SPACE SCIENCE

Astrophysics
- infrared and submillimetre astronomy
- ultraviolet and optical astronomy
- X-ray and gamma-ray astronomy

Planetary and space science
- space plasma physics
- planetary science
- cometary science

Solar and heliospheric physics

EARTH OBSERVATION AND ENVIRONMENTAL SCIENCE

Earth resources
- advanced remote sensing
- instrumentation: passive microwave radiometry and sounding, synthetic aperture radars, scatterometers and altimeters, multispectral scanner
- data processing methodologies: processing of image data, processing of synthetic aperture radar data and scatterometers
- atmospheric processes and their influence on remote sensing measurements
- advanced technology (satellite): large-scale memories, optical charge coupled and acoustic wave devices for image and side-looking radar data handling
- computer simulation of on-board processing systems

Geodesy, geophysics
- Earth kinematics studies
- refined studies on Earth potential
- geodynamics, earthquake prediction research
- position-determination and navigation systems
- physical oceanography
- ice dynamics
- studies of scientific and operational aspects of satellite observation laser systems for precise position determination and clock synchronisation
- satellite magnetometry

Meteorology, climatology, radiative budget of Earth

Software and systems
- picture processing (wind field extraction, sea-surface temperature), temperature profile inversion techniques (infrared and microwave)
- microwave radiometry and sounding applied to meteorology
- limb sounders, submillimetre heterodyne spectrometry, lidars

LIFE SCIENCES AND SCIENCE IN MICROGRAVITY CONDITIONS

Life sciences
- vestibular research, neurophysiology
- physiology, cardiopulmonary and musculoskeletal systems, regulatory processes
- cytology
- rhythms
- radiation biophysics
- developmental biology
- psycho-physiology
- biochemistry
- plant physiology
- microbiology
- bioengineering
- clinical medicine
- exobiology
- bioprocessing

Materials sciences
- fluid phenomena influencing the design of microgravity experiments
- experimental/mathematical modelling
- metallurgy, composites, glasses
- crystal growth
- chemistry
- techniques related to experimentation under microgravity
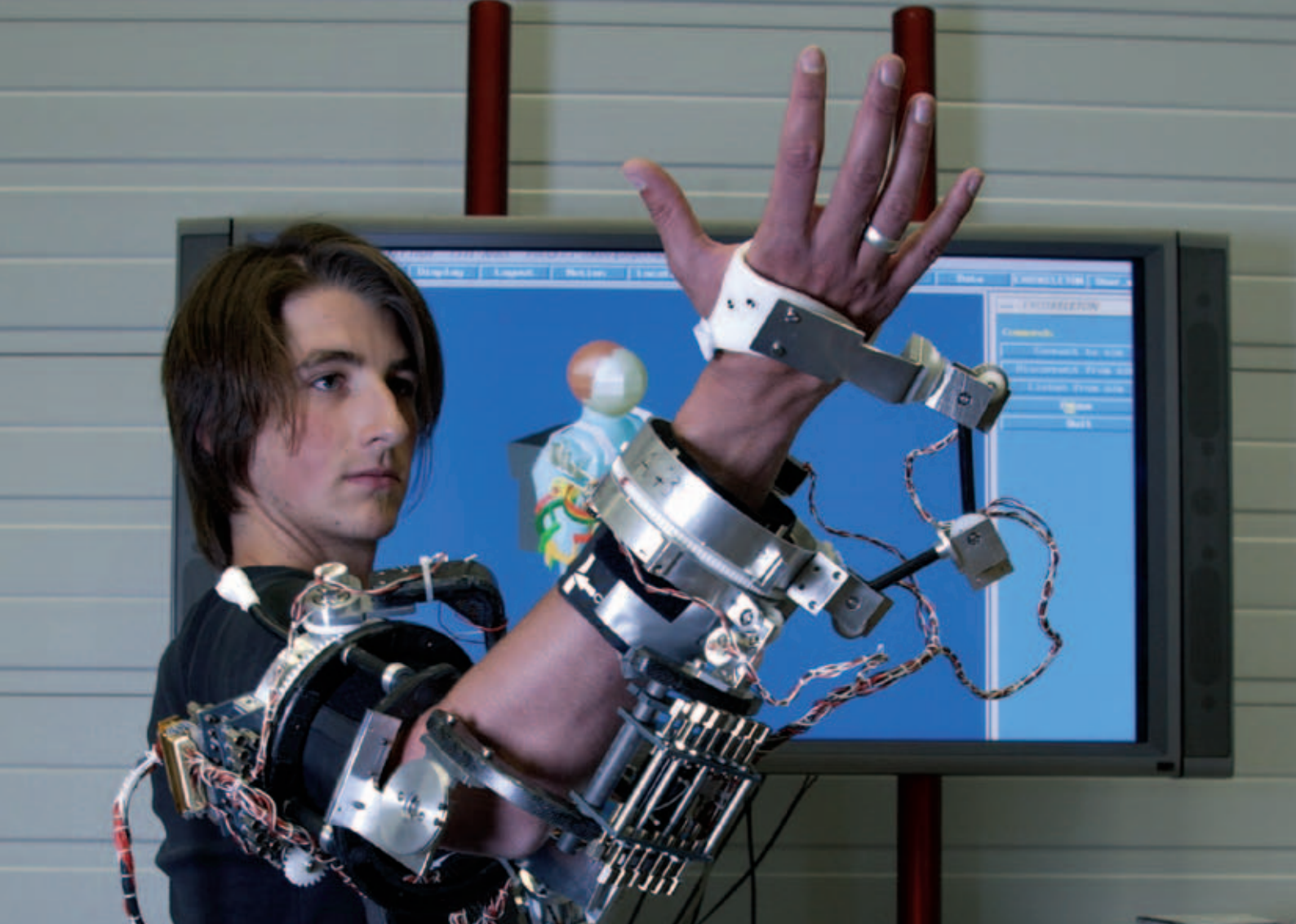
SPACE TECHNOLOGY

Spacecraft structures
- structure analysis methods (computer-aided design, dynamics, design verification
- advanced composite structures
- smart structures
- erectable structures (large areas)
- fatigue and fracture mechanics

Spacecraft propulsion
- Chemical propulsion
  - thermodynamic analyses of advanced engine cycles for storable and cryogenic bipropellant rocket engines
  - combustion instability studies
  - rocket exhaust plume analyses; plume flow-field characteristics; plume impingement effects
  - heat transfer analysis for rocket engines; regenerative cooling, film cooling
  - use of advanced materials for rocket engines (composites)

- Electric propulsion
  - mission analyses for orbital manoeuvres using electric propulsion; high-energy orbits, drag compensation for low orbits
  - plasma physics and electro-optical analyses for field emission electric propulsion

Launcher propulsion
- Rocket propulsion
  - derivation and thermodynamic performance analysis of advanced rocket engine cycles for future launchers: influence of combustion pressure, variable mixture ratio, external expansion nozzles, advanced materials, dual fuel and tripropellant engines

- Air-breathing propulsion
  - thermodynamic analysis of advanced engine cycles for hydrogen fuelled air-breathing engines, including combined-cycle engines, for use in future reusable launchers
  - analysis of the installed propulsive performance of air-breathing engines in reusable launchers: force accounting and balance for thrust, drag, lift and weight
  - derivation of installed engine performance, specific impulse and vehicle velocity losses as functions of altitude, Mach, incidence and bank angles

Mechanisms
- despun systems
- solar array drives
- space tribology
- deployment booms and large masts
- precision mechanisms for optical payload instruments

- advanced momentum/energy storage actuators
- precision-pointing mechanisms

Thermal control
- thermal analysis and modelling
- thermal software development

Thermal control technology
- heat transport (two-phase loops, heat pipes, fluid loops)
- heat rejection (passive, heat pipe, hybrid and advanced radiators)
- cryogenic cooling (cryostats, mechanical coolers and very-low-temperature cooling)
- thermal protection systems for reentry and planetary entry vehicles

Environment control and life support (ECLS)
- ECLS analysis and modelling
- life-support software development

Life-support technology (physico-chemical and biological)
- air management systems
- water management systems
- food management systems
- closed ecological life support systems (CELSS)

Habitability of manned vehicles and planetary bases
- architecture
- hygiene
- comfort
- psychological issues
- physiological issues

RF systems
- analogue and digital communication systems design and analysis, including space and ground segments
- communication techniques (coding, modulation, access, etc.)
- TT&C techniques
- Global navigation
- advanced remote sensing microwave instruments (radar radiometer, etc.), design and analysis
- microwave and digital technologies for satellite payloads (low-noise receivers, power amplification, frequency generation, filters, modems, etc.)
- equipment, subsystems, systems performance evaluation in RF system laboratories

Antennas, electromagnetism, propagation
- antenna design and simulation
- antenna calibration and measurement
- electromagnetic compatibility
- propagation, wave interactions

Attitude and orbit control
- dynamic simulation of large flexible spacecraft
- application of modern information/control theory to advanced attitude measurement/control systems and to robotic control
- control organisation for flexible robot manipulators
- use of onboard processors for attitude control
- dynamics of liquids (stability, energy, dissipation)
- use of attitude detectors and gyros for spacecraft control
- studies of gravity gradient and solar sailing
- expert systems for control and diagnosis
- studies of rendezvous and docking of spacecraft in orbit

Robotics
- kinematics and dynamic analysis and simulation
- control systems and algorithms computation
- robot programming and calibration
- diagnostics, planning and recovery
- sensor and sensor-based control systems
- joints and electro-mechanical actuators
- wrists, end-effectors and grippers
- electronic and electromagnetic drives
- collision avoidance and intelligent control

- teleoperation and man/machine interfaces
- space payload servicing and automation
- space capture and berthing

Optics
- advanced optical detectors (solid state, single point, array, matrix)
- advanced optical instrumentation for Earth observation
- optical computers
- components for astronomical observations at various wavelengths
- advanced optical methods for pattern recognition, data transfer, etc.
- coherent, superheterodyne and homodyne detection

Energy conversion

Solar cells and arrays

Batteries

Electronics power conditioning and control
- space environment
- electromagnetic shielding at low frequencies
- prediction of electromagnetic interference on board spacecraft
- control of spacecraft vibration tests
- alternative test methods to space simulation
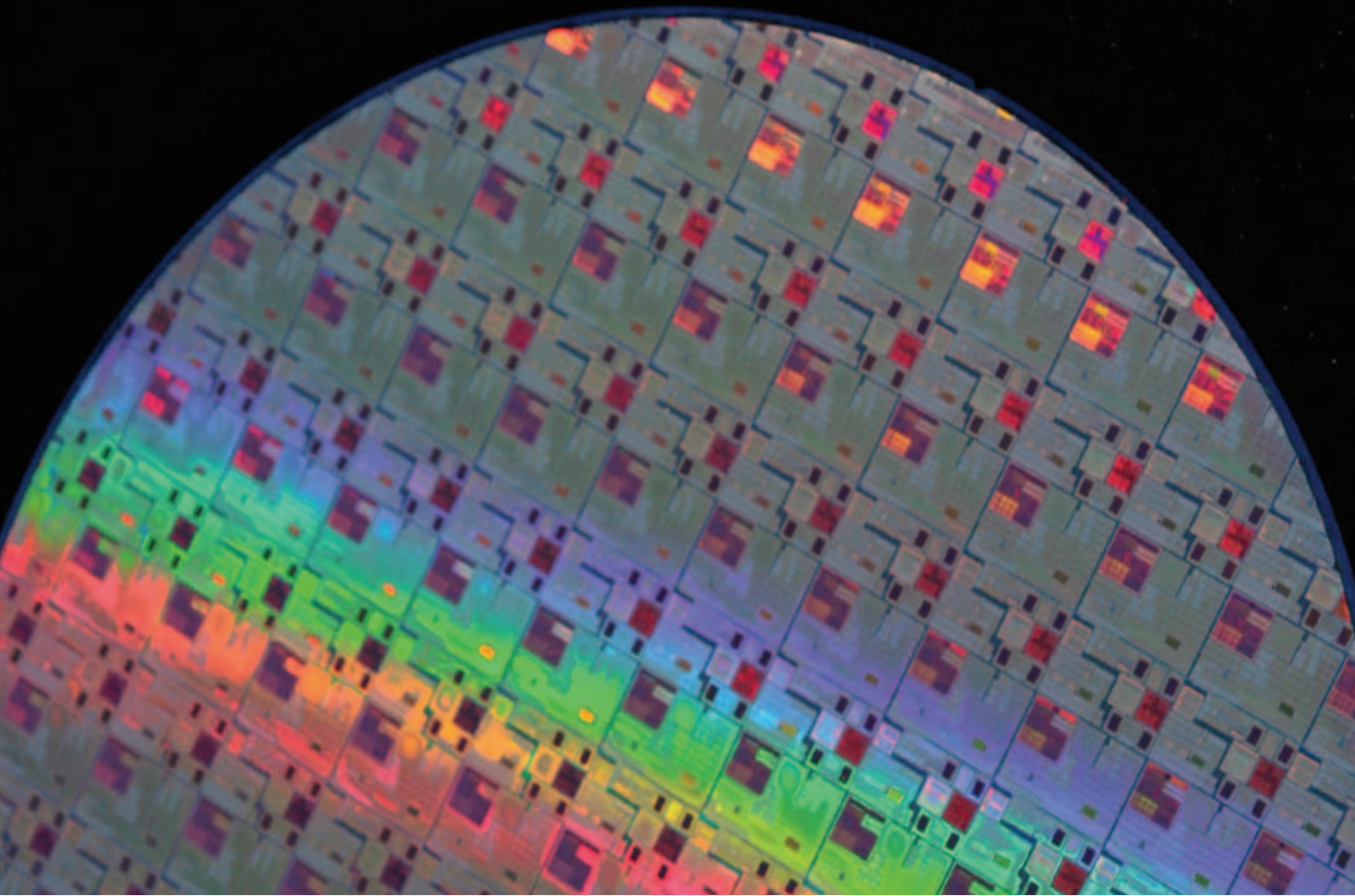
- modal survey tests versus systems tests, influence on cost, reliability and schedule
- spacecraft model philosophy, influence on reliability, cost and schedule

Product assurance
- cost-effectiveness
- availability and maintainability in space segment
- reliability of mechanical systems
- electronic, electrical and electromechanical components:
  - physics failure and reliability
  - new failure and analysis techniques for complex integrated circuits
  - effects of space radiation (e.g. particles, ions, X-rays) on advanced semi-conductor technologies
  - radiation hardening of MOS technologies
- biocompatibility of components in closed environmental systems
- software product assurance
- databases
- expert systems for RAMS
- sneak circuit analysis

System engineering applications
- long-term mission studies to determine technology developments needs
- studies on definition and coherence of future space programmes

- spacecraft and launcher system engineering concepts, optimisation
- space systems utilisation and mission studies
- space operations, in-orbit servicing and support

Tools and tool applications
- CAD for system level applications, visualisation tools
- expert systems and artificial intelligence in system design
- large collections of data – their handling and analysis including technical performance of systems and their costs, technology database

GROUND SEGMENT TECHNOLOGIES

Study, development and validation of ground-based technologies for support of mission operations in the following fields:
- ground data processing facilities for spacecraft monitoring and control, mission planning and management: expert systems, advanced man/machine interfaces, fault tolerance systems, object-oriented techniques, etc.
- communication network concepts and

protocols supporting different media and modes of operation in the space-to-ground link environment
- spacecraft attitude and orbit determination and control: modelling, numerical methods and techniques, manoeuvre optimisation
- ground station monitoring and control, data acquisition and transmission processing including associated coding techniques in different RF bands
- space debris assessment: debris observation techniques, modelling of space debris environment, debris risk analysis

APPLIED MATHEMATICS AND DATA PROCESSING

Applied mathematics
- mathematical analysis
- numerical integration
- estimation of theory
- optimisation procedures
- dynamic analysis of non-rigid systems
- orbital calculations and mission analysis
- CFD: computational fluid dynamics
- simulation of physical systems
- simulation and emulation of logical (computerised) systems with embedded software