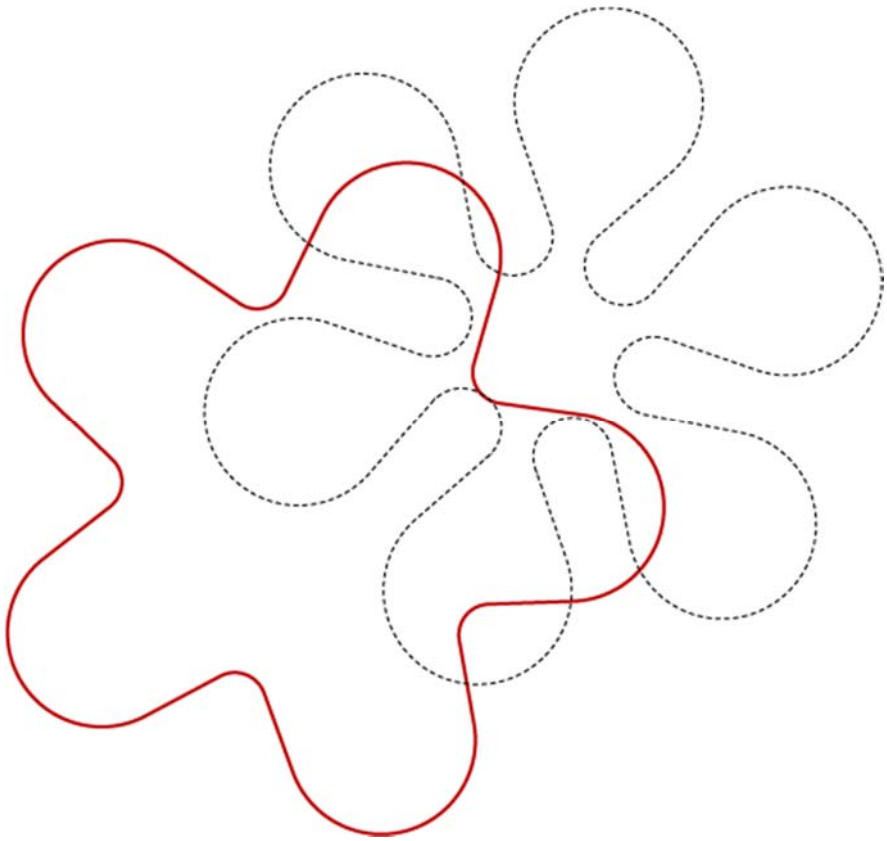
UNIVERSITÀ DEGLI STUDI DI TORINO
Direzione Ricerca e Terza Missione

UniTo Competencies

AEROSPACE



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DEPARTMENT OF CHEMISTRY

Metallic and Polymeric Materials Groups (prof. Baricco, prof. Zanetti)	
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Critical technology Descripti on	

Materials for Radiation Shielding

For space flights beyond the Earth's magnetosphere, both Galactic Cosmic Ray (GCR) and Solar Particle Event (SPE) environments pose a risk to astronauts for missions beyond Low Earth Orbit (LEO). The most significant constituents of this environment are energetic protons and heavy ions (85 percent protons, 14 percent alpha particles and 1 percent heavier nuclei).

Materials with the smallest mean atomic mass make the lightest and most efficient shields. Lithium hydride (LiH) is a highly efficient neutron-shielding material. It contains, combined into a single, stable compound, two of the most effective elements in attenuating and absorbing neutrons. However, light-metal hydrides react with air and moisture. This reactivity is of concern if the material is inside the living compartment where oxygen and water are both present.

LiH can be used in various forms for radiation shielding . It can be melted and cast in inert atmospheres or cold pressed from powder form into convenient shapes. LiH can be inertized molding it with a non-polar polymer with a good barrier effect against moisture and oxygen. LiH can be also mixed with carbon-based materials to obtain composites.

Current TRL	

TRL: 3. Research has been performed up to now with preliminary tests on sintered pellets. The goal is to increase the TRL with demonstration devices.

Compentencies	

Experiences and equipment available at the Department of Chemistry of the University of Turin will allow the preparation and characterization of suggested materials. Preparation will be possible with various available equipments (e.g. furnaces, ball miller, glove box,etc.). In addition, structural, mechanical, thermal and chemical characterizations will be performed with equipments available at the Department of Chemistry (www.chemistry.unito.it) and at NIS (www.nis.unito.it).

DEPARTMENT OF CHEMISTRY

Metallic Materials Group (prof. Battezzati)	
E-mail	livio.battezzati@unito.it
Critical technology description	
Materials science in space: use of microgravity facilities to obtain thermophysical properties of industrial alloys. Recent developments in modelling high-temperature melt processing can provide 3D analysis of melt convection, temperature and heat flux distribution and, thus, predictions for cast product quality. However, the lack of reliable thermophysical property (volume and surface) data of high-temperature melts as input parameters limit this attainment considerably. Measurements of thermophysical properties are difficult or impossible at elevated temperatures with conventional methods because of the generally high chemical reactivity and fluidity of metallic melts. Recent progress in container less levitation and processing techniques can overcome these experimental difficulties and enable measurements of various properties of “free-floating” metallic drops in the stable und undercooled liquid state. The data are used as benchmark for those obtained on ground. The research is meant to provide the casting industry with precise data for solidification modelling. Materials studied to date include: steels and cast irons, superalloys, Copper alloys, Titanium alloys, all of industrial origin as well as newly developed metallic glass-formers.	
Current TRL	
TRL 8. Samples have been delivered to ESA for space experiments which are presently performed employing the levitation facility implemented on the ISS.	
Compentencies	
Large preparatory program has been performed on-ground by measuring thermal properties (temperature of melting/solidification, other transformation temperatures, heat of fusion, specific heat, fraction solid for steels and cast irons, superalloys, Copper alloys, Titanium alloys.	
Background	
ThermoLab: precise measurement of thermophysical properties of industrial alloys: ESA-MAP project of the ELIPS program. CoolCop (now merged in Liphase): demixing from liquid alloys: ESA-MAP project of the ELIPS program. H.-J. Fecht, R. Wunderlich, L. Battezzati, J. Etay, E. Ricci, S. Seetharaman, I. Egry, Physics in Space - Thermophysical Properties of Materials Europhysicsnews, 39 (5) (2008) 19-21. L. Battezzati, D. Baldissin The Thermolab Project: Thermophysical properties of superalloys, High Temperature Materials and Processes, 27 (2008) 423-428. Ricci, E., Battezzati, L., Brooks, R., Chapman, L.A., Fecht, H.J., Giuranno, D., Novakovic, R., Seetharaman, S., Voss, D., Wunderlich, R. Thermophysical properties of Cu-based industrial alloys in the liquid phase, High Temperatures - High Pressures ,Volume 38, Issue 1, 2009, Pages 43-61 R. K. Wunderlich, H. -J. Fecht, I. Egry, J. Etay, L. Battezzati, E. Ricci, T. Matsushita and .Seetharaman Thermophysical Properties of a Fr- Cr- Mo Alloy in the Solid and Liquid Phase. Steel Research International, 83 (2012) 43-54. S. Amore, F. Valenza, D. Giuranno, R. Novakovic, G. Dalla Fontana, L. Battezzati, E. Ricci Thermophysical properties of some Ni-based superalloys in the liquid state relevant for solidification processing. J Mater Sci (2016) 51:1680–1691	

DEPARTMENT OF CHEMISTRY

Metallic Materials Group (prof. Battezzati)	
E-mail	livio.battezzati@unito.it
Critical technology description	
Materials for applications in extreme environment**:** Development of new multicomponent alloys (high entropy alloys) for high temperature and harsh environment application. Alloys based on transition and refractory elements, all in equal amount, are cast and characterized for their microstructure, corrosion resistance and mechanical properties. Their research applicability concerns at the moment: 1) aeronautical components 2) medical appliances 3) automotive components.	
Current TRL	
TRL 4. Research has been undertaken to pinpoint alloy composition. Synthesis has been successful in several cases. Properties (hardness, oxidation resistance, wear resistance) are encouraging. A prototype coating for seat valves is available.	
Compentencies	
Backgound on basic principles of alloy formulation. Experience on alloy synthesis and characterization.	
Background	
Nanosciences, nanotechnologies, materials &new production technologies Call identifier FP7-NMP-2010-4.0-3: Project Title: “The Accelerated Discovery of Alloy Formulations using Combinatorial Principles” Marco Gabriele Poletti, Livio Battezzati, Electronic and thermodynamic criteria for the occurrence of high entropy alloys in metallic systems Acta Materialia, 75 (2014) 297–306. Poletti MG, Fiore G, Gili F, Mangherini D, Battezzati L. Development of a new high entropy alloy for wear resistance: FeCoCrNiW0.3 and FeCoCrNiW0.3+5 at.% of C MATERIALS & DESIGN, 115 (2017) 247-254.	

DEPARTMENT OF CHEMISTRY

Metallic Materials Group (prof. Battezzati)	
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Critical technology description	
Rapid solidification and additive manufacturing. Additive Manufacturing by Selective Laser Melting (SLM) layers of metallic powders implies spreading on a preheated building platform and local melting by a concentrated high power laser. According to a CAD model, once the first layer is complete, the building platform drops one layer down, the material is recoated with new powder and the process is repeated until an entire build is additively manufactured. During this process the molten pool is quenched by the pre-solidified layers. Rapid solidification occurs whose microstructural features have consequences on the mechanical properties of the product. In order to understand in detail the solidification mechanism in SLM, Al-Si eutectic samples were produced using other rapid solidification techniques: Copper Mould Casting (CMC) and Melt Spinning (MS) spanning a large range of cooling rates. The materials are studied with a combination of laboratory techniques. From the results obtained in these experiments a microstructural correlation among techniques is established. From data on supersaturation, calorimetric responses, and size of the microstructural features a mechanism for solidification is proposed and validated by dendrite growth modelling which enables interpreting the fine microstructures occurring in AM and suggesting means for the control of processing.	
Current TRL	
TRL 4. Rapid solidification techniques are in place. Processes have been performed using industrial alloys, e. g. AlSi10Mg. Materials are characterized to reveal microstructure and properties (hardness, supersaturation, fraction of components). Correlation with processing parameters is being sought.	
Compentencies	
Backgound on basics of rapid solidification. Experience in alloy synthesis and characterization.	
Background	
Progetto di ricerca ”Sviluppo Tecnologico dell’Additive Manufacturing in Piemonte- STAMP”, Regione Piemonte, Piattaforma Tecnologica Fabbrica intelligente (2016).	

DEPARTMENT OF CHEMISTRY

Metallic Materials Group (prof. Castellero)	
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Critical technology description	

Thermoelectric materials for waste heat harvesting

Thermoelectric conversion of waste heat into electrical energy can be used in aerospace missions for supplying electrical energy through a reliable, robust, compact and long-standing technology. Efficiency of thermoelectric conversion depends of the figure of merit, ZT, and can be maximized by increasing the power factor (i.e. product of the electrical conductivity and the square Seebeck coefficient) and decreasing the thermal conductivity. However, the maximum value of ZT is limited by the correlation between the transport properties involved. At present, the following strategies are pursued in order to increase ZT: 1) the power factor can be maximized by tuning the charge carrier concentration through doping of TE semiconductors. Further increase of the power factor occurs by energy-dependent electron filtering when coherent nano-phases are embedded in the matrix; 2) thermal conductivity, electronic and phonon contributions can be decoupled by inserting centres for phonon scattering (point defects, grain boundaries, substitutional solid solutions). This approach has been applied to the following thermoelectric materials: Zn4Sb3, AgSbTe2, skutterudites, half-Heusler compounds.

Current TRL	

TRL: 3. Research has been undertaken to use non equilibrium processing techniques to obtain grain refined materials with reduced thermal conductivity. Thermoelectric properties of materials obtained by different processing routes were compared.

Compentencies	

Experiences and equipment available at the Department of Chemistry of the University of Turin will allow the preparation and characterization of suggested materials. Preparation will be possible with various available equipments (e.g. furnaces, ball miller, etc.). In addition, structural, microstructural, mechanical, thermal and chemical characterizations will be performed with equipments available at the Department of Chemistry (www.chemistry.unito.it) and at NIS (www.nis.unito.it).

Background	

Projects: BANDO CRT 2015, BANDO ATENEO/CSP 2016

Papers: Journal of Alloys and Compounds, Vol. 653 (2015), pp. 54-60.

Scripta Materialia, Vol. 113 (2016), pp. 110-113.

Journal of Nanoscience and Nanotechnology, Vol. 17 (2017), pp. 1650-1656.

DEPARTMENT OF CHEMISTRY

Metallic Materials Group (prof. Rizzi)	
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Critical technology description	
Development of new sintering techniques for the synthesis of wick for heat pipes for aeronautical applications. Production of wicks with optimised capillarity and permeability tailoring sintering parameters, i.e. powders morphology and composition, sintering temperatures and times, atmospheres and vacuum conditions.	
Current TRL	
TRL: 3. Research has been undertaken to define sintering parameters and alloy compositions in order to obtain an adequate porosity for optimised capillarity and permeability	
Compentencies	
Experience on metallic materials synthesis and characterisation	
Background	
Regional project (MESAP) HEAT.	

DEPARTMENT OF CHEMISTRY

FABLAB (Prof. Anfossi)	
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Critical technology description	
Stand-alone biosensors for monitoring cortisol in saliva as a biomarker of stress	
Current TRL	
TRL: 7-8	
Compentencies	
We are able to develop and produce prototypes of rapid strip tests (exploiting the lateral flow immunoassay technology) that allow measuring different hormones and other biomarkers in saliva to monitor astronaut wellbeing.	
Background	

We already developed a device for monitoring astronaut' stress by measuring their salivary cortisol as a partner of a joined project with the University of Bologna and ASI.

Some of the results obtained within the project have been published in:

- Zangheri M, Cevenini L, Anfossi L, Baggiani C, Simoni P, Di Nardo F, Roda A. A simple and compact smartphone accessory for quantitative chemiluminescence-based lateral flow immunoassay for salivary cortisol detection. Biosens Bioelectron. 2015,64:63-8. doi: 10.1016/j.bios.2014.08.048
- Zangheri M, Di Nardo F, Mirasoli M, Anfossi L, Nascetti A, Caputo D, De Cesare G, Guardigli M, Baggiani C, Roda A Chemiluminescence lateral flow immunoassay cartridge with integrated amorphous silicon photosensors array for human serum albumin detection in urine samples. Anal Bioanal Chem. 2016, 408:8869-8879. doi: 10.1007/s00216-016-9991-0

Besides, the research group's experience in the development of lateral flow-based assays allowed us to develop tests for disparate applications. We also designed a commercial device for detecting stress in dogs in partnership with a company.

- Di Nardo F, Anfossi L, Giovannoli C, Passini C, Goftman VV, Goryacheva IY, Baggiani C. A fluorescent immunochromatographic strip test using Quantum Dots for fumonisins detection. Talanta 2016, 150:463-8. doi: 10.1016/j.talanta.2015.12.072.
- Di Nardo F, Anfossi L, Ozella L, Saccani A, Giovannoli C, Spano G, Baggiani C. Validation of a qualitative immunochromatographic test for the noninvasive assessment of stress in dogs. J Chromatogr B Analyt Technol Biomed Life Sci. 2016, 1028:192-8. doi: 10.1016/j.jchromb.2016.06.019. Epub 2016 Jun 16.

DEPARTMENT OF CHEMISTRY

Toxicity and Biocompatibility of Materials (TBM) (dott. Turci, dott. Corazzari)	
E-mail	francesco.turci@unito.it
Critical technology description	
Feasible in vitro methods for the measurement of the potential toxicity of extra-terrestrial dusts during planetary exploration	
Current TRL	
TRL: 5	
Competencies	
We are able to develop in vitro tests to assess in situ the toxic potential of inhalable extra-terrestrial mineral dusts by evidencing their interactions with models of cell membrane, biological fluids and bio-molecules. High-throughput approaches and measurement automation are potentially available.	
Background	

As signaled by several Apollo's crews, manned exploration of extraterrestrial planets may expose astronauts' skin and lung to unknown mineral dusts. The proton and UV radiation, and micrometeorite impacts cause a high surface chemical reactivity of the dust, likely making the dust irritating or toxic for human lung and tissue. Using NASA Johnson Space Center's lunar dust simulant (JSC-1A), cell-free methods to assess the potential toxicity of lunar dust during IVA/EVA were developed. The project was conceived within the activities of the Topical Team for the Toxicity of Lunar Dust (T3LD) organized by ESA in 2010 and some of the results have been published in:

F Turci, I Corazzari, G Alberto, G Martra, and B Fubini. *Free-Radical Chemistry as a Means to Evaluate Lunar Dust Health Hazard in View of Future Missions to the Moon*, Astrobiology, **2015**.

The TBM group @ UniTO is active in the study of the interaction between inorganic materials and living matter and has developed a set of in vitro tests which may be employed to predict both environmental and occupational toxicity of unknown particulate matter. The group is also active in the evaluation of the biocompatibility of materials for biomedical applications.

I Corazzari, F A Deorsola, G Gulino, E Aldieri, S Bensaid, F Turci, D Fino, *Hazard assessment of W and Mo sulphide nanomaterials for automotive use, Journal of Nanoparticle Research*, **2014.**

F Turci, C Pavan, R Leinardi, M Tomatis, L Pastero, D Garry, S Anguissola, D Lison, B Fubini. *Revisiting the paradigm of silica pathogenicity with synthetic quartz crystals: The role of crystallinity and surface disorder*, Particle and Fibre Toxicology, **2016**.

I Corazzari, M Tomatis, F Turci, S Ferraris, E Bertone, E Prenesti, E Vernè. *Gallic acid grafting modulates the oxidative potential of ferrimagnetic bioactive glass-ceramic SC-45*, Colloids and Surfaces B: Biointerfaces, **2016**.

DEPARTMENT OF CHEMISTRY

SURFIN (Prof. Ricchiardi, prof. Scarano, dott. Cesano)	
E-mail	federico.cesano@unito.it
Critical technology description	
Fabrication and chemical physical analysis of ablative heat shields and other aerospace composite materials. Fabrication of low-density (0.3 g/cm^3) polymer-based carbon/ceramic composite monoliths. Large -area samples were obtained via a preliminary production stage, to be tested in the plasma wind tunnel (PWT) facility (STEPS-2Project, see below). Within two local Projects carried out in collaboration with several small, medium and large enterprises, chemical physical methods were adopted in the investigation of materials suitable for thermal protection systems in space missions (Mars and Earth return).	
Current TRL	
TRL: 4-5	
Competencies	
Lab-scale fabrication of organic-inorganic materials and composites, together with chemical physical analyses, including: morphology, structure, phase, composition, surface and bulk properties by means of TEM, SEM and SPM techniques, FTIR, Raman, and UV-Vis spectroscopies. Other skills and experimental techniques including X-ray diffraction, thermal analyses: calorimetry, differential scanning calorimetry, thermogravimetry, porosimetry, gas adsorption also are available. Furthermore, specific competencies (i.e. evaluation of emissivity, of formation enthalpy of new and of charred materials, specific heat, UV and X-ray material exposure testing, material failure and damaging analysis) are also accessible.	
Background	
“Sistemi e Tecnologie per l’EsPlorazione Spaziale” (STEPS), Misura Piattaforme Innovative" PROGETTO Regionale POR FESR 2007/2013. Thales (capofila),”2013-2015; Sistemi e Tecnologie per l’EsPlorazione Spaziale–fase 2”(STEPS-2), Misura Piattaforme Innovative" POR FESR 2007/2013. Thales (capofila), 2009-2012.	

DEPARTMENT OF PHYSICS

Experimental Astroparticle Physics Group (prof. Bertaina)	
E-mail	marioedoardo.bertaina@unito.it
Critical technology description	
Cosmic Ray Science *Detection and Remediation of Space Debris*	
Current TRL	
TRL: 3-5	
Compentencies	
Simulation of cosmic ray particles, their interactions in atmosphere and their detection from space. Simulation of space debris and principle of observation from space. *Development of detectors and related electronics for their observation from space.* *Experimental tests at TurLab facility at Physics Department – UNITO as well as prototype experiments on ground and from space.*	
Background	
Projects funded by INFN, ASI, MAECI under the reference: The JEM-EUSO Project and its pathfinders TA-EUSO, EUSO-Balloon, EUSO-SPB and Mini-EUSO for the study of cosmic rays at extreme energies and the Earth observation from the International Space Station." Publications: - Special Issue on The JEM-EUSO Mission, A., Medina-Tanco, G. & Santangelo, A.; Exp. Astron. (2015) 40: 1 (10.1007/s10686-015-9483-9) - T. Ebisuzaki et al., Acta Astronautica, vol.112, pp. 102–113 (2015)	

DEPARTMENT OF PHYSICS

Solid State Physics Group (dott. Olivero, prof. Truccato, prof.Vittone)	
E-mail	paolo.olivero@unito.it
Critical technology description	
Modelling and experimental protocol of ion beam induced damage in semiconductors *New micro-radiobiology devices for aerospace*; Monte Carlo numerical modelling of shielding systems for space radiation protection	
Current TRL	
Space radiation shields: 3; Ion beam induced damage in semiconductors: 4; New Micro-radiobiology devices for aerospace: 2	
Compentencies	
Magnetic shielding; integrated devices for the in vitro monitoring of cells and tissues under cosmic radiation; assessment of the radiation hardness of electronic devices for space applications.	
Background	

Title: Space Radiation Superconducting Shields – Research and Development (SR2S-RD)
Scope: Development of cosmic radiation shields based on the production of intense magnetic fields around the spaceship by means of superconducting materials
Budget: 35,000 €
Funding institution: Istituto Nazionale di Fisica Nucleare (INFN)
Main deliverable: Prototype of magnetic shield based on MgB_2 superconductor. Mathematical model of the shielding properties
Status: funded

Title: Monte Carlo numerical modelling of shielding systems for space radiation protection
Scope: Development of complex geometrical models for spacecraft and scientific equipment aimed at studying the shielding effect by means of Monte Carlo numerical simulations (Geant4), in order to transfer the external space radiation environment through the shields and determine the resulting internal radiation.
Budget: 12,500 €
Funding institution: Thales Alenia Space-Italia.
Main deliverable: Mathematical model of the shield-radiation interaction, selection of shielding materials
Status: funded

Title: Modelling and experimental protocol of ion beam induced damage in semiconductors
Scope: Development and experimental methodologies for the assessment of radiation hardness of semiconductors.
Budget: 10,000 € (research agreement within the coordinated research project F11016 “Utilization of ion accelerators for studying and modelling of radiation induced defects in semiconductors and insulators”)
Funding institution: International Atomic Energy Agency (IAEA)
Main deliverable: Theoretical-experimental protocol for the assessment of the radiation hardness of semiconductor devices
Status: funded

Title: “Diamond based detector for in vitro cellular radiobiology” (DIACELL)
Scope: Development and validation of integrated lab-on-chip devices for the simultaneous detection of the functionalities of living cellular networks and of the ionizing radiation hitting the biological sample.
Budget: 79,000 €
Funding institution: Istituto Nazionale di Fisica Nucleare (INFN)
Main deliverable: Prototype of integrated lab-on-chip / particle detector
Status: funded

Title: “New Micro-Radiobiology Devices for aeroSpace” (MiRaDS)
Scope: Development and validation in aerospace-like environments of integrated lab-on-chip devices for the simultaneous detection of the functionalities of living cellular networks and of the ionizing radiation hitting the biological sample.
Budget: 55,000 €
Funding insititution: Fondazione CRT
Main deliverable: Prototype of integrated lab-on-chip / particle detector for applications in aerospace
Status: funded

DEPARTMENT OF PHYSICS

Prof. A. Ferrari	
E-mail	ferrarim87@gmail.com
Compentences	

1. Promotion of scientific research;

2. Educating and training in space exploration science, interactive laboratory, hands-on experiments and gaming tools in science education

3. Public engagement: actively involve public audience into the organization of a spatial mission; increase scientific backgrounds of the audience; encourage young people towards science; highlight the importance of space exploration for its potential returns and applications to everyday life

Background	

1. Consorzio Interuniversitario per la Fisica Spaziale (1989-active) – CIFS: Within this frame UniTO has produced feasibility studies of ASI/ESA projects: ultraviolet astronomy within the "small missions" in the JUNO and FERMI missions and participates in the operations and theoretical studies of gamma astronomy in the AGILE project.

2. Data storage and analysis for the missions Hipparcos, SOHO and Hubble Space Telescope

3. Development of sensors for astrophysical observations at Millimeters and sub-millimeters wavelengths

- Management of the Data Reduction and Analysis Center of the Italian Mission SAX (Satellite for Astronomy X)

4. The Astronomical Park Infini.To and the Exploratorium Project: development of planetarium shows and hands-on exhibits in the science museum Infini.To

5. BANDO MIUR 2015 Cosmic Mission: l'esplorazione spaziale e la “gamification” al servizio della didattica della scienza - Associazione Apriticielo, INAF, Altec SpA

DEPARTMENT OF COMPUTER SCIENCE

Intelligent Semantic Technologies for Human and Artificial Agents Collaboration (IST-HAAC) (dott. Micalizio, dott. Torta)	
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Critical technology description	

Intelligent Support to Mission Planning and Mission Management for Autonomous Systems

In recent years there has been an increasing interest for using Unmanned Aerial Systems (UAS) or Unmanned Ground vehicles for carrying out missions which may be too long or too dangerous for humans. A similar trend is observed in the field of space exploration with the increasing relevance to robotic exploration performed by planetary rovers.

While progresses have been made for automating some of the functions (such as path planning, and obstacle avoidance), the problem of supporting all the phases of mission planning and mission management is still open.

This is particularly true when the unmanned systems have to work as a team, so that the dependencies, the possible negative interactions and the opportunities for cooperation have to be taken into account.

The technological challenge is to develop automated, intelligent systems for supporting human operators in the task of defining and supervising a mission involving a team of autonomous robots/UASs.

The problem of supporting different levels of autonomy for the robot/UAS and the shift of autonomy depending on the contextual conditions is an additional challenge.

We address intelligent agents able to:

- support the human operator in planning the mission by taking into account the capabilities of the UASs/rovers, the set of tasks to be performed, resource constraints, temporal aspects, dependencies among tasks;
- supervise the execution of a mission involving multiple UASs/rovers by determining which tasks have been successfully performed, detecting possible discrepancies between the planned activities and the actual execution, and singling out the occurrence of exogenous events which may compromise the mission;
- re-plan the mission in case of contingencies.

The involved technologies are the ones developed for multi-agent systems and in the area of Artificial Intelligence with particular attention to planning, intelligent monitoring, diagnosis, and temporal reasoning.

Current TRL	TRL: from 2 to 4 depending on the specific aspect addressed
Compentencies	

The research group has gained a significant experience in the field through the involvement in projects about intelligent supervision of complex systems in the field of space exploration since late nineties. The problem of mission planning and mission management has been investigated since 2003. The techniques and systems developed so far fall in the field of Artificial Intelligence, with particular attention to planning, intelligent monitoring, diagnosis, and temporal reasoning.

The group has developed innovative methods for:

- intelligent monitoring of teams of robotic agents
- automated solutions for mission planning and replanning
- mixed-initiative systems supporting mission planning
- solutions for involving human operators in the control loop
- adaptive approaches to plan execution depending on contextual conditions

The experience has been gained both in basic research projects and in industrial research with large industrial partners (see below).

DEPARTMENT OF COMPUTER SCIENCE

Background	

PROJECTS

On-line monitoring and intelligent supervision in autonomous space systems (2006-2008). Funded by Regione Piemonte within Bando Ricerca 2004 for Aerospace.

SMAT-F1 (Sistemi monitoraggio avanzato del territorio) (2009-2011). Funded by Regione Piemonte, was led by Alenia Aeronautica. Strong interaction of UniTo with Alenia Aeronautica, SELEX Galileo and ALTEC in the work packages devoted to design and implementation of the SSC (Stazione di Supervisione e di Controllo). Other partners were Politecnico di Torino and several SMEs.

STEPS (Sistemi e tecnologie per l'esplorazione spaziale) (2008- 2012). The project (funded by Regione Piemonte) was led by Thales Alenia Space. Strong interaction of UniTo with TAS-I, ALTEC, Politecnico di Torino, Università del Piemonte Orientale in the work package devoted to Human Robot interaction.

SMAT-F2 (Sistemi monitoraggio avanzato del territorio) (2013-2015). The project (funded by Regione Piemonte) is led by Alenia Aermacchi. The research group is involved in the WP devoted to increasing and improving the SSC (Stazione di Supervisione e di Controllo) functions (wp leader ALTEC).

Dynamic task allocation (research co-operation with Selex ES) (**2013-2015**)

PUBLICATIONS

- R. Micalizio, P. Torasso (2008). Plan Execution and Recovery in Multi Agent Systems for Space Applications. In: -. Proceedings of the 9th International Symposium on Artificial Intelligence, Robotics and Automation in Space. Los Angeles, 26-29 February **2008**, p. 1-8, Jet Propulsion Laboratory (JPL), Pasadena
- D. Tedone, S. Ferraris, E. Appella, C. Bar, M. Marello, B. Bona, A. Giordana, P. Torasso . STEPS: HMI results on First Working Prototype. In: Proc. 40th International Conference on Environmental Systems. Barcellona, pp. 2090-2103, American Institute of Aeronautics and Astronautics, **2010**
- C.M Lombardi, I. Musso, R. Micalizio, R. Trucco, G. Martucci, E. Pigozzi, P. Rosazza, S. Drovandi, Ground segment and operational concept for lunar and planetary robotic missions. Proc. *61st International Astronautical Congress 2010, IAC 2010* 10 , pp. 8351-8358, **2010**
- Roberto Micalizio, Giancarlo Nuzzolo, Enrico Scala and Pietro Torasso: Involving the Human User in the Control Architecture of an Autonomous Agent , IFIP Advances in Information and Communication Technology, Volume 331, Artificial Intelligence in Theory and Practice III, Pages 13-22, Spinger, **2010**
- P. Torasso, G. Torta. "Exploiting Automatic Validation in Human Mission Planning" in Research and Development in Intelligent Systems XXVIII, pp. 21-34, Springer, **2011**
- R. Micalizio, E. Scala, P.Torasso , Towards Robust Execution of Mission Plans for Planetary Rovers. Acta Futura, vol. 5, pp. 53-63, European Space Agency, **2012**
- M. Boccalatte, F. Brogi, F. Catalfamo, S. Maddaluno, M. Martino, V. Mellano, P. Rosazza Prin, F. Solitro, P. Torasso, G. Torta. "A Multi-UAS Cooperative Mission Over Non-Segregated Civil Areas", Journal of Intelligent & Robotic Systems, April **2013**, Volume 70, Issue 1-4, pp. 275-291
- R. Micalizio. Action failure recovery via model-based diagnosis and conformant planning. *Computational Intelligence* 29 (2) , pp. 233-280, **2013**
- R. Micalizio, P. Torasso. Cooperative Monitoring to Diagnose Multiagent Plans. J. Artif. Intell. Res. (JAIR) 51, pp. 1-70, **2014**
- E. Scala, R. Micalizio, P. Torasso. Robust plan execution via reconfiguration and replanning. AI Commun. 28(3), pp. 479-509, **2015**

DEPARTMENT OF COMPUTER SCIENCE

Real-Time Systems (Prof. Bini)	
E-mail	enrico.bini@unito.it
Critical technology description	
Real-Time Systems, Cyber-Physical Systems, Mixed-Criticality Systems, Control Systems, Adaptive Resource Management, Resource Partitioning, Integrated Modular Avionics (IMA), Resource Optimization	
Current TRL	TRL: 1 to 4
Compentencies	The Pi is a worldwide acknowledged expert in the field of real-time systems. Over the years he contributed in several areas: hierarchical scheduling (which is the theoretical foundation for IMA), adaptive resource management in presence of strict timing and physical constraints, and cyber-physical systems.
Background	

The PI contributed to several EU project when he was at Scuola Superiore Sant'Anna (Pisa, Italy) and at Lund University (Lund, Sweden). The most related ones are

ACTORS

http://www.control.lth.se/Research/finished-projects/actors-resources-in-embedded-systems.html

PREDATORS

https://www.predator-project.eu/

Feedback Computing in Cyber-Physical Systems

http://www.control.lth.se/Research/RealTimeComputing/feedback-computing-in-cyber-physical-systems.html

Biography available at http://www.di.unito.it/~bini/

PUBBLICATIONS

https://doi.org/10.1109/MM.2011.1
https://doi.org/10.1109/EMRTS.2003.1212738
https://doi.org/10.1109/TAC.2013.2279913

DEPARTMENT OF COMPUTER SCIENCE

EIDOSLAB: Digital image processing, computer vision and virtual reality	
E-mail	grangetto@di.unito.it
Critical technology description	
Virtual and Augmented reality for the simulation of environments, space missions and the prototyping of space vehicles	
Current TRL	
TRL: 3,4	
Compentencies	

Modelling of extraterrestrial environments and rover vehicles for their exploration.

Virtual and augmented reality for mission simulation, planning and training.

Virtual and augmented reality for rapid prototyping of aircraft.

The main necessary knowledge consists in creating systems suitable to get both synthesis of planetary surfaces and simulation of environmental conditions, achieving a proper degree of realism. The navigation of these environments takes place through virtual models of the lander and rover, in order to get best fit with prototypes developed by experts in various scientific contexts (mechanical, physical, etc.).

Extention, optimization and integration of currently used tools (e.g. Unity3, Irrlicht, OGRE, PhysX) can also be used to efficiently match the contraints of aeronautical applications.

Background

Sistemi e Tecnologie per l'EsPlorazione Spaziale (STEPS and STEPS2) project. The project has been funded by Regione Piemonte with UE funds. The prime contractor is Thales Alenia Space. Other partners are Politecnico di Torino, Università di Torino, other research centers and SMEs. Within the STEPS project we have collaborated with Thales Alenia Space, Seac02, ALTEC and SynArea.

Publications:

- Piovano, L., Brunello, M., Rocci, L., Basso, V., "Representing planetary terrains into a virtual reality environment for space exploration", Pattern Recognition and Image Analysis, 549-552, vol. 21, n. 3, 2011.
- Piovano Luca, Basso Valter, Rocci Lorenzo, Pasquinelli Mauro, Bar Christian, Marello Manuela, Vizzi Carlo, Lucenteforte Maurizio, Brunello Michela, Racca Filippo, Rabaioli Massimo, Menduni Eleonora and Cencetti Michele (2012). Virtual Simulation of Hostile Environments for Space Industry: From Space Missions to Territory Monitoring, Virtual Reality - Human Computer Interaction, Dr. Tang Xinxing (Ed.), ISBN: 978-953-51-0721-7, InTech.
- Soccini et al , Virtual Reality Interface for Multidisciplinary Physical Analysis of Space Vehicles, EuroVR 2014
- Soccini, Marello, Balossino, Basso , 'IXV-trajectory'and 'IXV-asset': Virtual reality applications for the aerothermodynamics analysis of IXV, IEEEVR 2015
- Soccini, Virtual Reality for Collaborative System Engineering supporting ESA experimental vehicles, EuroVR 2015
- Marello, Soccini, Rocci , VIRTUAL REALITY APPLICATIONS FOR RE-ENTRY VEHICLE AEROTHERMAL AND MISSION ANALYSIS, AIDAA 2015

DEPARTMENT OF COMPUTER SCIENCE

Machine Learning and Data Mining Group (dott. Botta, dott. Cancelliere, dott. Esposito, dott. Meo, dott. Pensa)	
E-mail	rossella.cancelliere@unito.it
Critical technology description	

Automatic Knowledge Discovery and extraction from large collection of data

We are interested in the design and development of computationally efficient algorithms and tools for automatically build predictive models from data, with applications to pattern recognition and classification tasks, as well as clustering and characterizations task

Current TRL	

Between 5 and 6

Compentencies	

Design and development of computationally efficient algorithms and tools for knowledge extraction for automatic classification

Background	

Some interesting machine learning techniques have been used in the framework of the European Space Agency (ESA) mission Gaia for global astrometry, aiming at measuring detailed properties of the 1 billion brightest stars in the sky and scheduled for launch in December 2013.

Scientific preparation of the mission involved the development of a data processing framework to handle the complex and large (in the order of 1 petabyte) data set, collected in the course of the five -year mission.

In particular neural networks are used for the diagnosis of chromaticity, an error that affects stellar measured position that was identified for the first time in the data analysis of the space mission Hipparcos of ESA. The detection and correction of chromaticity in different conditions has been addressed in recent years [1,2,3]; to this purpose, a single-hidden layer feed-forward neural network (SLFN), firstly trained by a classical back-propagation algorithm, was used to solve this diagnosis task.

After this first attempt a more efficient training algorithm based on matrix inversion has been used which allowed to reach more accurate results [4].

[1] Gai, M., Cancelliere, R.: Neural network correction of astrometric chromaticity. MNRAS 362(4), 1483–1488 (2005)

[2] Cancelliere, R., Gai, M.: Efficient computation and Neural Processing of Astrometric Images. Computing and Informatics 28, 711–727 (2009)

[3] R. Cancelliere, M. Gai, A. Slavova, Application of Polynomial Cellular Neural Networks in Diagnosis of Astrometric Chromaticity, Applied Mathematical Modelling, vol. 34, n. 12, (2010), pp. 4243 -4252

[4] R. Cancelliere, M. Gai, T. Artières, P. Gallinari. Matrix pseudoinversion for image neural processing, Lecture Notes in Computer Science, vol. 7667, part V, Springer-Verlag Berlin Heidelberg, (2012), pp.116-125

National Projects:

- PRIN 2005: Infrared Interferometry: optimisation of astrophysical observations
- COFIN 2003: Cophasing techniques and astrophysical applications of interferometry
- COFIN 2001: 3-D structure of galaxy

DEPARTMENT OF COMPUTER SCIENCE

Human Computer Interaction group (prof. Gena)	
E-mail	cristina.gena@unito.it
Critical technology description	

Persuasive technologies for human error management in the context of extensively automated, high-risk plants, Human Factors for User-centered Design; Choice and Decision Making for HCI<, Natural Interaction, Augmented reality

Current TRL	TRL 6
Compentencies	

The research team has experience in the following fields:

- Human Computer Interaction, HCI; Interaction Design, User Experience;
- Information visualization;
- Brain-computer interaction;
- Mobile, Natural, Gestural Interaction, etc.;
- Interaction with social robot in educational context
- Web-Human Interaction, Web Usability and Web Accessibility;
- Intelligent User Interfaces, their Design and Evaluation;
- User Modeling, Adaptive, and Personalized Systems and their Empirical Evaluation;

The team has also experience in the study of human error in connection with accident genesis in the context of technologically advanced, extensively automated, high-risk plants (e.g., chemical plants). To this respect, the team has explored how the adoption of persuasive technologies can help reduce the occurrence of human errors and potentially dangerous behaviours, as well as improve human actors' awareness of risks.
In an environment that requires a complex human-machine interaction, a user-centered design approach that relies on human factors competences is needed for preventing the human error and optimizing the cognitive workload. The team ha experience in i) analyzing the performance and the cognitive effort of the users; ii) co-designing with users interfaces that make events, changes, anomalies visible and reduce the complexity of operations, modes and mappings; iii) evaluating systems in order to redesign them for freeing up resources, focusing user attention and facilitating the error recovery.
Finally the research team has a more general background and experience in interaction design for supporting human choices and decisions, and in natural interaction design for augmented reality frameworks.

Background	

Publications

- Fabiana Vernero, Roberto Montanari. **Persuasive technologies in the interface of a high-risk chemical plant production processes management system**. *Cognition, Technology & Work*, 12(1), pp. 51-60, 2010.
- Fabiana Vernero, Roberto Montanari. **Risk Management Persuasive Technologies: The case of a Technologically Advanced, High-Risk Chemical Plant.** *PsychNology Journal*, 5(3), pp. 285-297, 2007.
- Anthony Jameson, Bettina Berendt, Silvia Gabrielli, Federica Cena, Cristina Gena, Fabiana Vernero and Katharina Reinecke
  Choice architecture for human-computer interaction
  Foundations and Trends in Human-Computer Interaction, 7(1-2), 1-235.
- Rapp, A; Gena, C.: **Immersion and involvement in a 3D training environment: Experimenting different points of view**. Â Computational Intelligence and Virtual Environments for Measurement Systems and Applications (CIVEMSA), 2014 IEEE International Conference on , vol., no., pp.18-23
- Amon Rapp, Federica Cena, Cristina Gena, Alessandro Marcengo, Luca Console, **Using game mechanics for field evaluation of prototype social applications: a novel methodology**
  Behaviour & Information Technology, DOI:, 10.1080/0144929X.2015.1046931
- Luca Console, Fabrizio Antonelli, Giulia Biamino, Francesca Carmagnola, Federica Cena, Elisa Chiabrando, Vincenzo Cuciti, Matteo Demichelis, Franco Fassio, Fabrizio Franceschi, Roberto Furnari, Cristina Gena, Marina Geymonat, Piercarlo Grimaldi, Pierluigi Grillo, Silvia Likavec, Ilaria Lombardi, Dario Mana, Alessandro Marcengo, Michele Mioli, Mario Mirabelli, Monica Perrero, Claudia Picardi, Federica Protti, Amon Rapp, Rossana Simeoni, Daniele Theseider Dupré, Ilaria Torre, Andrea Toso, Fabio Torta, Fabiana Vernero. **Interacting with social networks of intelligent things and people in the world of gastronomy**. *ACM Transactions on Interactive Intelligent Systems (TiiS)*, 3(1): 4 (2013),
- Assunta Matassa, Fabiana Vernero, **Using the critical design approach for rethinking citizens' emotional bond with urban spaces**. ICST Trans. Ambient Systems 2(8): e5 (2015)

DEPARTMENT OF MATHEMATICS

Numerical Analisys Group (prof. Dagnino)	
E-mail	catterina.dagnino@unito.it
Critical technology description	
Planet surfaces Rocks, stones, wind simulations. Objectives: Create a Virtual Environment able to support Rovers/Landers systems performances simulations at design stage, in order to improve performances and results in space applications	
Current TRL	
Compentencies	
Distribution models, systems of differential equations	
Background	
Project: RP/STEPS 1- M. M. Brunello, "Studio di tecniche di modellazione tridimensionale procedurale nell'ambito della ricostruzione di superfici planetarie", Tesi di laurea magistrale a.a. 2008-2009; relatori: Nello Balossino, Catterina Dagnino - supervisore aziendale: Valter Basso 2- E. Menduni, "Studio delle condizioni meteorologiche marziane nel Pathfinder Site mediante un'analisi teorica e sperimentale di un modello numerico di previsione atmosferica alla mesoscala e sviluppo di un'interfaccia software", Tesi di laurea magistrale a.a. 2010-2011; relatore: Catterina Dagnino - supervisori aziendali: Lorenzo Rocci, Valter Basso	

DEPARTMENT OF MATHEMATICS

Mathematical Physics Group (prof. Fatibene)	
E-mail	lorenzo.fatibene@unito.it
Critical technology description	
Gravity, General Relativity, Special Relativity, synchronizations We work in general relativity and we are interested in any test of GR and problematics in synchronization, positioning, astrophysical and cosmological observations. We worked on extended theories of gravitation and applications to dark matter and dark energy.	
Current TRL	
Compentencies	
Geometrical methods for classical field theories; Relativistic theories, natural and gauge-natural theories; Conservation laws; Black holes entropy; Spin structures and spinor theories; Extended theories of gravitation; Quantum gravity	
Background	
• M. Di Mauro, L. Fatibene, M.Ferraris, M.Francaviglia, Further Extended Theories of Gravitation: Part I Int. J. Geom. Methods Mod. Phys. Volume: 7, Issue: 5 (2010), pp. 887-898; gr-qc/0911.2841 • L.Fatibene, M.Francaviglia, Weyl Geometries and Timelike Goedesics (In press on Int. J. Geom. Methods Mod. Phys.); arXiv:1106.1961v1 [gr-qc]	

DEPARTMENT OF MATHEMATICS

Probability and Statistics Group (prof. Zucca)	
E-mail	cristina.zucca@unito.it
Critical technology description	

GPS systems: Atomic clock errors.

Study of stochastic models describing the dynamics of the error with reference to the times when these stochastic processes exit from a preassigned strip (times for the realignment of the clocks). Forecasting of the realignment time.

Changing time of stochastic dynamics. Proposal of statistical methods for an optimal detection of the times when the atomic clock starts to be affected by a not acceptable error. An improvement of the knowledge of atomic clock error may improve the precision of GPS instruments. Galileo Positioning system (GPS) is a satellite-based navigation system made up of a network of several satellites that circle the earth in a very precise orbit and transmit signal information to earth. The GPS receiver compares the time a signal was transmitted by a satellite with the time it was received. The time difference gives an estimation of the distance from the satellite itself. GPS receivers take this information and use spherical positioning to calculate the user's exact location.

This method always works on the assumption that the satellite and the receiver are perfectly synchronized. However, this assumption is not realistic. Hence the importance of further investigating the metrology of time and frequency to control the behaviour of different atomic clocks that characterize the system.

One of the fundamental aspects is to model and estimate what might be the clock error related to the positioning. In fact, a clock error of only 100 nanoseconds can give rise to an error in the pseudo distance, and therefore in the recognition of the position, of at least 30 meters.

It is clear that the precision of the atomic clocks is a key point for GPS. In this framework an improvement of the knowledge of atomic clock error may refine the precision of GPS instruments.

The scientists of INRIM together with scientist of the Dept. of Mathematics already published several papers in major area journals concerning stochastic models for the atomic clock error. Such models can be improved in order to describe the clock error behaviour in a more complete way.

Current TRL	
Compentencies	

Probabilistic methods that allow a correct study of models and that provide the source of researches on reliable algorithms for the solution of nonlinear differential equations and for studies on integrated Brownian motion and on Fractional Brownian motion.

Background	

It exists a partnership with INRIM (Torino). The existing collaboration with scientists.

- G. Galleani, L., Sacerdote, L., Tavella, P. and C., Zucca (2003) A mathematical model for the atomic clock error. Metrologia 40, 257-26P.

- Tavella and C. Zucca (2005) The Clock Model and its Relationship with the Allan and related Variances IEEE Transactions on Ultrasonics, Ferroelectrics, and Frequency Control (TUFFC) 52 (2): 289-296.

- G. Panfilo, P. Tavella, C. Zucca (2004) Stochastic processes for modeling and evaluating atomic clock behavior. Advanced Mathematical and Computational Tools in Metrology VI, 229-239

-E. Bibbona, G. Panfilo, P. Tavella (2008) The Ornstein–Uhlenbeck process as a model of a low pass filtered white noise Metrologia 45, 6, S117-S126

DEPARTMENT OF MOLECULAR BIOTECHNOLOGIES AND HEALTH SCIENCES

Prof. Aime – Prof. Altruda	
E-mail	silvio.aime@unito.it
Critical technology description	
Radio-Biology: analysis of mutations induced by radiations on cellular systems and animal models; protection from radiations. Effects associated to the absence of magnetic and gravitational fields. Design and testing of biological and imaging sensors.	
Current TRL	
Compentencies	
The Dept. owns a consolidated experience in the field of cellular engineering, genetic and biological assays, preparation and characterization of animal models.	
Background	
Feed-back from therapeutic studies and biodata collections will be made available to these research activities.	

DEPARTMENT OF MEDICAL SCIENCES

NeuroMuscularFunction research group (Prof. Rainoldi)	
E-mail	alberto.rainoldi@unito.it
Critical technology description	
This group is national and international leader in the use of surface EMG for the non invasive assessment of the neuromuscular system and to drive devices (such as exoskeleton) with EMG based techniques.	
Current TRL	
Compentencies	
The information extracted from sEMG signals allows to study muscle fatigue, to assess CNS strategies for muscle recruitment in the condition of lack of oxygen, or lack of movement and disuse, in pathologies, to monitor the effectiveness of a training conditioning, to drive human computer interfaces... All the above listed fields of possible uses represent actual competences of the group developed in previous research projects as described by the list of projects and papers below.	
Background	

2012-2014 Poli di Innovazione MESAP Project HEXEC (Hand Exoskeleton Emg Controlled)

2009-2013 Regione Piemonte Project ActOnAgeing (assessment of effectiveness of exercise training program in elderly people)

Casale R., Rainoldi A, Nillson J., Bellotti P., Can continuous physical training counteract aging effect on myoelectric fatigue? A surface electromyography study application, Arch Phys Med Rehabil, 84(4):513-517, 2003.

Casale R., Farina D., Merletti R., Rainoldi A, Myoelectric manifestations of fatigue during exposure to hypobaric hypoxia for 12 days, Muscle Nerve, 30(5):618-625, 2004.

Rainoldi A, M. Gazzoni, R. Merletti, M. Minetto, Mechanical and EMG

responses of the vastus lateralis and changes in biochemical variables to isokinetic exercise in endurance and power athletes, J Sport Sci, 26 (3):321-331, 2008

Rainoldi A, Gazzoni M., Melchiorri G., Differences in myoelectric manifestations of fatigue in sprinters and long distance runners, Physiol Meas, 29(3):331-340, 2008

Boccia G, Dardanello D, Coratella G, Rinaldo N, Schena F, Rainoldi A., Differences in age-related fiber atrophy between vastii muscles of active subjects: a multichannel surface EMG study, Physiol Meas. 2015 Jun 9;36(7):1591-1600

Boccia G, Dardanello D, Rinaldo N, Coratella G, Schena F, Rainoldi A., Electromyographic Manifestations of Fatigue Correlate With Pulmonary Function, 6-Minute Walk Test, and Time to Exhaustion in COPD, Respir Care. 2015 Sep;60(9):1295-302. doi: 10.4187/respcare.04138

Boccia G, Coratella G, Dardanello D, Rinaldo N, Lanza M, Schena F, Rainoldi A. Severe COPD Alters Muscle Fiber Conduction Velocity During Knee Extensors Fatiguing Contraction. COPD. 2016: 27007486.

Boccia G, Dardanello D, Zoppirolli C, Bortolan L, Cescon C, Schneebeli A, Vernillo G, Schena F, Rainoldi A, Pellegrini B. Central and peripheral fatigue in knee and elbow extensor muscles after a long-distance cross-country ski race. Scand J Med Sci Sports. 2016, doi: 10.1111/sms.12718.

DEPARTMENT OF PSYCHOLOGY

NeuroPsychology (dott. Ricci)	
E-mail	raffaella.ricci@unito.it
Critical technology description	

Human Spaceflight: Effects of microgravity on plasticity of the sensorimotor system and their behavioral and cognitive consequences using models of limb disuse in healthy humans. Understanding microgravity induced maladaptive plasticity will help design effective interventions.

Human visuo-spatial and motor performance in microgravity is crucial to the success of long-term space station and interplanetary missions. To assure maximum performance capabilities in the space environment, the acute and long-term effects of weightlessness on the central nervous system and specifically the sensorimotor system will be investigated. Models of limb disuse will be used to simulate microgravity. Multiple non-invasive methods of mapping brain function (e.g. Transcranial Magnetic Stimulation, functional Magnetic Resonance Imaging) will be employed to study changes in brain plasticity. Given the tight link between sensorimotor and visuo-spatial systems, potential effects of microgravity on spatial cognition will be also investigated using behavioral visuo-spatial and motor tasks. Indeed, the effects of microgravity on spatial cognition need to be clarified. It is likely that cortical sensorimotor map reorganization occurs as an adaptive response to the microgravity environment. Some research on the effects of microgravity on the nervous system suggest that alterations in cortical excitability occur in a model for microgravity. Although this adaptation may be useful in a microgravity environment, it may not be optimal for return to Earth or operations on a planetary surface or in the case of an emergency landing where optimal motor and visuo-spatial performances are required for safe egress. Indeed, many astronauts on prolonged flights are unable to walk on return from flight even with regular use of resistance and bicycle devices on the space station. The identification and proper understanding of cortical plasticity in microgravity and its relationship to astronaut cognitive and motor performance is a critical step in preparing for future long-term human space habitation

Current TRL	TRL: 5
Compentencies	

Dr Ricci has specialized in the study of motor and attentional systems, neuroplasticity of the visual-motor system and its neuro-rehabilitative aspects in humans. Her research work involves the use of multiple and complementary cognitive neuroscience tools such as cognitive and behavioral experiments in healthy participants, neuropsychological studies in neurological patients, Transcranial Magnetic Stimulation (TMS), and functional Magnetic Resonance Imaging (fMRI), and neuronavigation systems (Softaxic).

She also has theoretical and operative statistical competences to analyze behavioral, TMS and fMRI data using different statistical packages (e.g. for cognitive and behavioral data SPSS, STATISTICA; for fMRI data SPM8, Mricron). Finally, as a researcher, she has expertise in data interpretation and dissemination (writing scientific papers, presenting to seminar and conferences).
Dr Ricci's expertise and competence on research involving TMS and fMR is testified by her scientific production on international specialized journals (11 papers and 3 book chapters) on this topic, besides other papers on cognitive neuroscience topics (about 26 papers on international journals). In particular, and in relation to this project, Dr Ricci has been involved in NASA funded work on motor cortex plasticity changes (as measured through TMS and fMRI) following temporary lower limb immobilization (Roberts, Ricci, et al, 2007, 2010; Ricci et al., 2008; for more details please see below).

Background	

The study Ricci et al. (2008 Ther Clin Risk Manag.; 4: 1127-34) was funded by NASA – Epscor award number NCC5/575.

The study Roberts et al. (2010 Aviat Space Environ Med.; 81:30-40) was supported by NASA grant number NNJ04HF70G and NIH grant number NNJ06HB811.

DEPARTMENT OF PSYCHOLOGY

Background

Background Dr. Ricci has been previously involved by Dr Mark George and his team at the Medical University of South Carolina, in NASA funded work on motor cortex plasticity changes (as measured through TMS and fMRI) following temporary lower limb immobilization - i.e. 10 days of casting - (Roberts, Ricci, et al, 2007; Exp Brain Res.; 181(2):213-20 http://www.researchgate.net/publication/6446655_Lower_limb_immobilization_is_associated_with_increased_corticospinal_excitability) and brain reorganization after long term immobilization –i.e. 3 months of bed rest- (Roberts et al., 2010 Aviat Space Environ Med.; 81(1):30-40).

She also conducted a study on the feasibility and safety of daily 1 Hz rTMS during the weeks of casting to prevent or reduce brain reorganization due to immobilization (Ricci et al., 2008 Ther Clin Risk Manag.; 4(5): 1127-34 http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2621395/pdf/tcrm-4-1127.pdf).
In July 2015, the team has been involved by Thales Alenia Space Italia (TAS-I), Pininfarina Extra (PFE), Blue Group, and Vastalla, four main companies of the Piedmont region working in the Aerospace and Aeronautics industry in an industrial collaboration. In April, 2016 Prof Ricci with the companies went to NASA Johnson Space Center in Houston, TX to discuss future Deep Space Habitats for manned missions. In July 2016 two other companies, Desmotec and Stam, joined the group. These activities lead to the preparation and submission (September 2016) of the following project in which TAS-I is the leading company:

Title: DOMUS, Design and Outfitting solutions for Modules Utilization in Space
Scope: the UniTo team will provide expertise to measure and evaluate the benefits of a well-designed spacecraft interior to crew wellbeing and performance in confined, harsh, micro-g or artificial-g environment in order to optimize crews sensorimotor and cognitive performance during man/machine interactions.
Budget: -
Funding institution: Regione Piemonte
Main deliverable: the project is currently under evaluation (phase 1)
In January 2017, the research team has submitted the following project to the call 'Progetti di Ateneo/Compagnia di San Paolo Linea 2' 'Research for the Territory' in collaboration with Thales Alenia Space Italia, Pininfarina Extra, Blue Group, and Vastalla.

Title: GraviTo, Attention to Space and Gravitational Inputs
Scope: To investigate specific aspects of human cognition (spatial attention and perception) in response to conditions encountered during spaceflight missions (i.e. altered gravitational input), using two ground-based models of microgravity.
Budget: UniTo team has submitted a budget of 75.000 €
Funding institution: Compagnia di San Paolo/Unito
Main deliverable: the project is currently under evaluation, the result of the evaluation process is expected by the end of March.
In collaboration with TAS-I, the research team will attend the 8th International Conference on Applied Human Factors and Ergonomics (AHFE 2017) with a paper entitled 'Habitability issues in long duration space missions far from Earth'.
Research Team: permanent staff Raffaella Ricci, Anna Berti, technicians; non-permanent staff: post-docs and student fellows. http://www.psicologia.unito.it/do/docenti.pl/Show?_id=rricci#profilo

DEPARTMENT OF EARTH SCIENCES

Stratigraphy and sedimentary geology group (prof. Dela Pierre)	
E-mail	francesco.delapierre@unito.it
Critical technology description	

Evaporite and cold seep systems:

The research objective is to assess and evaluate in the field and in the laboratory the exobiological potential, biosignature preservation and detection of Earth analogues to key Mars sedimentary deposits. Among the most suited sediments for such an approach are the evaporite deposits and the so-called cold seep systems related to the emission on the Earth surface of methane-rich fluids. This because:

1) modern and ancient evaporites facies could be used as analogues for the interpretation of extraterrestrial sediments; in addition, the study of microbial remnants in fluid inclusions incorporated in evaporite minerals is probably the most promising possibility to directly sample ancient or recent possible traces of life on Mars;

2) methane-related cold seep carbonates are also significant analogues as the finding of methane in Martian atmosphere may suggest other possible similarities with Earth environments and deposits strongly related to microbial life.

Current TRL	
Compentencies	

Experience in stratigraphic and sedimentological analysis of Meso-Cenozoic successions, studies on Cenozoic cold seep carbonate deposits and on the stratigraphy and geobiology of the Messinian succession of the Mediterranean area; carbonate sedimentology and petrology, especially of cold seep carbonates and on microbial-related structures in carbonates; geochemical and geomicrobiological aspects of cold seep deposits and on the fluid inclusion study of Messinian evaporites; evidence of syndepositional tectonics and fluid flow through the sedimentary successions of Western Alp tectonic units.

Background	

- Natalicchio M., Dela Pierre F., Clari P., Birgel D., Cavagna S., Martire L., Peckmann, J., 2013. Hydrocarbon seepage during the Messinian salinity crisis in the Tertiary Piedmont Basin (NW Italy). Palaeogeography, Palaeoclimatology, Palaeoecology 390, 68-80.
- Dela Pierre, F., Clari, P., Bernardi, E., Natalicchio, M., Costa, E., Cavagna, S., Lozar, F., Lugli, S., Manzi, V., Roveri, M., Violanti, D., 2012. Messinian carbonate-rich beds of the Tertiary Piedmont Basin (NW Italy): Microbially-mediated products straddling the onset of the salinity crisis. Palaeogeography, Palaeoclimatology, Palaeoecology 344-345, 78-93.
- Natalicchio, M., Birgel, D., Dela Pierre, F., Martire, L., Clari, P., Spötl, C., Peckmann, J., 2012. Polyphasic carbonate precipitation in the shallow subsurface: Insights from microbially-formed authigenic carbonate beds in upper Miocene sediments of the Tertiary Piedmont Basin (NW Italy). Palaeogeography, Palaeoclimatology, Palaeoecology 329-330, 158-172.
- Dela Pierre, F., Martire, L., Natalicchio, M., Clari, P.A., Petrea, C., 2010. Authigenic carbonates in the upper Miocene sediments of the Tertiary Piedmont Basin (NW Italy): vestiges of an ancient gas hydrate stability zone. Geological Society of America Bulletin 122, 994-1010.
- Clari, P., Dela Pierre, F., Martire, L., Cavagna, S., 2009. The Cenozoic CH4-derived carbonates of Monferrato (NW Italy): A solid evidence of fluid circulation in the sedimentary column. Marine Geology 265, 167-184.
- Clari P., Cavagna S., Martire L., Hunziker J., 2004. A Miocene mud volcano and its plumbing system: a chaotic complex revisited (Monferrato, NW Italy). Journal of Sedimentary Research, 74, 662-676.