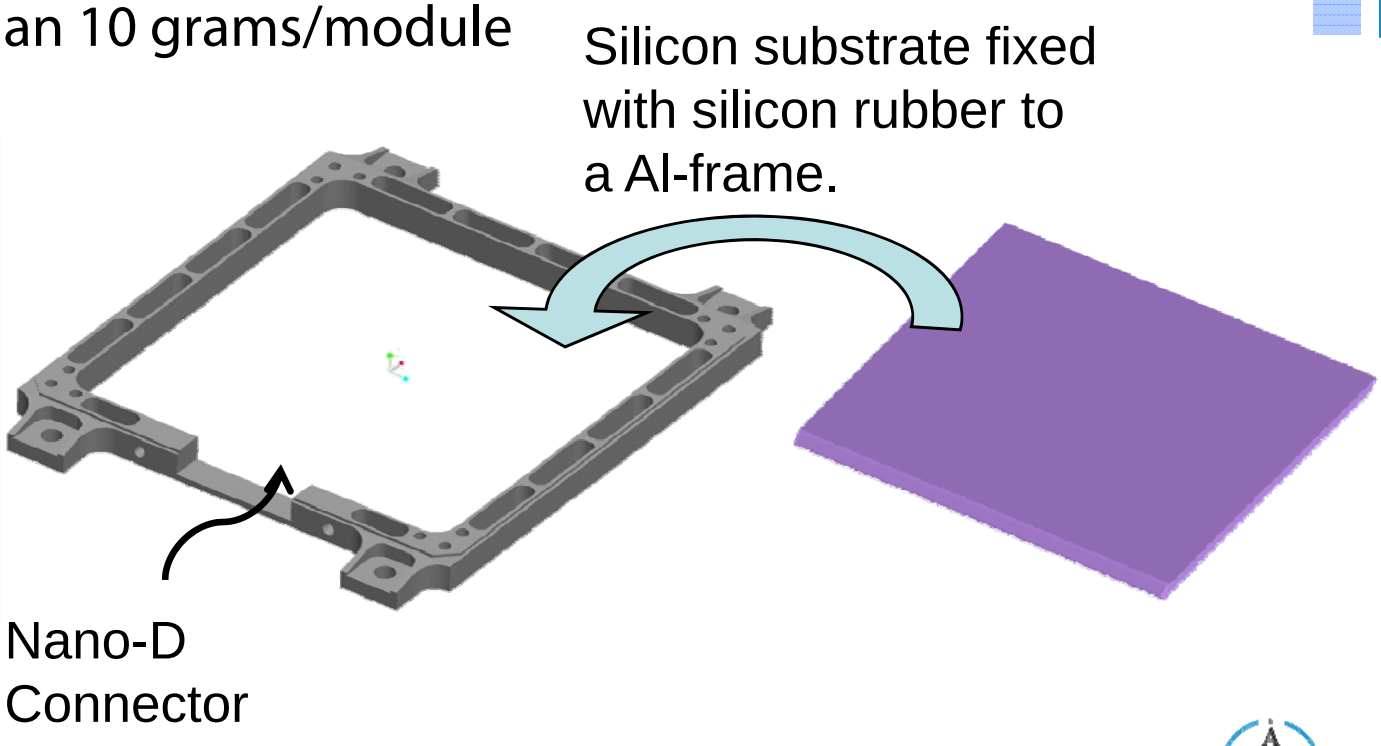
- QM includes everything in 3D-SiP.
- ICoupler is still TBD from Phase 1.



Phase 3 – QM preliminary concept design

- ✓ QM is expected to work to -160 to 150 degrees C
- ✓ The silicon rubber interface between the substrate and the protective box need further investigation
- ✓ The box protects the 3D-SiP technology from dust and provides radiation protection
- ✓ 50 x 50 x 3 mm^3
- ✓ Weight: less than 10 grams/module





Potential Implementation Examples

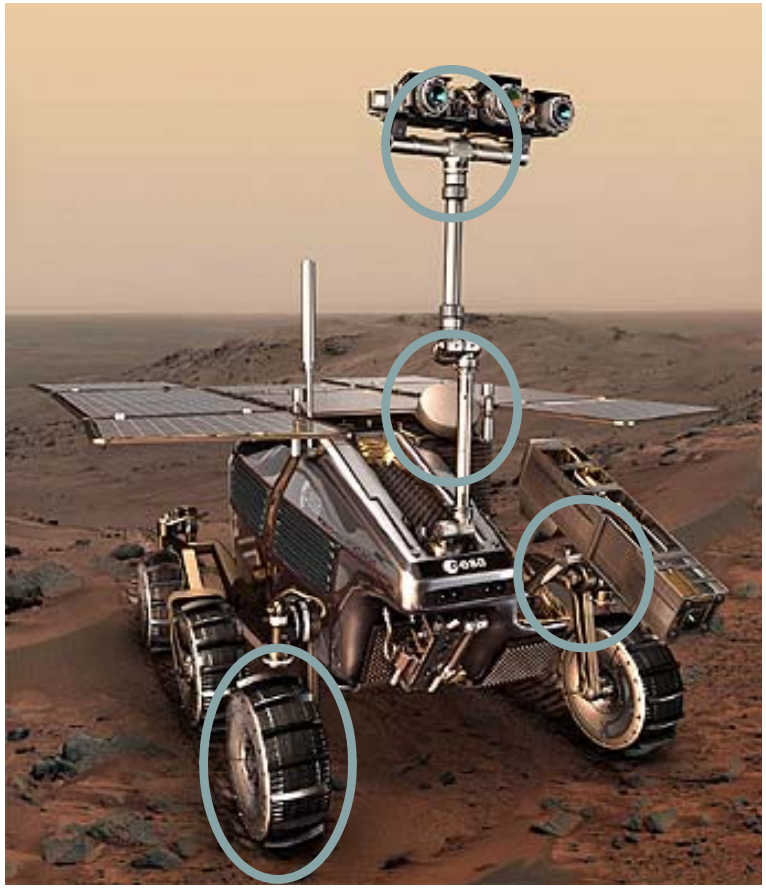


Image: ESA

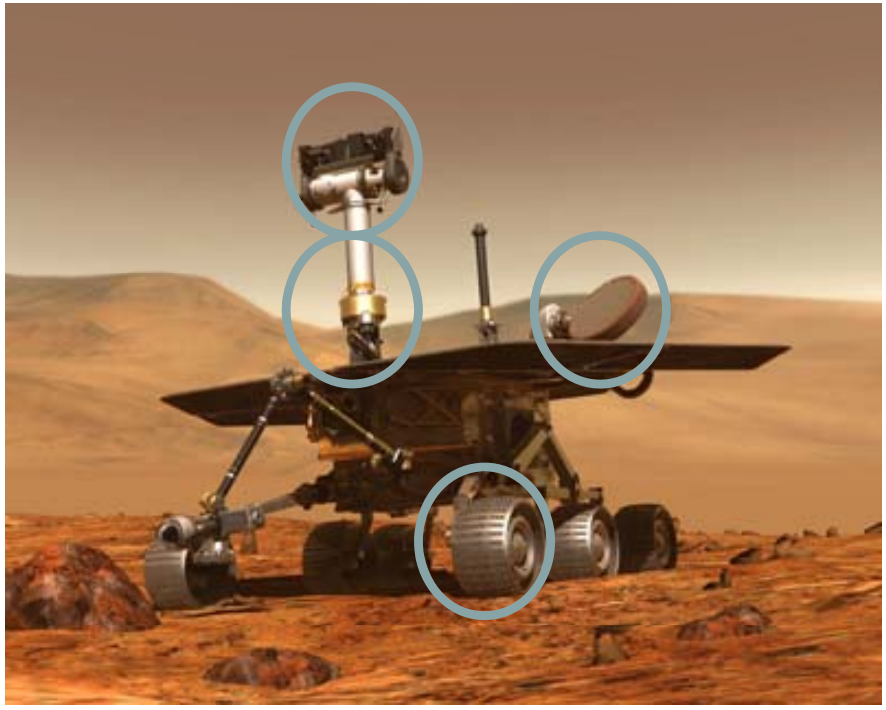


Image: NASA

Conslusions

- Heritage from ÅAC 3D-SiP technology show that the development is feasible
- Qualification issues are to be discussed with ESA
- Enables a massive increase of payload on large complex robots and rovers
- Enables a much easier system integration as a multifunctional element (thermal properties, structural element, electrical function, and possible electromechanical function)

THANK YOU FOR YOUR ATTENTION