



UNIVERSITÀ  
DEL SALENTO

# CMIS 2018

Contact Mechanics International Symposium



May 16–18, 2018  
Sanctuary of Oropa, Biella, Italy

web: [CMIS2018.unisalento.it](http://CMIS2018.unisalento.it)  
e-mail: [cmis2018@unisalento.it](mailto:cmis2018@unisalento.it)  
location: [www.santuariodioropa.it](http://www.santuariodioropa.it)





# **CMIS 2018**

**IX Contact Mechanics  
International Symposium**

**16-18 May 2018 – Oropa (Biella), Italy**

**General Information  
&  
Daily Program**



# **CONTACT MECHANICS INTERNATIONAL SYMPOSIUM**

Proceedings of the IX Contact Mechanics International  
Symposium, held in Oropa (Biella), Italy

**16-18 May 2018**

Edited by

**Giorgio Zavarise**

*Politecnico di Torino, Italy*

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*Laboratoire de Mécanique et d'Acoustique CNRS, France*

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*Leibniz Universität Hannover, Germany*

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## PREFACE

Following the tradition started in 1992 with the first symposium, the aim of CMIS 2018 is to gather researchers from the mathematical and engineering communities working on various aspects of contact mechanics, using theoretical, experimental and computational approaches.

Hence, in order to reinforce the interactions and collaborations between various communities, the symposium addresses a wide panorama of topics in the area of contact mechanics. Among them we cite:

- Models, interface laws; wear; tribological modeling; cohesive zone models; rolling;
- Emerging computational approaches: methods, algorithms and numerical analysis;
- Mathematical analysis;
- Dynamic contact problems, instabilities;
- Micromechanics of contact and multiscale approaches;
- Multiphysics and thermomechanical coupling;
- Granular materials and rigid bodies;
- Contact modeling in mechanical and civil engineering, biomechanics and geomechanics.

The series of CMIS symposia started in 1992 in Lausanne. The locations have always been selected with the idea of providing a quiet and confidential environment to encourage exchanges of ideas among the participants. Following such tradition, CMIS 2018 will be held at the Sanctuary of Oropa (Biella), Italy, on May 16-18, 2018, and it will be the 9th event of the series.

- I. Lausanne, Switzerland, 1992
- II. Carry Le Rouet, France, 1994
- III. Peniche, Portugal, 2001
- IV. Hannover, Germany, 2005
- V. Chania, Greece, 2009
- VI. Cargese, France, 2012
- VII. Abu Dhabi, United Arab Emirates, 2014
- VIII. Warsaw, Poland, 2016
- IX. Oropa (Biella), Italy, 2018

Oropa, May 2018

The Chairmen  
G. Zavarise, M. Raous, P. Wriggers

## PATRONAGES & SPONSORS

The conference organizers acknowledge the support towards the organization of the CMIS 2018 to the following organizations:

 <p><b>UNIVERSITÀ DEL SALENTO</b></p> <p>Università del Salento</p>	 <p>Department of Innovation Engineering</p>	
 <p>Dipartimento di Matematica e Fisica "Ennio De Giorgi"</p> <p>Department of Mathematics and Physics "Ennio De Giorgi"</p>	 <p>Laboratoire de Mécanique et d'Acoustique</p>	
 <p>Leibniz Universität Hannover</p> <p>Leibniz Universität Hannover</p>	 <p>EnginSoft S.p.A.</p>	
 <p>MIUR PRIN</p> <p>PRIN 2015 Prog. 2015JW9NJT-PE8</p>	 <p>Biella TURISMO</p>	 <p>ATL Biellese</p>
 <p>Piemonte Region</p>	 <p>Province of Biella</p>	 <p>City of Biella</p>



## CONFERENCE ORGANIZERS

### CHAIRMEN

**Giorgio Zavarise** (Chairman)

University of Salento - Department of Innovation Engineering  
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### SCIENTIFIC SECRETARY

**Maria Laura De Bellis**

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**Daniela Dell'Anna**

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### WEBSITE ADMINISTRATOR

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**INTERNATIONAL SCIENTIFIC COMMITTEE**

<b>Pierre Alart</b>	Laboratoire de Mécanique et de Génie Civil CNRS, Montpellier, France
<b>James R. Barber</b>	Department of Mechanical Engineering, University of Michigan, Hayward, USA
<b>Michele Campiti</b>	University of Salento, Lecce, Italy
<b>Rossana Dimitri</b>	University of Salento, Lecce, Italy
<b>Zdeněk Dostál</b>	Technical University Ostrava, Czech Republic
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<b>Tod Laursen</b>	Khalifa University of Science, Abu Dhabi, United Arab Emirates
<b>Frederic Lebon</b>	Laboratoire de Mécanique et d'Acoustique CNRS, Marseille, France
<b>Jean-Francois Molinari</b>	Ecole Polytechnique Fédérale de Lausanne, Lausanne, Switzerland
<b>Marco Paggi</b>	IMT School for Advanced Studies - Lucca, Italy
<b>Valentin Popov</b>	Technische Universität Berlin - Berlin, Germany
<b>Alexander Popp</b>	Institute for Computational Mechanics, Technische Universität München, München, Germany
<b>Mike Puso</b>	Lawrence Livermore National Laboratory, Livermore, USA
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<b>Stanislaw Stupkiewicz</b>	Polish Academy of Sciences, Warsaw, Poland
<b>Ilker Temizer</b>	Department of Mechanical Engineering, Bilkent University, Ankara, Turkey
<b>Tarek Zohdi</b>	University of California at Berkeley, Berkeley, USA

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**KEYNOTE LECTURERS**

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**Patrick Ballard**

Institut Jean le Rond d'Alembert, Université La Sorbonne,  
Paris, France.

*On the coupling between dry friction and linear elasticity*

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**Zdenek Dostal**

Technical University Ostrava, Czech Republic

*Toward solving contact problems with trillion variables*

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**Jakub Lengiewicz**

Institute of Fundamental Technological Research of the  
Polish Academy of Sciences, Warsaw, Poland

*Multiscale frictional effects in rough soft contacts*

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**Manuel D. P. Monteiro Marques**

Dpt. de Matemática and CMAF-CIO, Universidade de Lisboa,  
Lisboa, Portugal

*J. J. Moreau's mathematical toolkit for Nonsmooth Mechanics*

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**Jaen-Francois Molinari**

Laboratoire de simulation en mécanique des solides, Ecole  
Polytechnique Fédérale de Lausanne, Switzerland

*Friction and wear across scales*

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**Yves Renard**

Laboratoire de Mécanique des Contacts et des Structures,  
CNRS - INSA-LYON, Villeurbanne, France

*Explicit integrators for the impact of elastic solids: a  
comparison of a Nitsche-based approach with existing ones*

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## VENUE



The conference takes place at the “Oropa Sanctuary”, Oropa (Biella).

The **Oropa Sanctuary** is the most important and largest Sanctuary dedicated to the Virgin Mary to be found in the Alps. It is located in a unique, natural and unspoilt setting at 1200 mt. a.s.l., just at 20 minute drive from the city of Biella. Historical lore states that the Sanctuary was founded in the 4th century. The Sanctuary grew and has been developed through the years into a spectacular architectural ensemble of important monumental buildings. This led to a change in the use of Oropa from one of transit to a destination used by pilgrims brought here by their strong sense of devotion.

The complex is made up of three large courtyards built on three levels and was designed by the great Savoyard architects Arduzzi, Gallo, Beltramo, Juvarra, Guarini, Galletti and Bonora between the mid 17th and 18th centuries finishing with the Upper Basilica which was consecrated in 1960.

## CONFERENCE INFORMATION

### Pre-Registration

Conference registration will start on **Tuesday, May 15** during the **Welcome Cocktail at Oropa Sanctuary - Ristorante Croce Bianca**, between 5.00 – 7.00 p.m.

### Registration

You can register on-site and pick up the conference material at the Conference Registration Desk on:

Wednesday	May 16	8:00 -18:20
Thursday	May 17	8:20 -18:20
Friday	May 18	8:00 -13:00

The Registration Desk will also serve as Conference Office during the conference

### Presentations: Time & Equipment

Each regular presentation is allocated to 20 minutes, including questions.

Each keynote lecture presentation is allocated to 40 minutes, including questions.

If you wish to use your own PC, connection to the projector **must be tested** before the beginning of your session.

### WI-FI facilities

Wireless connections are available in the Sanctuary. Passwords will be provided together with the badge and the receipt.

### Coffees & Lunches

A coffee break area will be available at the conference venue.

A lunch buffet is also offered every day to the participants.

## EVENTS & LOCATIONS

### TUESDAY, May 15

- **17:00 - 19:00 - Pre-registration & welcome cocktail**  
The event will take place at Oropa Sanctuary – Ristorante Croce Bianca

### WEDNESDAY, May 16

- **8:00 – 9:20 - Registration & opening**
- **18:20 - Guided tour of the Sanctuary**

### THURSDAY, May 17

- **19:15 – Departure from the Sanctuary for the Conference Dinner**

### FRIDAY, May 18

- **16:40 - Conference Closure**

## SCIENTIFIC PROGRAM

### Wednesday, 16 May

<b>8:00</b>	<b>Registration</b>	
<b>9:00</b>	<b>Opening</b>	
<b>9:20</b>	<b>Keynote 1, Chaired by Michel Raous</b>	
	<b>Monteiro Marques</b>	<b>J. J. Moreau's mathematical toolkit for Nonsmooth Mechanics</b>
<b>10:00</b>	<b>Session 1, dedicated to Jean-Jacques Moreau, Chaired by Michel Raous</b>	
	10:00	V. Acary, M. Brémond, O. Huber Formulations and extensive comparisons of 3D frictional contact solvers based on performance profiles
	10:20	T. Ndzana Satoh, M. Renouf, S. Grac A local multi-physical approach to model braking materials
	10:40	A. Gravouil, F. Fekak, M. Brun, D. Dureisseix Heterogeneous asynchronous time integrators for non-smooth dynamics
<b>11:00</b>	<b>Coffee break</b>	
<b>11:20</b>	<b>Session 2, Chaired by Udo Nackenhorst</b>	
	11:20	A.A. Maitlo, <u>F. Lebon</u> Derivation of a model of soft imperfect interface with non local damage and unilateral contact conditions
	11:40	<u>R. Dimitri</u> , G. Zavarise Numerical study of the mixed-mode delamination of composite interfaces
	12:00	<u>K.S. Parel</u> , R.J. Paynter, D.A. Hills Frictional receding contact problems with separation of interface at remote points
	12:20	<u>R. Serpieri</u> , E. Sacco Are mode II and mode III fracture energies real material properties? A response based on a 3D DCB FEA with frictional multiplane CZMs
	12:40	G. Alotta, R. Dimitri, F.P. <u>Pinnola</u> , G. Zavarise, M. Zingales Non-local interface model based on fractional operators

<b>13:00</b>	<b>Lunch</b>	
<b>14:20</b>	<b>Keynote 2, Chaired by Valentin Popov</b>	
	<b>J.F. Molinari</b>	<b>Friction and wear across scales</b>
<b>15:00</b>	<b>Session 3, Chaired by Valentin Popov</b>	
15:00	<u>V.A. Yastrebov</u> , G. Anciaux, J.F. Molinari	An Interplay of Nayak and Hurst parameters in mechanical contact of rough surfaces
15:20	<u>G. Costagliola</u> , F. Bosia, N.M. Pugno	A 2-D model for friction of complex anisotropic surfaces
15:40	<u>A. Papangelo</u> , M. Ciavarella	Strong adhesive performance of indenters on thin layers
16:00	<u>R. Pohrt</u>	Usage of an asperity-free formulation in asperity models
<b>16:20</b>	<b>Coffee break</b>	
<b>16:40</b>	<b>Session 4, Chaired by Marius Cocou</b>	
16:40	<u>C. Stolz</u>	Optimal control approach to simulating wear under cyclic loading
17:00	<u>B.R. Akula</u> , J. Vignollet, V.A. Yastrebov	Frictional contact and wear along virtual interfaces
17:20	<u>E. Arfa</u> , V. Magnier, P. Dufrénoy, G. de Saxcé	Modeling of wear considering heterogeneous friction material
17:40	F. Forsbach, M. Schuster, D. Pielsticker, <u>Q. Li</u> , V.L. Popov	Wear analysis of a multiphasic heterogeneous cylinder
18:00	<u>M. Jureczka</u> , A. Ochal	Error estimation and computational simulation of contact problem with wear
<b>18:20</b>	<b>Guided tour of the Sanctuary</b>	



## Thursday, 17 May

<b>8:00</b>	<b>Registration</b>		
<b>8:40</b>	<b>Keynote 3, Chaired by Peter Wriggers</b>		
	<b>P. Ballard</b>	On the coupling between dry friction and linear elasticity	
<b>9:20</b>	<b>Session 5, Chaired by Peter Wriggers</b>		
9:20	M.J. Lewandowski, <u>S. Stupkiewicz</u>	Non-classical contact conditions and size effects in Cosserat solids	
9:40	<u>B. Rousselet</u>	Equilibrium solutions in structural mechanics with a small Lipchitz continuous or with a monotone non linearity	
10:00	<u>M. Cocou</u>	A class of contact problems with rate-dependent surface constraints	
10:20	P. Areias, <u>A. Pinto da Costa</u>	The discrete quasi-static incremental frictional contact problem: an alternative formulation	
10:40	<u>M. Ciavarella</u> , A. Papangelo	A new lengthscale in wear problems with adhesion	
<b>11:00</b>	<b>Coffee break</b>		
<b>11:20</b>	<b>Session 6, Chaired by Hachmi Ben Dhia</b>		
11:20	A. Popp, <u>I. Steinbrecher</u> , C. Meier	Beam-to-solid contact interaction in stent graft modeling for endovascular repair	
11:40	<u>A. Konyukhov</u> , K. Schweizerhof	A new analysis for parallel beams contact	
12:00	<u>F. Bussolati</u> , <u>O. Allix</u> , <u>P.A. Guidault</u> , <u>M. Guiton</u> , Y. Poirrette	Toward a two-scale modeling of spiral strand wire rope for floating offshore wind turbine to predict fatigue damages: possibilities and difficulties in using a legacy code	
12:20	<u>G. Fortese</u> , <u>A. Carpinteri</u> , <u>S. Vantadori</u> , <u>A. Zanichelli</u>	Stress gradient effect in estimating fretting fatigue life	

	12:40	<u>I.P. Shatskyi</u>	Dynamical interaction of an elastic rod and rigid foundation through a viscous-elastic-plastic layer
<b>13:00</b>	<b>Lunch</b>		
<b>14:20</b>	<b>Keynote 4, Chaired by Stanislaw Stupkiewicz</b>		
		<b>T. Brzobohatý, Z. Dostál, T. Kozubek, D. Horák</b>	<b>Toward solving contact problems with trillion variables</b>
<b>15:00</b>	<b>Session 7, Chaired by Stanislaw Stupkiewicz</b>		
	15:00	<u>W.T. Rust, P. Wriggers</u>	Sliding contact using adaptive node insertion with the Virtual Element Method
	15:20	<u>M.A. Chaudry, C. Woitzik, C. Weißenfels, A. Düster, P. Wriggers</u>	Computational modelling of ship collision
	15:40	<u>U. Nackenhorst, T.A. Palanichamy, A. Suwannachit</u>	On the simulation of treaded tires in rolling contact: A coupled Lagrangian - ALE approach
	16:00	<u>H. Ben Dhia, S. Du</u>	Solving Lennard-Jones-based adhesive problems with a contact model-adaptivity methodology
<b>16:20</b>	<b>Coffee break</b>		
<b>16:40</b>	<b>Session 8, Chaired Michele Ciavarella</b>		
	16:40	<u>H.N. Andresen, D.A. Hills</u>	Frictional energy dissipation in an incomplete contact for a tilted flat and rounded punch with varying normal load
	17:00	<u>F.O. Falope, L. Lanzoni, E. Radi</u>	Shear deformable beams in contact with an elastic half-plane
	17:20	<u>I. Argatov, G. Mishuris</u>	Surface stretch produced by a hemispherically-ended indenter
	17:40	<u>Y. Makhovskaya</u>	A model of friction of rough bodies taking into account adhesion and hysteresis losses at microlevel
	18:00	<u>I. Tsukanov, I. Goryacheva</u>	Partial elastic contact of nonsinusoidal wavy surfaces
<b>19:15</b>	<b>Bus departure for Conference dinner</b>		

## Friday, 18 May

<b>8:00</b>	<b>Registration</b>	
<b>8:40</b>	<b>Keynote 5, Chaired by Giorgio Zavarise</b>	
	<b>J. Lengiewicz</b>	<b>Multiscale frictional effects in rough soft contacts</b>
<b>9:20</b>	<b>Session 9, Chaired by Giorgio Zavarise</b>	
9:20	T. Gustafsson, R. Stenberg, J. Videman	An error analysis of Nitsche's method for contact problems
9:40	V.L. Popov, R. Pohrt, Q. Li	Adhesive contacts of complex shape: simulation by Boundary Element Method with mesh-dependent detachment criterion
10:00	Q. Gomez, O. Ciobanu, I.R. Ionescu	Discontinuous Galerkin modeling of wave propagation in a solid with micro-cracks in frictional contact
10:20	A. Spagnoli, M. Terzano, J.R. Barber	The effect of plasticity on the shakedown of coupled frictional contacts
10:40	C. Pozzolini, Y. Renard	Nitsche's methods for elasto-plastic contact small deformation problems: theoretical and numerical aspects
<b>11:00</b>	<b>Coffee break</b>	
<b>11:20</b>	<b>Session 10, Chaired by Claude Stolz</b>	
11:20	M. Harmel, R.A. Sauer	A thermo-mechanical contact formulation for liquid and solid membranes
11:40	C. Putignano, G. Carbone	Numerical approaches to dry and lubricated contact mechanics between linearly viscoelastic rough solids
12:00	R. Guarino, N.M. Pugno	Patterned and hierarchical surfaces for fluid and granular lubrication
12:20	A.G. Shvarts, J. Vignollet, V.A. Yastrebov	Trapped fluid in contact interface

	12:40	<u>C. Gnanasambandham</u> , P. Eberhard	Investigating methods to influence particle damper nonlinearities using coupled SPH-DEM simulations
<b>13:00</b>	<b>Lunch</b>		
<b>14:20</b>	<b>Keynote 6, Chaired by Frédéric Lebon</b>		
		<b>F. Chouly, Y. Renard</b>	Explicit integrators for the impact of elastic solids: a comparison of a Nitsche-based approach with existing ones
<b>15:00</b>	<b>Session 11, Chaired by Frédéric Lebon</b>		
	15:00	<u>C. Floris</u>	Random response of a sliding block with Coulomb friction
	15:20	R. Sahli, G. Pallares, C. Ducottet, I.E. Ben Ali, S. Al Akhrass, M. Guibert, <u>J. Scheibert</u>	Evolution of real contact area under shear and the value of static friction of soft materials
	15:40	V.N. Pajmushin, <u>M. Makarov</u> , S.A. Kholmo-gorov, A. Konyukhov	Experimental validation of three-points bending test with various contact approaches
	16:00	<u>S. Fukagai</u> , R. Lewis	An experimental study of traction characteristics at wheel flange/rail gauge corner interface
	16:20	<u>M. Nebab</u> , H. Ait Atmane	Free vibration of functionally graded plates resting on elastic foundation
<b>16:40</b>	<b>Conference closure</b>		
<b>16:50</b>	<b>Coffee break</b>		

## SOCIAL PROGRAM

### **Guided tour of the Sanctuary Wednesday, May 16, 18:20**

The participants will be divided in small groups, each one with a touristic guide, for a short visit of the most important places of the Sanctuary



**The Ancient Basilica**, the spiritual heart of the Sanctuary, was erected in the 17th century, in the aftermath of the plague of 1599, to fulfill a vow made by the Municipality of Biella. When the church was completed in 1620 a solemn coronation was held, the first of a series that would enrich the history of the Sanctuary every hundred years. The façade, designed by the architect Francesco Conti, whose sober elegance owes much to the green-veined local stone, is embellished by the darker tinge of the doorway, displaying in the upper part the Sabaudian coat of arms of Duke Carlo Emanuele II, sustained by two stone angels. The inscription "O quam beatus, O Beata, quem viderint oculi tui" is carved on the architrave of the doorway. Since the first decade of the 17th century the inscription is the welcoming greeting received by the pilgrim crossing the threshold of the Basilica.

**The Upper Basilica** is a grandiose edifice whose erection was promoted by the latest generations of the residents of Biella, as well as by many other devotees of the 'Vergine Bruna'. The names of the devotees who have contributed to the erection of the church are carved on the marble walls of the underground crypt of the suffrage. The latter displays a rare interesting collection of nativities coming from various countries around the world, a testimony of faith and cultural diversity crossing time and space, currently welcomed in the arms of the Black Madonna of Oropa.

**Conference Dinner****Thursday, May 17, - Bus departure from the Sanctuary at 19:15**

The dinner will take place in the meeting room of the Circolo Sociale Biellese. It is probably the most amazing place in the town, and it is available just for special events.



The entrance to the club “Circolo Sociale Biellese” is usually reserved for members. The club is home to several associations and service clubs in Biella. It offers restaurant service and rooms for meetings.

**Address:** Circolo Sociale Biellese  
Piazza Martiri della Libertà, 16  
13900 Biella (BI)

## OROPA - AIRPORTS CONNECTIONS

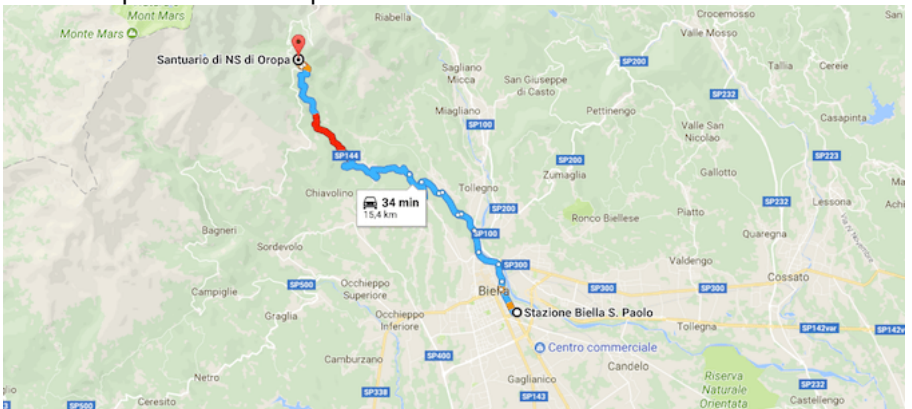
### OROPA

The Sanctuary of Oropa is located in the North-West of Italy, at about 14 km from the city of Biella, in between Milan and Turin.



### Biella – Oropa connection

Biella-Oropa is a 14 km trip in the mountains.



### Bus service

A bus service from the station is available, with a reasonable number of rides per day, but there are several stops, hence it takes 44 min.  
<http://www.atapspa.it/en/pianifica-transit/>

### Taxi service

At the train station a taxi service is available. The Biella-Oropa price is € 33 (max 4 persons).

## TRAVELING BY PLANE

Four airports can be considered: Milan-Linate, Milan-Malpensa, Milan-Bergamo and Turin.



### Airport connections by bus & train

- **Landing in Milan-Linate, Milan-Malpensa and Milan-Bergamo:**  
Take the bus to the Milan Central Train Station, and from there take the train to Biella S. Paolo Station (see below).  
If you land in Milan-Malpensa you can also take the bus to Novara, <http://www.stnnet.it/novaramalpensa.html> (not so many connections per day), and from there take a train to Biella S. Paolo Station.
- **Landing in Turin:**  
Take the bus to Turin Porta Susa train station. From there, take the train to Biella S. Paolo (see below).



**Airport connections by taxi service**

A pool taxi service is provided from the airports, at the following prices:

**Transport service provided by:****Autoservizi Biellesi Consorziati**

Cell: +39 335 6195337 - Tel: +39 015 29999

FROM/TO		Total price for the ride (€) max 8 persons
Biella (train station)	Oropa	33
Milan-Malpensa airport		143
Milan-Linate airport		220
Milan-Bergamo airport		242
Turin-Caselle airport		154
Taxis from Biella to Oropa stand right in front of the train station.		
Transfers from/to the airports must be booked at least 2 days in advance: By mail: manuele.canevarolo@gmail.com By phone: +39 335 6195337		

**Transport service provided by:****Consorzio Biellese Taxi**

Tel: +39 015 30055

FROM/TO		Total price for the ride (€) max 6 persons
Biella (train station)	Oropa	33
Milan-Malpensa airport		143
Milan-Linate airport		231
Milan-Bergamo airport		286
Turin-Caselle airport		154
Taxis from Biella to Oropa stand right in front of the train station.		
Transfers from/to the airports must be booked at least 2 days in advance: By mail: marcello.cadeddu@gmail.com		

**TRAVELING BY TRAIN**

- **From Milan:**  
Take the train to Biella S. Paolo (you have to commute in Novara).
- **From Turin:**  
Take the train to to Biella S. Paolo (you have to commute in Santhià).

For more information about train timetable: <http://www.trenitalia.com/tcom-en>

## TRAVELING BY CAR

- **If you arrive from Milan**

Take the highway to Turin, then exit at the Carisio gate, and follow the directions for Biella. From Biella follow the directions for Oropa.

- **If you arrive from Turin**

Take the highway to Milan, then exit at the Santhià gate, and follow the indications for Biella. From Biella follow the directions for Oropa

- **Distances**

from **Biella**: 14 km. (road S.P. 144)

from **Vercelli**: 56 km.(road S.P. 230)

from **Torino**: 87 km. (motorway A4 TO-MI/ exit Santhià)

from **Milan**: 115 km.(motorway A4 TO-MI/ exit Carisio)

from **Alessandria**: exit Santhià / road S.P. 143

from **Aosta** : road Ivrea-Santhià /exit Santhià

## CONTACTS

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