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TALLINNA TEHNIKAÜLIKOOL

Institute of Cybernetics at Tallinn University of Technology
Research Laboratory for Proactive Technologies, Tallinn University of Technology

CENS

Centre for Nonlinear Studies

Annual Report

2009

Tallinn, Estonia

Contents

Abstract

The Report reflects the state of art and studies of CENS in 2009, which marks its 10th anniversary. Described are studies and results on: (i) dynamics of microstructured materials and solitons; (ii) general nonlinear wave theory; (iii) fractality and econophysics; (iv) software development; (v) water waves and coastal engineering; (vi) biophysics and cell energetics; (vii) optical nonlinearity and photoelasticity; (viii) nonlinear and robust control systems; (ix) proactive technologies. The Report presents the list of projects and grants, the list of published papers, presentations at conferences, etc. Teaching activities are also described. The Annex includes a short overview on CENS over 10 years (1999 – 2009) and main results of the CENS-CMA project.

Keywords: nonlinear dynamics, soft matter physics, microstructured solids, solitons, acoustodiagnostics, photoelasticity, cell energetics, water waves, extreme waves, coastal engineering, differential equations, control theory, proactive technology.

Sisukord

Lühikokkuvõte

Aruanne käsitleb Mittelineaarsete Protsesside Analüüsi Keskuse (CENS) tegevust aastal 2009, mis oli CENSi 10. tegevusaasta. Põhitulemused on kirjeldatud järgmiste alateemade lõikes: (i) lainelevi mikrostruktuursetes materjalides ja solitonid; (ii) mittelineaarne laineleviteooria; (iii) fraktaalsus ja ökonofüüsika; (iv) tarkvara arendus; (v) lained veepinnal ja rannikutehnika; (vi) biofüüsika ja rakuenergeetika; (vii) optiline mittelineaarsus ja fotoelastsus; (viii) mittelineaarsed ja robustsed juhtimissüsteemid; (ix) proaktiivtehnoloogia. On antud ülevaade CENSi projektidest ja grantidest ning esitatud publikatsioonide, konverentsiettakannete, külalisteadurite, seminaride jm nimekirjad, sh. ka õppetöö kirjeldus. Lisas on lühi ülevaade CENSi; 10 aasta tegevusest ning CENS-CMA mitmeaastase programmi tulemuste kokkuvõtte.

Võtmesõnad:
mittelineaarne dünaamika, pehmisefüüsika, mikrostruktuuriga materjalid, solitonid, interaktsioonisolitonid, akustodiagnostika, fotoelastsus, südamelihase kontraktsioon ja rakuenergeetika, signaalitöötlus, pinnalained, rannikutehnika, ekstreemlained, diferentsiaalvõrrandid.

The Institute of Cybernetics was founded on September 1st, 1960 as an Institute of the Estonian Academy of Sciences. The year 1. Sept. 2009 – 1. Sept. 2010 is the 50th year of activities, presently IoC is at the Tallinn University of Technology.

1. Introduction

This Report covers, like the previous ones, all the activities carried on by fellows. Section 2 is a short summary on the structure of CENS (for more detailed description see Annual Report 2008). Then in Section 3, an overview on current research in 2009 is presented. Next Sections describe the funding (Section 4) and publications, conferences, seminars, etc. (Section 5). Section 6 covers all the other activities like the courses, graduate studies, visitors, etc. Finally, in Section 7 some conclusions are given.

In 2009, CENS celebrated its 10th anniversary (see also Section 6.1.1.). Some additional materials which characterize the activities of CENS are presented in Annex.

2. Overview on CENS

Structurally CENS is based on the following departments and laboratories:

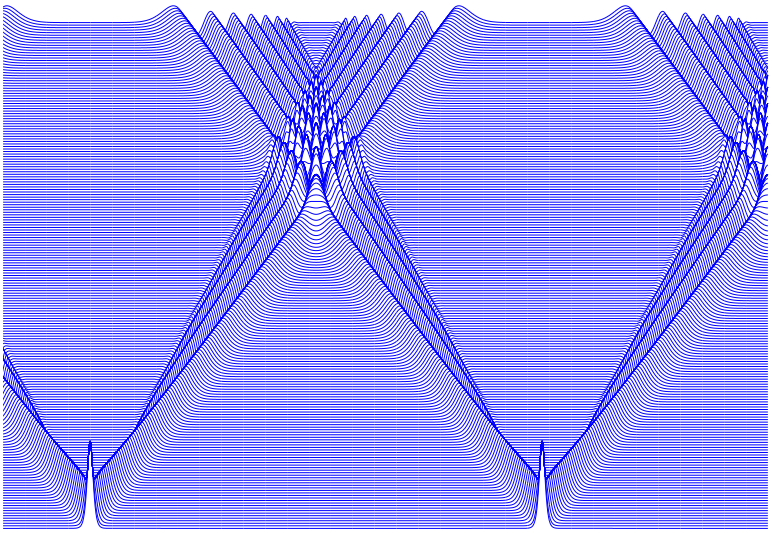
Institute of Cybernetics at Tallinn University of Technology:
Department of Mechanics and Applied Mathematics (head: J.Engelbrecht);
Laboratory of Photoelasticity (head: H.Aben);
Laboratory of Systems Biology (head: M.Vendelin);
Laboratory of Wave Engineering (head: T.Soomere);
Department of Control Systems (head: Ü.Kotta);
Tallinn University of Technology, Department of Computer Control:
Research Laboratory for Proactive Technologies (head: L.Mõtus).

The following long-term block grants support the studies:

Nonlinear dynamics and complex systems (supervisor J.Engelbrecht);
Synthesis of complex nonlinear control systems (supervisor Ü.Kotta)
Proactivity and situation awareness (supervisor L.Mõtus).

The international grants, etc. are listed in Section 4.

CENS has been awarded with the title "Centre of Excellence in Research" within Tallinn University of Technology for years 2009 – 2011.



3. Current results 2009

3.1 Institute of Cybernetics, Department of Mechanics and Applied Mathematics, Tallinn University of Technology

3.1.1 Dynamics of microstructured materials and solitons

Generalized thermomechanics with dual internal variables
The formal structure of generalized continuum theories is recovered by means of the extension of canonical thermomechanics with dual weakly non-local internal variables. The canonical thermomechanics provides the best framework for such generalization. It is demonstrated that the structure of Cosserat, micromorphic, and second gradient elasticity theories can be recovered in terms of dual internal variables in a natural way. However, the external couples cannot be deduced in the fully thermodynamical approach. It should be emphasized, however, that any new balance laws has not been introduced; only the Clausius-Duhem inequality was exploited for the derivation of evolution equations for the dual internal variables (A.Berezovski, J.Engelbrecht, G.A.Maugin).

Propagation of singular surfaces in thermoelasticity
The exploitation of the canonical formulation of continuum thermomechanics to the study of the irreversible propagation of singular surfaces is performed. The latter are mathematical models of sharp transition zones where entropy grows as a consequence of a necessarily present dissipation. In contrast with the standard theory of shock waves and Landaus theory of phase transitions, here a nonvanishing driving force is generally acting on the singular surface, and its dissipated power is none other than the entropy source. Applications are given to the propagation of both phase-transition fronts and shock waves. Numerical applications for propagating phase fronts deal with three cases: the 1D propagation of adiabatic fronts in a bar of shape-memory alloy, the 2D interaction of a wave front in an austenitic phase containing a martensitic inclusion, and the 2D progress of a wave due to the step-wise loading in a plate of thermoelastic shape-memory alloy. This exploits numerical methods developed by the authors (A.Berezovski, G.A.Maugin).

Jump conditions and kinetic relations at moving discontinuities
The problem of the kinetics of moving discontinuities is explained on the example of the propagating phase-transition front that corresponds to a stress-induced martensitic transformation in an elastic bar. The kinetic relation is derived under the assumption of a linear dependence be-

tween the stress jump at the phase boundary and the driving force. The derived kinetic relation is consistent with jump relations and satisfies limiting requirements. The comparison of the developed theory with available experimental data is made in the case of the dynamics of a straight brittle crack. The corresponding kinetic relation is derived under the same assumption as in the case of phase boundary. Classical results for Homalite-100 as well as recent experiments for Polyester/TiO2 are compared with the prediction of the kinetic relation. The agreement between theory and experiment is rather good, especially for such a simple theoretical model (A.Berezovski, G.A.Maugin).

Waves in inhomogeneous solids
Numerical technique used in simulating the propagation of waves in inhomogeneous elastic solids is explained. The basic governing equations are solved by means of a finite-volume scheme that is faithful, accurate, and conservative. Furthermore, this scheme is compatible with thermodynamics through the identification of the notions of numerical fluxes (a notion from numerics) and of excess quantities (a notion from irreversible thermodynamics). A selection of one-dimensional wave propagation problems is presented, the simulation of which exploits the designed numerical scheme. This selection of exemplary problems includes (i) waves in periodic media for weakly nonlinear waves with a typical formation of a wave train, (ii) linear waves in laminates with the competition of different length scales, (iii) nonlinear waves in laminates under an impact loading with a comparison with available experimental data, and (iv) waves in functionally graded materials (A.Berezovski, M.Berezovski, J.Engelbrecht).

Solitary waves in microstructured solids
The Mindlin-type model is used and the evolution equation (one-wave) equation is derived in the one-dimensional case using the asymptotic (reductive perturbation) method. The evolution equation as an extended Korteweg-de Vries equation is integrated numerically under harmonic as well as localized initial conditions maxing use of the pseudospectral method. Analysis of the results demonstrates that the derived evolution equation is able to grasp essential effects of microinertia and elasticity of a microstructure. The influence of these effects can result in the emergence of asymmetric solitary wave (M.Randrüüt, J.Engelbrecht, A.Salupere).

The nonlinear evolution is also solved approximately by a series expansion in a small parameter representing the micro-nonlinearity. Already the first approximation indicates the asymmetry of the solitary waves. It is shown that solitary waves will propagate only it the micro-nonlinearity does not exceed some upper bound. For a limiting case, an analytic solution of the extended KdV equation can be provided and used as a reference for the approximate solutions (M.Randrüüt, M.Braun).

The balance of spin from the point of view of mesoscopic continuum physics for liquid crystals
Mesoscopic continuum physics is reviewed using generalized coordinates in the context of liquid crystals. A special focus is put on the balance of spin (internal angular momentum). Mesoscopic continuum physics introduces variables describing the micro-structure – like the orientation of crystals – into the domain of the fields, thus treating them equivalently to space. The theory of mesoscopic continuum physics has been reformulated, resulting in more compact equations. In this formulation the balance of spin shows up naturally as component equations of the balance of momentum, this is an advantage over the standard formulation of mesoscopic continuum physics (H.Herrmann, J.Engelbrecht).

Solitary waves in Mindlin-type microstructured solids
Mindlin–Engelbrecht–Pastrone (MEP) model is used for describing the longitudinal deformation waves in microstructured solids. MEP models include Mindlin theory of continua with microstructure and the concept of wave hierarchies and they are able to take into account nonlinear and dispersive effects on the micro- as well as on the macrolevel. After introducing free energy function one gets a system of equations of motion from the Euler–Lagrange equations. These are referred as full equation system below. By applying slaving principle the micro-deformation can be eliminated from the latter. This procedure results in a hierarchical wave equation of Boussinesq type. Equations are solved numerically under localized initial conditions. For numerical integration Fourier transform based pseudospectral method is used. The influence of free energy parameters on the character of dispersion and wave propagation are studied. Numerical results of hierarchical approximation and full equation system are compared and the quality of the approximation is discussed (K.Tamm, A.Salupere).

Solitary waves in granular materials — hierarchical KdV-type model
A hierarchical Kortewegde Vries type evolution equation is applied for modelling solitary wave interactions in dilatant granular materials. The model equation is integrated numerically under sech^2type initial conditions in order to simulate emergence, propagation and interactions of solitons and solitary waves. For numerical integration the discrete Fourier transform based pseudospectral method is used. The accuracy of the numerical simulations is verified by the first and the second conservation law, ensuring a sufficiently high number of space-grid points for numerical integration.

Numerical solutions are found for model equation over wide range of material parameters. In 2009 results from earlier years were generalized and summed up. Depending on the character of solutions, four solution types are defined:
(i) single KdV soliton;
(ii) KdV soliton ensemble (with a weak tail);
(iii) soliton with a strong tail;
(iv) solitary wave with a tail and a wave packet.

Solitonic behaviour of solutions is demonstrated for the first three solution types. For the first and the second solution type accordance with solutions of KdV equation is demonstrated. Dependencies between solution types and material parameters are established and the influence of the amplitude of initial solitary wave on the character of the solution is analysed. Selection phenomenon is examined for third and fourth solution type. The formation of the wave packets has been explained in terms of time averaged normalised spectral densities (L.Ilison, A.Salupere).

Solitary deformation waves in a compressible hyperelastic rod
Propagation of axisymmetric deformation waves in circular cylindrical rods of compressible hyperelastic material is studied. Corresponding model equation that describes propagation of waves of moderate wave-length takes into account the coupling effect of the material nonlinearity and the geometric size of the rod is derived by Hui-Hui Dai. Numerical simulations are carried out over a wide range of material parameters making use of the discrete Fourier transform based pseudospectral method and localised initial conditions of sech^2-type. The influence of material parameters as well as the amplitude of the initial pulse on the character of the solution is studied and different solution types – including single solitary waves and trains of interacting solitons – are detected (A.Salupere, M.Vallikivi).

3.1.2 General nonlinear wave theory

Acoustodiagnostics of inhomogeneous and prestressed solids

Theoretical investigation of inverse problems to characterize the essentially variable properties of functionally graded materials (FGMs) on the basis of direct solutions to the problems of ultrasonic wave propagation is carried on. FGMs are perspective man-made materials like composite materials and they are widely used not only in thermal-protection systems of space planes but also in electrical, chemical and many other technologies. A large group of FGMs are designed with essentially changing properties close to the boundaries to improve the resistance of material to the different external affects (extreme temperature, intensive wastage, etc). Also in this year the main attention was paid to such materials with exponentially variable properties in the boundary region.

Counter-propagation and interaction of ultrasonic waves in the physically nonlinear elastic FGM with considerably and exponentially changing properties was studied theoretically using the symbolic manipulation software Maple. The numerical experiments were implemented. Analyses of the results of numerical simulations led to the conclusion that the profiles of the recorded boundary oscillations are informative and may be used for nondestructive characterization of material properties. The properties of the nonlinear elastic FGM are defined by the density and the combinations of the second and the third order elastic coefficients. It was shown that changes of boundary oscillation profiles caused by variable in space density and linear elasticity are of the same order while changes caused by nonlinear elasticity are the higher order small phenomena. The influence of symmetric and asymmetric exponential variation of material properties on the modulation of the boundary oscillations was studied in detail one by one and in complex.

The changes in material properties were clearly reflected in the changes of boundary oscillation profiles. Consequently, on the basis of boundary oscillation profile data evoked by ultrasonic counterpropagating waves in the material is possible to propose a method for qualitative nondestructive characterization of FGMs with essentially changing continuous properties. This qualitative method enables to distinguish specimens made by
(i) homogeneous material,
(ii) symmetrically distributed material properties,
(iii) asymmetrically distributed material properties
and also distinguish the most relevant property of the material responsible for inhomogeneity.

The research on the propagation and reflection of harmonic burst in the FGM with weak exponentially variable properties deal with the extension of the results of the last year. A thorough study of the harmonic burst propagation and reflection in homogeneous material reveals an interesting nonlinear phenomenon: the increase of nonlinear effects prior to the reflection and decrease after the reflection from a free boundary. This is an effect that can be compared with several works that report the same phenomenon. In addition, the method for nondestructive evaluation of materials with functionally graded surface layer has been worked out by clarifying the harmonic phase speed, amplitude and phase shift dependence on the material inhomogeneities (A.Ravasoo, A.Braunbrück).

Inverse problems

A one-dimensional coupled system for macro- and microdeformations occurring in Mindlin model of microstructure was studied. In linear case it was proved theat 4 of 5 coefficients of this system can be uniquely determined by phase- and group velocities of two localized wave packets. In nonlinear case necessary and sufficient conditions for the existence of solitary waves were deduced (J.Janno).

Piano hammer-string interaction – investigation of a contact time duration of strike.
The main goal is investigation of influence of the elastic parameters of the bass hammers on the contact time duration of the hammer strike. Two models that describe the hammer-string interaction are considered and studied. The first model is based on the nonlinear hysteretic model of piano hammer that is in a good agreement with experimental data, and gives the possibility to calculate the motion of strings and hammers, and to simulate the piano hammer-string interaction. The second model takes into account that the mass of bass hammer is much less than the mass of the string, and it makes possible to consider the hammer-string interaction as a hammer strike against a rigid surface. According to these models (and in reality), the contact time duration of a hammer strike decreases with increasing of the hammer velocity. It means that the speed of a deformation wave, traveling from the contact point to the hammer kernel and back, increases with the growth of its amplitude. Both models give similar predictions for the duration of the hammer strike (A.Stulov, D.Kartofelev).

3.1.3 Fractality and econophysics

Stochastic processes
In collaboration with the Akhiezer Institute for Theoretical Physics. National Science Center Kharkov Institute of Physics and Technology, we have continued our studies of the diffusing particles in continuous random walk processes (CTRW). We have predicted theoretically and confirmed numerically that the density field of the particles is of multifractal character, and derived the multifractal scaling exponents.

Previously, we have established a connection between the anomalous scaling in the case of ACTRW (aging CTRW) and in the case of experimental time-averaging of CTRW-like processes. In order to reveal the details of this connection, we have studied theoretically the anomalous diffusion in comb-like structures for different initial conditions (J.Kalda, M.Säkki).

Statistical topography
The statistical topography of polymer films containing PEDT/PSS complex has been studied in cooperation with the TUT Institute of Material Sciences (Dr. Ülo Lille); the anisotropy of the correlated percolation network has been established. A percolation model for describing the conducting properties of these films is developed.

A simple lattice model for describing the fragmentation of drying gel-films is constructed; preliminary results are in a good agreement wit the experiments and reproduce the formation of parallelogram-shaped fragments.

The fractal dimension of the isolines for random surfaces is determined numerically in the range of parameters corresponding to the correlated percolation. It is shown that the universality class of the uncorrelated percolation is narrower than previously thought: the fractal dimension of the isolines is affected by much weaker long-range correlations than the correlation exponent ν (J.Kalda).

Turbulent diffusion
The scaling exponent describing the small-scale anisotropy of passive scalar turbulence is analytically derived; the result are in a good agreement with the simulation results using the one-dimensional turbulent mixing model, as well as with the experimental results of other research groups.

The rain nucleation process in warm clouds is studied by extending the previously developed "triplet"model of passive scalar mixing in Kolmogorov turbulence. The probability density function of the width of the droplet-size spectrum is derived; this is the first step in explaining the experimentally observed anomalously fast nucleation process.

The passive scalar decay and probability density function of the tracer concentration has been studied theoretically, experimentally and numerically (in collaboration with IRPHE, University of Marseille) (J.Kalda, M.Kree, A.Morozenko).

Econophysics
In order to analyse and test the superuniversal distribution of low-variability periods using various financial time-series, an original method for the scaling analysis of sparse statistical data has been developed. The obtained results are applied to the portfolio risk analysis (J.Kalda, R.Kitt, M.Säkki).

3.1.4 Software development

- Pearu Peterson. PyLibNIDAQmx: exposes NI-DAQmx software driver to Python. `http://code.google.com/p/pylibnidaqmx/`;
- Pearu Peterson. PyLibTiff: wraps libtiff library to Python. `http://code.google.com/p/pylibtiff/`;
- Pearu Peterson, Martin Laasmaa. IOC Microscope: tools for manipulating and analyzing 3D microscope images.

The project for developing C^{++} software for driving experiment protocols on fluorescence and confocal microscopes has been continued.

3.1.5 Laboratory of Wave Engineering

Wave climate and oceanography
The highlights of the studies of physical oceanography of the Gulf of Finland, the Baltic Sea, in 1997–2007 that serve, or can be interpreted, as evidence of shifts or changes in the local climate, are thoroughly reviewed. Also, several findings that can be used as a starting point of studies of climatic changes are described. The studies include extensive analyses of historical and recently collected data sets, numerical modelling, and introducing of new theoretical concepts, and cover all basic disciplines of physical oceanography: hydrography, marine optics, marine meteorology, circulation, sea level, waves, and ice conditions (T.Soomere, in cooperation with K.Myrberg, FIMR, M.Leppäranta).

Seasonal and long-term variations of wave conditions in the northern Baltic Sea and the related uncertainties have been analysed by means of merging historical visual observations and numerical hindcasts to reveal the basic features of the wave properties. Wave conditions, their seasonal cycle, and inter-annual and long-term variations are quantified based on (i) visual observations along its eastern coast at Vilsandi and Pakri, (ii) instrumentally measured wave properties at Almagrundet on the western coast, (iii) directional wave statistics from the northern Baltic Proper, and (iv) wave hindcast using a fetch-based point model and a shorter hindcast with the WAM wave model forced by geostrophic and MESAN winds.

The monthly mean wave height follows the seasonal variation in wind. The observed annual mean wave height reveals nearly synchronous, substantial decadal-scale variations in the entire region, an increase until the mid-1990s and a decrease since 1997, although the mean wind speed continues to increase over the area. The WAM model qualitatively represents the temporal course of the wave intensity and the basic features of wave fields. Neither of the models is able to systematically reproduce extreme wave conditions or spatial variability of wave fields. The mismatches between the existing observed and hindcast data mostly stem from the insufficient quality of the marine wind information (I.Zaitseva-Pärnaste, T.Soomere, A.Räämet, T.Soomere, in cooperation with Ü.Suursaar, T.Kullas, Estonian Marine Institute).

Long-term, seasonal, and diurnal variations of the wind speed are analysed for a wind data set from Pakri (1969–1992, the North Estonian coast). It is shown that both the interannual and seasonal variations of the annual mean wind speed are mostly ± 1 m/s from the overall average (5.1 m/s). No clear trend in the annual mean wind speed existed in 1966–1992. Wind speed frequency distributions show the largest seasonal differences for west and north-west winds. While there is almost no dependence of the wind speed on the measurement time in winter and in autumn, there is a large daily cycle in spring and summer (± 0.75 m/s from the average) (T.Soomere, in cooperation with S.Keevallik, Marine Systems Institute).

Long waves

The mechanism of the 1956 Greek tsunami recorded at Yafo, Israel was reproduced by numerical modeling and analysis of the tide-gauge records. The landslide movement, triggered by the main shock and/or by the largest aftershock, is suggested as a source of these tsunami waves (I.Didenkulova, in cooperation with S.Beisel, L.Chubarov, Yu.Shokin, ICT SB RAS, E.Kit, Tel Aviv Uni, A.Levin, M.Sladkevich, Coastal Marine Eng Res Institute, E.N.Pelinovsky, IAP RAS).

Long wave dynamics along the convex bottom profile $h(x) \sim x^{4/3}$ can be considered as "non-reflecting"wave propagation. In this case, shoaling effects are very strong, and wave reflection occurs in the immediate vicinity of the shoreline. It is shown that in certain cases the runup height along the convex profile is considerably larger than for beaches with a linear slope (I.Didenkulova, T.Soomere, in cooperation with E.N.Pelinovsky, IAP RAS).

Existence of *non-dispersive nonlinear traveling waves propagating without internal reflection in inclined water channels* of arbitrary slope is demonstrated. It is shown that traveling non-monochromatic waves exist in both linear and nonlinear shallow water theories in the case of a uniformly inclined channel with a parabolic cross-section. Amplitudes of nonlinear traveling waves deviate from the linear Green's law and negative amplitude grows faster than positive (I.Didenkulova, in cooperation with E.N.Pelinovsky, IAP RAS).

Nonlinear long-wave deformation and run-up in a basin of varying depth is analyzed in the framework of 1D nonlinear shallow-water theory. The basin depth is slowly varied far offshore and joins a plane beach near the shore. It is demonstrated that wave steepness is the most significant parameter characterizing the runup process. The comparison between different transition zones shows that in the general case, the concave beach gives a larger increase in the wave steepness and greater amplification of the wave amplitude (I.Didenkulova).

Descriptions and manifestations of *tsunami-like phenomena in Russian inland water bodies* (lakes, rivers and water reservoirs) are collected and analyzed for the time period of 400 years. Data analysis confirms the possibility of tsunami wave generation in all types of inland waters (I.Didenkulova, in cooperation with E.N.Pelinovsky, IAP RAS).

Coastal engineering

A simple method is proposed for a *rapid estimate of the net sand loss or gain for "almost equilibrium"beaches* that are close to Dean's equilibrium beach profile (EBP) conditions. Sediment loss or gain is expressed in terms of the changes of the dry land area, the width of the EBP, and the uplift or downsinking rate. Information necessary for applying the method consists of (i) the basic properties of the local wave climate, (ii) changes of the location of the coastline, (iii) grain size along the beach and (iv) uplift or downsinking rate. An example of the sediment budget for Pirita Beach is presented (T.Soomere, A.Kask, N.Delpeche, in cooperation with T.Healy, Univesity of Waikato).

Intensification of coastal processes in the eastern Gulf of Finland and on the Curonian Spit (Kaliningrad region, Baltic Sea) is analysed based on historical materials, archive aerial photographs and modern high-resolution satellite images together with on-land investigations. A new interpretation of the sediment distribution and sedimentation processes in the Russian part

of the Curonian Spit was obtained on land and offshore data from 2006 and 2007. The spit migrates 0.4–0.5 m/year over the last 5000 to 6000 years. The main reason for erosion of the spit is sediment deficit in the coastal system whereas a more likely reason in the eastern Gulf of Finland is the combination of anthropogenic pressure and climate change (in particular, shortening of ice period and frequent occurrence of high water levels in ice-free time) (D.Kurennoy, in cooperation with V.A.Zhamoida, D.V.Ryabchuk, Y.P.Kropatchev, V.L.Boldyrev, V.V.Sivkov, L.Sukhacheva, M.Spiridonov, VSEGEI).

Patterns of wave-orbital speed and skin friction under estuarine (fetch-limited) waves have been established based on results of field experiments in a large New Zealand estuary (fetch lenths up to 25 km) under locally generated waves (heights up to 1 m, periods 2–6 s). The variation in the near-bed wave-orbital speed depends on a balance between instantaneous water depth, wave height and period, all of which vary over the tidal cycle. Whilst increasing depth retards the penetration of wave-orbital motions down to the bed, increasing period and height result in an increase in wave-orbital speed at the bed, wave-induced skin friction, and sediment entrainment. Sediment flux also depends on the tidal current, which is not necessarily coupled with the elevation on the flat (T.J.Dolphin, M.O.Green).

Wind waves and vessel wakes in Tallinn Bay

The almost-tideless Tallinn Bay is one of the few places in the world where high-speed ferries operate close to the shoreline and where wake-waves may have a significant effect on the morphology and the sediment dynamics on medium-energy beaches. A new class of large, conventional, highly powered ships operating at $\sim$ 50 km/h has been introduced in recent years. The properties of ship waves were measured continuously over a four week period in summer 2008; in 2.5–3 m water depth $\sim$ 100 m offshore from a semi-sheltered an almost non-reflecting beach located $\sim$ 2700 m from the sailing line. During calm conditions, vessel generated non-broken waves of up to 1.5 m, with periods of 10–13 seconds were measured in the nearshore. The typical daily highest ship wave is approximately 1.2–1.4 m.

Variability in the properties of wakes generated by high-speed ferries. The data from > 400 wakes are used for the construction of empirical probability distribution functions of different wake properties (maximum height, wake energy, and energy flux). The periods of the highest waves vary insignificantly and are closely related to the cruise speed of the vessels. An appropriate measure of the properties and variability of wakes is the maximum wave height. Wakes from 'classic' high-speed ships are very variable. Wakes from large, basically conventional, but strongly powered ferries show quite limited variability, thus, both the average and extreme wake properties of such ships can be more easily adjusted by changing their sailing regime (D.Kurennoy, T.Soomere, in cooperation with K.E.Parnell, James Cook University, Australia).

The relative influence of wind-wave and vessel-wake energy in Tallinn Bay has been re-evaluated. Analysis of signals of > 650 ship wakes shows that (i) the daily maximum heights of vessel wakes have increased considerably since the beginning of the decade while (ii) the leading wave periods and integral properties of wakes such as the total wave energy and its flux have remained largely unchanged. The typical daily largest ship waves are equivalent to the annual highest 0.8–1.8% of wind waves and the highest ship waves (1.7 m) to the highest 0.25% of wind waves. Unlike the Baltic Proper, the overall wind wave intensity has varied insignificantly over the last three decades in Tallinn Bay where vessel wakes contribute about 10% in terms of wave energy and 25% in terms of energy flux (L.Kelpšaite, T.Soomere).

Vessel-wave induced potential long shore sediment transport. The wind-wave time series at the SW coast of the Island of Aegna in 1981–2008 is modelled on the basis of a simplified scheme for a long-term wave hindcast with the use of a triple-nested version of the WAM model. Longshore drift created by waves of different origin is estimated by the CERC energy flux model. Vessel wakes cause longshore drift that had in 2007–2008 a magnitude about 25%

of and opposite directed to that produced by wind waves (L.Kelpšaite, T.Soomere).

Shoaling and run-up of long waves induced by high-speed ferries in Tallinn Bay is examined theoretically and experimentally, focusing on the dependence of runup height on the incident wave properties. Experimental data from 212 wake events in Tallinn Bay demonstrate that the largest ship generated waves approaching the coast break in the nearshore and have only weak wave amplification at the beach. On average the runup height of ship wakes exceeds the wave height offshore at the depth of 2.7 m by a factor of 1.3, and this amplification factor decreases with an increase in wave amplitude. This effect is explained by wave breaking and dissipation in the turbulent bottom boundary layer (I.Didenkulova, T.Soomere, D.Kurennoy, in cooperation with K.E.Parnell and E.Pelinovsky).

Simulation of patterns of wakes from high-speed ferries, their spatial variability and far-field properties in Tallinn Bay has been performed with the use of the COULWAVE model forced by ship motions for several GPS-recorded tracks. The model is implemented with a resolution of 10 m for the entire bay (about 10×20 km). The modelled ship wave properties reasonably match the measured waves in terms of both wave heights and periods. The results show considerable spatial variability in the wave amplitude distribution, due to particular properties of the ship movement, the bathymetry, and the coastline topography. The largest waves (up to 3 m) were created when the ship sailing to Tallinn entered into supercritical regime whereas along other sections of the track the wave height was about 1 m. The spatial extent of the wake patterns is very sensitive to small variations in sailing conditions. This feature leads to large variations of ship wave loads at different coastal sections. The highest waves hit the area of Pirita Beach.The runup of the largest ship wakes on the beach increases significantly with an increase in wave height whereas shorter (period $< 2-5$ s) waves merge into longer waves in the shoaling and runup process (T.Torsvik, T.Soomere, I.Didenkulova, K.E.Parnell).

Crest-trough asymmetry of waves generated by high-speed ferries. It is shown that, on average, wave crests deviate from still water level 1.4 times greater than the wave troughs for waves from the first group of the wake. The most frequent values for the ratio of the crest height over the trough depth lie between 1 and 1.6. In extreme cases, the crest height exceeds the trough depth by up to a factor of 3. It is demonstrated that asymmetry is an important parameter of the wakes, the values of which do not necessarily correlate with the maximum wave height in the wakes. The results for the ratio of the crest height over the trough depth coincide with estimates made using classical cnoidal wave theory (D.Kurennoy, I.Didenkulova, T.Soomere).

Implications of fast-ferry wakes for semi-sheltered beaches. The potential of ship wakes to alter the natural beach processes is demonstrated based on in situ observations. Beach profiles of the SW coast of Aegna were measured up to several times a day for more than 20 days. An adjacent jetty restricts sediment transport from the east. Overnight and during high-energy wave conditions, wind generated waves build the beach adjacent to the jetty. During calm periods the beach is not replenished and significant loss of sediment across the beach profile is evident, due to ship wakes. The beach, therefore, never reaches an equilibrium shape. Instead, the area offshore adjacent to the jetty serves as a sink for the beach sediments sediments (T.Soomere, I.Didenkulova, K.E.Parnell).

Complexity issues: A thorough overview *the physics and mathematics of interactions of solitons* in different media has been presented from the viewpoint of complexity and systems science, from the basic definitions of solitons and ending with the latest developments in the theory of solitons and foresight into future research. In particular, research into solitonics made in the CENS within last decades has been positioned on the background of worldwide developments in this field (T.Soomere). A short overview of achievements in the medical 3D field has been compiled (E.Quak).

Highlights

- Seasonal and long-term variations of wave conditions in the northern Baltic Sea and the related uncertainties have been established by means of merging historical visual observations and numerical hindcasts;
- A simple method is developed for a rapid estimate of the net sand loss or gain for "almost equilibrium"beaches;
- The potential reasons for intensification of coastal processes in the eastern Gulf of Finland and on the Curonian Spit have been established;
- The patterns of wave-orbital speed and skin friction under estuarine (fetch-limited) waves have been evaluated;
- Variability in the properties and runup features of wakes generated by different generation of high-speed ferries has been quantified based on high-resolution recording of > 650 ship signals in 2008 and extensive numerical simulations;
- The relative influence of wind-wave and vessel-wake energy, related long shore sediment transport and the potential impact on cross-shore transport has been established for the entrance area of Tallinn Bay;
- A thorough overview the physics and mathematics of interactions of solitons in different media has been presented from the viewpoint of complexity and systems science;
- The landslide mechanism of the 1956 Greek tsunami recorded at Yafo, Israel is reproduced by numerical modeling and analysis of the tide-gauge records;
- It is shown that waves along the specific "nonreflecting"bottom configurations propagate without inner reflection that leads to extreme shoaling and runup;
- It is shown that wave steepness together with the self-similarity (Iribarren) parameter are the most significant parameters characterizing wave breaking and runup on a beach.

3.1.6 Laboratory of Systems Biology

Biophysics and cell energetics

Mathematical model of heart muscle fibers. Several experiments on permeabilized heart muscle fibers suggest the existence of diffusion restrictions grouping mitochondria and surrounding ATPases. The specific causes of these restrictions are not known, but intracellular structures are speculated to act as diffusion barriers. In this work, we assume that diffusion restrictions are induced by sarcoplasmic reticulum (SR), cytoskeleton proteins localized near SR, and crowding of cytosolic proteins. The aim of this work was to test whether such localization of diffusion restrictions would be consistent with the available experimental data and evaluate the extent of the restrictions. For that, a three-dimensional finite-element model was composed with the geometry based on mitochondrial and SR structural organization. Diffusion restrictions induced by SR and cytoskeleton proteins were varied with other model parameters to fit the set of experimental data obtained on permeabilized rat heart muscle fibers. There are many sets of model parameters that were able to reproduce all experiments considered in this work. However, in all the sets, $< 5-6\%$ of the surface formed by SR and associated cytoskeleton proteins is permeable to metabolites. Such a low level of permeability indicates that the proteins should play a dominant part in formation of the diffusion restrictions.

Intracellular diffusion restrictions in isolated cardiomyocytes from rainbow trout. Restriction of intracellular diffusion of adenine nucleotides has been studied intensively on adult rat cardiomyocytes. However, their cause and role *in vivo* is still uncertain. Intracellular membrane structures have been suggested to play a role. We therefore chose to study cardiomyocytes from rainbow trout (*Oncorhynchus mykiss*), which are thinner and have fewer intracellular membrane structures than adult rat cardiomyocytes. Previous studies suggest that trout permeabilized cardiac fibers also have diffusion restrictions. However, results from fibers may be affected by incomplete separation of the cells. This is avoided when studying permeabilized, isolated cardiomyocytes. The aim of this study was to verify the existence of diffusion restrictions in trout cardiomyocytes by comparing ADP-kinetics of mitochondrial respiration in permeabilized fibers, permeabilized cardiomyocytes and isolated mitochondria from rainbow trout heart. Experiments were performed at 10, 15 and 20 degrees C in the absence and presence of creatine. Trout cardiomyocytes hypercontracted in the solutions used for mammalian cardiomyocytes. We developed a new solution in which they retained their shape and showed stable steady state respiration rates throughout an experiment. The apparent ADP-affinity of permeabilized cardiomyocytes was different from that of fibers. It was higher, independent of temperature and not increased by creatine. However, it was still about ten times lower than in isolated mitochondria. The difference between fibers and cardiomyocytes suggest that results from trout heart fibers were affected by incomplete separation of the cells. However, the lower ADP-affinity of cardiomyocytes compared to isolated mitochondria indicate that intracellular diffusion restrictions are still present in trout cardiomyocytes despite their lower density of intracellular membrane structures. The lack of a creatine effect indicates that trout heart lacks mitochondrial creatine kinase tightly coupled to respiration. This argues against diffusion restriction by the outer mitochondrial membrane. These results from rainbow trout cardiomyocytes resemble those from other low-performance hearts such as neonatal rat and rabbit hearts. Thus, it seems that metabolic regulation is related to cardiac performance, and it is likely that rainbow trout can be used as a model animal for further studies of the localization and role of diffusion restrictions in low-performance hearts.

Bidirectionality and compartmentation of metabolic fluxes are revealed in the dynamics of isotopomer networks. Isotope labeling is one of the few methods of revealing the *in vivo* bidirectionality and compartmentalization of metabolic fluxes within metabolic networks. We argue that a shift from steady state to dynamic isotopomer analysis is required to deal with these cellular complexities and provide a review of dynamic studies of compartmentalized energy fluxes in eukaryotic cells including cardiac muscle, plants, and astrocytes. Knowledge of complex metabolic behaviour on a molecular level is prerequisite for the intelligent design of genetically modified organisms able to realize their potential of revolutionizing food, energy, and pharmaceutical production. We describe techniques to explore the bidirectionality and compartmentalization of metabolic fluxes using information contained in the isotopic transient, and discuss the integration of kinetic models with MFA. The flux parameters of an example metabolic network were optimized to examine the compartmentalization of metabolites and and the bidirectionality of fluxes in the TCA cycle of *Saccharomyces uvarum* for steady-state respiratory growth.

F2PY: a tool for connecting Fortran and Python programs: In this paper we tackle the problem of connecting low-level Fortran programs to high-level Python programs. The difficulties of mixed language programming between Fortran and C are resolved in an almost compiler and platform independent way. We provide a polished software tool F2PY that can (semi-)automatically build interfaces between the Python and Fortran languages and hence almost completely hide the difficulties from the target user: a research scientist who develops a computer model using a high-performance scripting approach.

Application of regularized Richardson-Lucy algorithm for deconvolution of confocal microscopy images. Confocal microscopy has shown itself as a valuable tool to study morphology

and processes in live cells. While confocal microscopes have considerably smaller contribution of out-of-focus light than widefield microscopes, the confocal images can still be enhanced mathematically if the optical and data acquisition defects are accounted for. For that, several deconvolution algorithms have been proposed. As a practical solution, maximum-likehood algorithms with regularization have been used. However, an open source implementation of these algorithms is absent. The aims of this work were: to develop an open source software package that would allow testing different deconvolution algorithms and that would be easy to use in practice; to find good estimates of deconvolution parameters. One of the maximum-likehood algorithms — Richardson-Lucy algorithm — has been implemented together with the total variation (TV) regularization in an open source software package. The influence of TV regularization on deconvolution process is determined by one parameter. Here, we derived a formula to estimate this regularization parameter automatically from the images as the algorithm progresses. To assess the effectiveness of this algorithm, synthetic images were composed on the basis of confocal images of rat cardiomyocytes. The synthetic images were altered by convolving them with an experimentally determined point spread function and applying different levels of noise. From the analysis of deconvolved results, we have determined under which conditions our estimation of TV regularization parameter gives good results. The estimated TV regularization parameter can be monitored during deconvolution process and used as a stopping criterion. Finally, we demonstrate the use of the developed software by deconvolving confocal images of rat cardiomyocytes with stained mitochondria and sarcolemma. We have developed an open source software package that can be used for deconvolving microscope images in practice. In addition, the software package can be used as a platform for testing new deconvolution algorithms. We have derived a formula to estimate the TV regularization parameter for the regularized Richardson-Lucy deconvolution algorithm. In addition, a new criterion for stopping the deconvolution process is proposed (M.Vendelin, et al.).

3.1.7 Laboratory of Photoelasticity

Optical nonlinearity and photoelasticity

The aim of the investigations has been development of the theory and algorithms of integrated photoelasticity for the determination of three-dimensional stress fields.

The influence of the rotation of the principal stress axes on the integrated fringe pattern has been considered in the general form. It is shown that the rotation diminishes the distance between interference fringes and the contrast of the fringe pattern is diminished. This result is in correlation with the theory of interference blots.

A technology of scalar field tomography, the Abel inversion, has been generalized for the case of axisymmetric tensor fields. The peculiarity in determining the stress tensor field is that on every light ray two integrals of the field are measured and for complete determination of all the components of the stress tensor, equations of the theory of elasticity are used.

In integrated photoelasticity, the normal and shear stress components of an axisymmetric state of stress can be directly determined from the measurement data. The radial and circumferential stress components can be calculated by integrating the compatibility and the equilibrium equations. It was found that results of the integration are sensitive to small changes in initial values when the direction of the integration direction is towards the axis of symmetry. The direction of the integration was reversed to start from the axis, where radial and circumferential stresses are equal to each other; initial values were chosen such that calculated radial and circumferential stresses would satisfy the boundary conditions at the external surface of the specimen. This scheme was found to be stable relative to small changes in initial values. As a practical application, complete stress distribution in an optical fibre, indented by a metal sphere, was determined (H.Aben, et al.).

3.2. Institute of Cybernetics: Control Systems Department

3.2.1. Control systems and computer algebra

Many algebraic concepts such as Ore (skew) polynomial rings, modules over skew polynomial rings, difference fields and ideals play a prominent role in (nonlinear) control theory. Their applications, in general, require the help of computer algebra software. In Maple there exists a built-in package, OreTools, that addresses the computations with Ore polynomials. Unfortunately, this package, though being a good starting point for control applications, cannot handle the Ore polynomials associated to nonlinear control systems without further extension. The reason is that one cannot describe the relations between control system variables explicitly in this package, as well as take these relationships into account in calculations with Ore polynomials. The extension of the package so that it can address the control problems, is not immediate and trivial, especially for discrete-time systems. The main goal of our research was to build a solid mathematical ground that will help to implement the required changes.

An algebraic construction of the inversive difference field associated with a discrete-time rational nonlinear control system under the assumption that the system is submersive has been described. We have proven that a system is submersive if and only if its associated difference ideal is proper, prime and reflexive. Next, we have shown that Kähler differentials of the above inversive field define a module over the corresponding ring of Ore operators and we have related its torsion submodule to the vector space of autonomous one-forms, introduced elsewhere. The above results allowed us to check accessibility property and simplify transfer functions with computer algebra techniques (Ü.Kotta).

3.2.2 Nonlinear control systems on (regular) time scales

An algebraic formalism of differential one-forms, associated with nonlinear control systems, defined on non-homogeneous, but regular time scales has been developed. The formalism unifies the existing theories for continuous and discrete-time systems and accommodates also the nonuniformly sampled systems. A ring of meromorphic functions, corresponding to a control system, has been introduced. It is equipped with two operators whose properties are studied. An inversive closure of this ring is constructed. Compared with the homogeneous case the main difficulties are non-commutativity of delta derivative and shift operators and the fact that additional time variable t appears in the ring, associated to control system (Ü.Kotta).

3.2.3 Transformation of the nonlinear system into the observer form

More direct and simple necessary conditions for the existence of state and output coordinate transformations, allowing to transform the continuous-time nonlinear single-input single-output control system into the observer form have been given. Both the old and new conditions require that the certain n differential one-forms, associated with the nth order differential input-output equation (corresponding to the state equations), and depending on a unknown single-variable output function, are the total differentials of certain functions (V.Kaparin, Ü.Kotta)

3.2.4 Realizability conditions for bilinear input-output equations

The constraints on the coefficients a_i, b_i, c_{ij} of the bilinear continuous-time input-output model have been suggested that yield generalized state equations with input derivative order lower than that in the input-output equations. In the limiting case when one removes the input derivatives altogether, these conditions provide a solution of the realizability problem. The new state coordinates have been found step by step. We first found a coordinate transformation allowing the reduction of the maximal order of the input time derivatives by one and then wrote the corresponding state equations. At the second step we found the next coordinate transformation to lower the maximal order of input time derivative in the new state equations, etc. At each step we checked, what condition the coefficients should satisfy to make the next step possible (P.Kotta, Ü.Kotta, T.Mullari, M.Tõnso).

3.2.5 Realization of continuoustime nonlinear inputoutput equations: polynomial approach

We have applied the polynomial methods to nonlinear realization problem. The problem that we dealt with is that of recovering the state-space model, whenever possible, starting from an arbitrary nonlinear higher order i/o differential equation. A new formula has been found which allows to compute the differentials of the state coordinates directly from the polynomial description of the nonlinear system, yielding a shorter and more compact program code in Mathematica implementation (Ü.Kotta, M.Tõnso).

3.2.6 Neural-networks-based ANARX models

The main problem which we have dealt with was the model matching problem (MMP) for the specific classes of nonlinear control systems called Additive Nonlinear AutoRegressive eXogenous (ANARX) and Neural Networks based ANARX (NN-ANARX) models, respectively. One aspect we focused on was constructing the time-varying model, that guarantees the prespecified poles of the closed-loop system. The other subproblems addressed were developing the neural network-based controller for systems with relative degree greater than one and extending the known output feedback linearization method for multi-input multi-output systems (J.Belikov).

3.2.7 Robust control via convex approximation of stability domain

In the field of robust control of discrete-time systems the reflection coefficient approach combined with stability domain methods has been extended by the use of two linear Schur invariant transformations with a free parameter in the space of coefficients of closed loop characteristic polynomials. The main idea of these transformations is based on the multilinearity of the transformation between reflection coefficients and polynomial coefficients.

The first transformation maps an arbitrary stable polytope of n-dimensional polynomials into another stable polytope of n-dimensional polynomials. In fact, this transformation with a free parameter changes only the last reflection coefficients of all the polynomials of the primary stable polytope so that the secondary polytope will be stable. The last reflection vectors of an arbitrary Schur stable polynomial are invariant with respect of this transformation. By the use of this transformation the stability domain defined by well known Cohn's condition and discrete Kharitonov's theorem can be easily extended. The volume of stable polytopes is studied depending on the choice of the free parameter.

The second transformation maps a stable n-dimensional tilted hyperrectangle given by discrete Kharitonov's theorem into a stable $(n+1)$-dimensional stable polytope. This transformation gives a possibility to increase the dimensionality of stable polytopes starting from discrete Kharitonov's theorem (Ü.Nurges).

3.2.8 Robot scrub nurse

Main goal of joint research project with Tokyo Denki University is to develop a robot to replace human scrub nurse (specially trained nurse to assist operating surgeon) during laparoscope surgery. Replacing human in such delicate area like medicine imposes certain requirements on the way how robot behaves and communicates. Behavioral control of the scrub nurse robot is implemented in the form of timed automata. Such decision making unit generates decisions about necessity of certain assistive action based on the surgery scenario, behavioral models of the surgeon and scrub nurse and information about current stage of the surgery. Since operating surgeon's attention is concentrated on patient, voice communication is reduced to the minimum; scrub nurse robot should follow surgery procedure (detect current stage of the surgery) by observing hand movements of the surgeon. During previous years number techniques were developed for this purpose.

Obviously no one of the techniques separately can guarantee hundred percent correct recognition. In order to combine strengths of all available techniques voting automaton based hybrid detection approach were proposed. First an automaton was designed to control hybrid detec-

tion system of three predefined detection techniques [1]. While such approach demonstrates higher detection quality it requires human not only to design the automaton but also redesign it if at least one detection technique was modified. In order to overcome this problem an approach towards open architecture was taken. In [2] main attention is paid to the design of voting automata using supervised learning technique. Application of supervised learning allowed combining arbitrary number of detection techniques, excluding the human factor from automata design (S.Nõmm, J.Vain).

3.2.9 The model-based synthesis of reactive planning software testers

The method of model-based synthesis of reactive planning software testers (RPT), suggested in 2007, was developed further. Main improvement of the method incorporates parametric modulation algorithm of the RPT's planning cone. We demonstrated that the adjustable planning horizon algorithm provides close to optimal solution within the equivalence class of test traces of same coverage. The class of models used in the tester synthesis algorithm is output-observable nondeterministic Extended Finite State Machines with finite data domains. The performance evaluation of the synthesized testers is based on the comparison with other well-known online testing control strategies such as 'Random walk' and 'Anti-ant' on the same set of benchmark examples. Our method outperformed both competing strategies providing 10 to 1000 times shorter test traces, showing up clear advantage in the cases where the System under Test (SUT) models have deep nested loops, high degree of non-determinism and 'code-lock' like structure (K.Raiend, J.Vain).

3.3 Research Laboratory of Proactive Technologies, Tallinn University of Technology

The Annual Report 2009 continues the structure of 2008 Report (www.proactivity-lab.ee) and is a combination of a white paper explaining the research plans and illustration of some research results. Whereas the 2008 Report concentrated on the large picture – general research issues in networked proactive and pervasive computing systems, with special attention on enabling factors for emergent behaviour and models of situation-aware interactive computation – this year's report focuses on adaptive and self-organising subclass of such systems.

The Report starts with taxonomy of computer applications – transformational, reactive and proactive computing systems. It is stated that while adaptation is a usual property in reactive systems, self-organisation can earnestly be observed, applied, and verified only starting from proactive computing systems. At the same time, being pedantic, adaptation and learning should not be allowed in transformational systems – just to avoid violation of basic axioms of Turing computable functions. The previous statement is true in the ideal world, and we all know that the pragmatic, non-ideal world never has crisp domains and theories are often being applied vaguely within in their domains of definition.

The Report includes essays on:

- Adaptation and self-organisation (T.Lints);
- Architectural control in virtual organisations (T.Kangilaski);
- Simulations in ad hoc networks, and simulators (T.Tomson);
- Acquisition and pre-processing of situational information (J.S.Preden).

In addition to the essays the report includes short abstracts of PhD thesis in progress and statistical data – e.g. superficial data about research grants, industrial contracts, attended conferences, and publications (see also below Sections 4–6).

The current research results of 2009 are reflected in published papers (see Section 5) including the analysis of situation awareness of vehicles, nonlinear discrete-time systems, computational intelligence methods for process control, etc. (L.Mõtus, et al.).

3.4 Research within international programmes

3.4.1 FP6, Marie Curie Transfer of Knowledge Development Scheme CENS-CMA (MTKD-CT-2004-013909)
"Co-operation of Estonian and Norwegian Scientific Centres within Mathematics and its Applications"(01.05.2005 – 30.04.2009). Collaboration project with CMA (Centre of Mathematics for Applications), Oslo, Norway. Responsible scientist J.Engelbrecht. Technical manager E.Quak.

3.4.2 FP6, Marie Curie Research and Training Network SEAMOCS (MRTN-CT-2005-019374)
"Applied stochastic models for ocean engineering, climate and safe transportation"(01.11.2005 – 31.10.2009; led by Lund University (Prof. Georg Lindgren). The Wave Engineering Laboratory is leader of the work package 3 "Models on local scale"; responsible scientist T.Soomere. The partners are: University of Sheffield (UK), Université Paul Sabatier (Toulouse, France), Katholieke Universiteit Leuven (Belgium), Chalmers Technical University (Göteborg, Sweden), Royal Netherlands Meteorological Institute (De Bilt, The Netherlands), Swedish Meteorological and Hydrological Institute (Norrköping, Swedem), Det Norske Veritas (Oslo, Norway).

3.4.3 FP7, FET (Future and Emerging Technologies), CA (Coordination Action) GSD
"Global System Dynamics and Policies: simulation and visualisation technologies"
(01.05.2008 – 30.04.2010), led by University College London (United Kingdom); partners: Utrecht University (Netherlands), Max Planck Institute of Meteorology (Germany), European Climate Forum e.V. (Germany), Chalmers Tekniska Hoegskola AB (Sweden), Unit for Research into Changing Institutions (United Kingdom), IMCS Intercollege Ltd. (Cyprus), Universidad de Alcala (Spain), Ecole des Hautes Etudes en Sciences Sociales (France), Potsdam Institute for Climate Impact Research (Germany). Responsible scientist T.Soomere.

3.4.4 FP7 Marie Curie Re-integration grant ESTSpline (FP7-PEOPLE-2007-2-2-ERG) "Educational, Scientific and Technological aspects of Splines"(01.05.2008 – 30.04.2011), Principal Scientist E.Quak.

3.4.5 EEA grant EMP41 "Shoaling and runup of long waves generated by high-speed ferries", 2008–2010) Collaboration between Irina Didenkulova and (i) University of Bergen, Norway: Tomas Torsvik, (ii) Dept. of Mathematics, University of Oslo, Norway: Prof. Geir Pedersen, and (iii) Inst. of Applied Physics, Nizhny Novgorod, Russia: Prof. E.N.Pelinovsky. Responsible scientist I.Didenkulova.

3.4.6 FP7 ICT Coordination Action FOCUSK3D (ICT 214993) "Foster the comprehension and use of knowledge intensive 3D media"www.focusk3d.eu (01.03.2008 – 28.2.2010), led by National Research Council Institute for Applied Mathematics and Information Technology - Genova (Italy), partners: Laboratory for Information Systems and Services, Center for Research and Technology – Thessaly (Greece); Vrlab – Ecole Polytechnique Fédérale de Lausanne (Switzerland); Fraunhofer Institute for Computer Graphics Research (Germany); INRIA – Institut National de Recherche en Informatique et Automatique (France); MIRALab – Université

de Genève (Switzerland); Stiftelsen SINTEF (Norway); Utrecht University (The Netherlands); Task Leader Project Evaluation and Assessment: E.Quak.

3.4.7 FP7 Marie Curie Initial Training Network (FP7-PEOPLE-1-1-ITN) Shapes, Geometry, Algebra www.saga-network.eu (01.11.2008 – 31.10.2013), led by Stiftelsen SINTEF (Norway); partners: University of Oslo (Norway); Johannes Kepler Universität Linz (Austria); Universidad de Cantabria (Spain); Vilnius University (Lithuania); National and Kapodistrian University Athens (Greece); INRIA – Institut National de Recherche en Informatique et Automatique (France); Fondazione GraphiTech (Italy); Missler Software (France); Kongsberg SIM (Norway); Participating Scientist: E.Quak.

3.4.8 BONUS+ (Baltic Organisations' Network for Funding Science) project BalticWay "The potential of currents for environmental management of the Baltic Sea maritime industry"(2009 – 2011). Collaboration with the Swedish Meteorological and Hydrological Institute (Norrk?ping), Laser Diagnostic Instruments (Tallinn), Danish Meteorological Institute, Department of Meteorology, University of Stockholm, Institute for Coastal Research, GKSS Geesthacht, Finnish Institute of Marine Research, and Leibniz Institute of Marine Sciences at the University of Kiel. Project coordinator T.Soomere.

The project aims at developing the innovative concept of fairway design to reduce the danger to vulnerable areas through a substantial decrease of marine-industry-induced environmental risks and impacts on bio-diversity, particularly on fragile ecosystems. The core objective is to develop a scientific platform for a low-cost technology of environmental management of shipping, offshore, and coastal engineering activities. The technology will be applied to place dangerous activities in areas, where an accident will have a minimum impact to vulnerable areas.

The approach makes use of the existence of semi-persistent current patterns that considerably affect the properties of pollution propagation: the probability of transport of dangerous substances from different open sea areas to the vulnerable areas is largely different. For certain regions (called areas of reduced risk) this probability is relatively small. The location of areas of reduced risk will be established numerically and verified experimentally. A combination of the classical risk analysis with novel mathematical methods (such as inverse methods) will be applied to identify the persistence, properties, and potential effect of such areas, and to establish generic criteria for their existence. Based on existing results, the investigations concentrate on the Gulf of Finland and the Darss Sill.

As a first step the project work in 2009 considers (i) the consequences of current-induced propagation of oil spills released from ships, aiming to route ships along the least dangerous paths, much like dangerous transports on land follow predefined routes, and (ii) estimates of the wave-induced radiation stress and the related transport in the surface layer.

3.4.9 Estonian-Polish joint research project "Equivalence and reducibility of nonlinear control systems on time scales"(2007 – 2009), PI: Ü. Kotta.

3.4.10 NOE Euron European Robotic Network, PI: Jüri Vain.

3.4.11 Project "Knowledge Environment for Interacting ROBOt SWARMs" (2006 – 2009), PI: Jüri Vain.

3.4.12 NordForsk (Coordinating and Funding Nordic Research Advisory Body on Nordic Research Policy) project "Nordic Network on Dependability - NODES"2006 – 2011 (Member of board: J.Vain).

3.4.13 FP7 Project ESTwave "Educational, Scientific and Technological Aspects of Mesoscopic Continuum Physics for Waves in Complex Materials", PERG04-GA-2008-238191, H.Herrmann

3.4.14 COST - European Cooperation in Science and Technology COST action 295 - "Dynamic Communication Networks: Foundations and Algorithms", (2005–2009).
Members of the management committee - M.Meriste and L.Mõotus (ProLab); J.-S.Preden participated in the work of the Action 295.

3.4.15 COST action IC0603 - "Antenna Systems & Sensors for Information Society Technologies "(ASSIST). Member of the management committee is J.-S.Preden (ProLab), (2007–2011).

3.4.16 COST Action IC0801 – "Agreement Technologies", (2009–2012), http://www.agreement-technologies.eu/.

3.4.17 Deployment of Model-based Technologies to Industrial Testing (D-MINT) (2007–2009), an ITEA-2 project

3.4.18 Innovative Manufacturing Engineering Systems Competence Center (IMECC)
Duration: June 2009 – June 2013 Partners: Alise Technic OÜ, AQ Lasertool OÜ, Bestnet AS, Datel AS, Fujitsu Services AS, Favor AS, Hanval Metall OÜ, Ferreks TT AS, Paide Masinatehas AS, Sumar Instrument OÜ, AMS Elektronic OÜ, Robomente OY, ELI OÜ, Norcar BSB Eesti AS, Pro-Step OÜ, Tallinn University of Technology (Dept. of Computer Control (Lab for Proactive Technologies), Dept. of Mechatronics, Dept. of Materials Engineering, Dept. of Machinery).

4. Funding

4.1 Target funding through the Ministry of Education and Research

1. Block grant SF0322521s03 "Nonlinear dynamics and complex systems", PI: J.Engelbrecht.
2. Block grant SF0140018s08, "Synthesis of complex nonlinear systems", PI: Ü.Kotta.
3. Block grant SF0140113s08 "Proactivity in the artificial world", PI: L.Mõtus.

4.2 Estonian grants (Estonian Science Foundation)

1. H.Aben, ETF grant 7840, "Complex algorithms for tomography of photoelasticity", (2009–2011).
2. A.Berezovski, ETF grant 7037, "Multiscale dynamics in microstructured solids", (2007–2010).
3. T.Soomere, ETF grant 7000, "Real time optical measurements and modelling of wave-induced resuspension of bottom sediments", (2007–2010) (together with Ants Erm, Marine Systems Institute).
4. T.Soomere, ETF grant 7413, "Spatial and temporal variability of the Baltic Sea wave fields in changing climatic conditions", (2008–2011).

5. A.Salupere, ETF grant 7035, “Deformation waves in microstructured solids — multiscale models”, (2008–2011).

6. Ü.Kotta, ETF grant 6922, “Control systems on time scales”, (2007–2010).

7. S.Nõmm, ETF grant 6884, “Identifiability and Identification of NARX models (My First Grant)”, (2006–2009).

8. J.Vain, ETF grant 7667, “Synthesis of model-based reactive planners for nondeterministic and distributed systems”, (2008–2011).

9. M.Vendelin, ETF grant 7344, “Mechanoenergetics of an isolated single cardiomyocyte”, (2008–2011).

10. I.Didenkulova, EEA grant EMP41, “Shoaling and runup of long waves generated by high-speed ferries”, (2008–2010).

11. E.Rüstern, ETF grant 6837, “Robust methods for complex systems control: and integrated approach”, (2006–2009).

12. A.Udal, ETF grant 6914, “Modelling of semiconductor quantum well nanostructures and carbon nano-tubes”, (2007–2009).

13. R.Savimaa, ETF grant 7693, “Modelling of time-sensitive processes and emergent behaviour in multi-functional and virtual organisations”, (2008–2011).

14. J.Janno, ETF grant 7728, “Inverse problems for materials with complex properties”, (2009–2012).

15. R.Birkedal, ETF grant 8041, “Role of the Na+/Ca2+-exchanger in excitation-contraction coupling and energetics in rainbow trout cardiomyocytes”(2009–2012).

4.3 International grants (see also 3.4)

1. Feodor Lynen fellowship of the German Alexander von Humboldt foundation (initially awarded 2008–2010) – H.Herrmann.

2. FP6, Marie Curie Transfer of Knowledge Development Scheme “Co-operation of Estonian and Norwegian Scientific Centres within Mathematics and its Applications”(CENS-CMA) – E.Quak.

3. FP6 Marie Curie Research and Training Network “Applied stochastic models for ocean engineering, climate and safe transportation”(SEAMOCS) – T.Soomere.

4. FP7, Future and Emerging Technologies), CA (Coordination Action) “Global System Dynamics and Policies: simulation and visualisation technologies”(GSD) – T.Soomere.

5. EEA grant EMP41 “Shoaling and runup of long waves generated by high-speed ferries”– I.Didenkulova.

6. FP7 Marie Curie Re-integration grant “Educational, Scientific and Technological aspects of Splines”(ESTSpline) – E.Quak.

7. FP7 ICT Coordination Action “Foster the comprehension and use of knowledge intensive 3D media”(FOCUSK3D) – E.Quak.

8. FP7 Marie Curie Initial Training Network “Shapes, Geometry, Algebra”(SAGA) – E.Quak.
9. Norwegian Centre of Excellence “Mathematics for Applications”(CMA) – E.Quak.
10. BONUS+ project “The potential of currents for environmental management of the Baltic Sea maritime industry”(BalticWay) – T.Soomere.
11. Wellcome Trust International Senior Research Fellowship (2007–2012) – M.Vendelin.

4.4 Additional funding

1. J.Ernits, J.Vain. EAS funding scheme “Eureka ITEA D-MINT”, (2008–2009).

4.5 Supportive grants (travel, etc.)

1. J.Engelbrecht, A.Ravasoo, M.Kutser – exchange scheme of Estonian and Hungarian Academies of Science for participating at FudoM 09, Rackeve, Hungary.
2. T.Peets, ESF DoRa programme grant for attending the IUTAM Symposium on Recent Advances of Acoustic Waves in Solids, Taipei, May 25–28, 2009.
3. M.Berezovski – Kristjan Jaak travel grant for participation in the 2nd International Symposium on Computational Mechanics (ISCM II) and the 12th International Conference on Enhancement and Promotion of Computational Methods in Engineering and Science (EPMESC XII), Hong Kong – Macau, November 30 – December 3, 2009
4. J.Belikov, ESF DoRa programme grant for attending 3rd IEEE Multi-conference on Systems and Control (MSC 2009) in St. Petersburg, Russia.
5. J.Belikov, EITSA travel grant for attending The Seventh IEEE International Conference on Control and Automation (ICCA 2009) in Christchurch, New Zealand.
6. V.Kaparin, EITSA travel grant for attending The 7th IEEE International Conference on Control and Automation (ICCA 2009) in Christchurch, New Zealand.
7. Ü.Nurges, EITSA travel grant for attending Chinese Control and Decision Conference (CCDC), Guilin, China.
8. Ü.Nurges, EITSA travel grant for attending The 7th IEEE International Conference on Control and Automation (ICCA 2009) in Christchurch, New Zealand.
9. S.Nõmm. SA Archimedese Kristjan Jaak support grant for attending ICROS-SICE International Joint Conference, Fukuoka City, Japan.
10. S.Nõmm, EITSA travel grant for attending 4th IEEE Conference on Industrial Electronics and Applications (ICIEA), Xi’an, China.
11. V.Kaparin, J.Belikov, European Embedded Control Institute grants for attending HYCON-EECI Graduate School on Control, 18 January – 7 February, 2009.
12. M.Tõnso, EITSA travel grant for attending 17th International Conference on Process Control (PC), Strbske Pleso, Slovakia.
13. A.Illaste, SA Archimedes Kristjan Jaak grant funding a research scholar position at Mount Sinai School of Medicine, New York, USA, 15 January – 15 July, 2009.

14. M.Sepp, M.Laasmaa, N.Sokolova, M.Vendelin, M.Kalda, D.Schryer – Activity 8 of the ESF DoRa travel grant for attending The Biophysical Society's 53rd Annual Meeting, Boston, USA, 28 February – 04 March, 2009.

15. T.Kangilaski, EITSA travel grant to IEEE-ICIT 2010 International Conference on Industrial Technology, 11–13 March, Viña del Mar, Chile.

16. T.Lints, EITSA travel grant to IEEE Symposium on Intelligent Agents (March 2009) in Nashville, Tennessee, USA.

17. J.Preden, participation in IEEE International Conference on Adaptive Science & Technology (ICAST 2009) in Ghana was partially supported by Archimedes DoRa scholarship.

5. Publicity of Results

5.1 Publications

5.1.1 Books, proceedings and theses

1. Applied Wave Mathematics: Selected Topics in Solids, Fluids, and Mathematical Methods / Eds. E.Quak, T.Soomere. Heidelberg, Springer, 2009. xii, 471 p.

2. Special issue on oceanography, meteorology and coastal engineering. - In: Estonian J. of Engineering / Eds. T.Soomere [et al.]. Tallinn, Estonian Academy Publishers, 2009, 15, 149–239.

3. L.Kelpsaite. Changing properties of wind waves and vessel wakes on the eastern coast of the Baltic Sea. Tallinn, TUT Press, 2009, 138 p., ill. Theses of Tallinn University of Technology, Thesis on Civil Engineering; F23.

4. D.Kurennoy. Analysis of the properties of fast ferry wakes in the context of coastal management. Tallinn, TUT Press, 2009, 164 p., ill. Theses of Tallinn University of Technology, Thesis on Civil Engineering; F24.

5. A.Kask. Lithohydrodynamic processes in the Tallinn Bay area. Tallinn, TUT Press, 2009, 101 pp. Theses of Tallinn University of Technology, Thesis on Civil Engineering; F22.

6. L.Ilison. Solitons and solitary waves in hierarchical KdV-type systems. Tallinn, TUT Press, 2009, 168 pp., ill. Theses of Tallinn University of Technology, Thesis on Natural and Exact Sciences; B83.

5.1.2 Papers (refereed)

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5. M.Berezovski, A.Berezovski, J.Engelbrecht. Macroscopic dynamics of materials with microstructure. Acta Mechanica, (submitted).

6. M.Berezovski, A.Berezovski, J.Engelbrecht. Waves in materials with microstructure: numerical simulation. Proc. Estonian Acad. Sci. (submitted).

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19. K.Tamm, A.Salupere. On propagation of 1D solitary waves in Mindlin-type microstructured solids. Mathematics and Computers in Simulation, (submitted).

20. M.Vallikivi, A.Salupere, Hui-Hui Dai. Numerical simulation of propagation of solitary deformation waves in a compressible hyperelastic rod. Mathematics and Computers in Simulation, (submitted).

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22. A.Stulov, D.Kartofelev. Vibration spectrum of a piano string with nonlinear contact condition. Int. J. Non-Linear Mechanics, (submitted).

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24. N.C.Delpeche, T.Soomere. The generation and dissipation of solitonic internal waves in the Saint John River estuary, New Brunswick, Canada. Proc. Estonian Acad. Sci (submitted).

25. I.Didenkulova, A.V.Sergeeva, E.N.Pelinovsky, S.N.Gurbatov. Statistical estimates of characteristics of long wave runup on a beach. Izvestiya, Atmospheric and Oceanic Physics (submitted).

26. I.Didenkulova, E.N.Pelinovsky. On reflection of long sea waves from the underwater slope. Oceanology (submitted).

27. I.Didenkulova, E.N.Pelinovsky. Runup of tsunami waves in U-shaped bays. Pure and Applied Geophysics (submitted).

28. I.Didenkulova, E.N.Pelinovsky, T.Soomere. Can the waves generated by fast ferries be a physical model of tsunami? Pure and Applied Geophysics (submitted).

29. I.Didenkulova. Shapes of freak waves in the coastal zone of the Baltic Sea (Tallinn Bay). Boreal Environment Research (submitted).

30. I.Didenkulova, E.N.Pelinovsky, A.Sergeeva. Statistical characteristics of long waves nearshore. Coastal Engin. (submitted).

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36. T.Soomere, K.E.Parnell, I.Didenkulova. Water transport in wake waves from high-speed vessels. J. of Marine Systems (submitted).

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45. D.Kurennoy, T.Soomere. Measurements of high speed vessel-induced wakes. 2010 Ocean Sciences Meeting, 22–26 February, 2010, Portland, Oregon, USA, (accepted).

46. T.Kangilaski. Enterprise Architecture Management in Virtual Organization. Proc. of IEEE-ICIT 2010 Int. Conf. on Industrial Technology, 11–13 March, Viña del Mar, Chile, (accepted).

47. T.Lints. The Essentials of Defining Adaptation. IEEE Int. Systems Conf., April 5–8, 2010, San Diego, CA, US, (accepted).

48. T.Lints. Coordination Issues in Modular Systems. IEEE Int. Systems Conf., April 5–8, 2010, San Diego, CA, US, (accepted).

49. T.Lints. Diversity Issues in Adaptive Modular Systems. IEEE Int. Systems Conf., April 5–8, 2010, San Diego, CA, US, (accepted).

5.1.5 Popular science / Science policy

1. J.Engelbrecht. Academic thoughts. Eesti TA Aastaraamat 2008, Tallinn, Eesti TA, 2009, 228–232.

2. J.Engelbrecht. Memory, Culture, and Science. Talk on Centennial Festivities of the Estonian National Museum; www.erm.ee

3. J.Engelbrecht. ALLEA unites National Academies in Europe. In. Proc Int. Conf. "Role of National Science Academies in the 21st Century". The Montenegrin Academy of Sciences, Podgorica, 2009, 53–58.

4. J.Engelbrecht. European Academies and Research (talk at the Int. Conf. European Research on the Move, Wroclaw, 4-5 Sept, 2009). Science and Society (submitted).

5. J.Kalda. In the land of rice and bikes. Horisont, 1, 51–52 (in Estonian).

6. J.Kalda. Physicists between the ruins of Mayan temples. Horisont, 5, 51–52 (in Estonian).

7. J.Kalda. The most interesting and useful discipline. Horisont, 3, 43–44 (in Estonian).

8. J.Vain. Robots in surgery. Horisont, 2009, 1, 39–41 (in Estonian).

9. T.Soomere. Sea currents bring pollution to the Estonian coasts. Postimees (The Postman, the leading daily newspaper), 57(5537), March 11, 2009, 5 (in Estonian).

10. T.Soomere. What would think Andres and Pearu about a gas pipeline at the border of their land sections? Newspaper of the Estonian University of Life Sciences, 161, March 23, 2009, 2 (in Estonian).

11. Interview with T.Soomere. Research into the Baltic Sea may teach the entire world). Mente et Manu (newspaper of the Estonian University of Technology) 7(1764), April 17, 2009, p. 3 and 8(1765), May 8, 2009, p. 3 (in Estonian).

12. T.Soomere, R.Vaikmäe. Progress in understanding the mechanisms of climate change. Postimees, 178(5658), August 5, 2009, 10 (a full page story about recent developments in climate research, in Estonian).

13. Interview with T.Soomere by J.Holvandus. Nord Stream is the challenge for society. Estonian Church, weekly newspaper of the Estonian Lutheran Church, 33(989), September 9, 2009, 4–5 (in Estonian).

14. T.Soomere. Nord Stream eirab tundliku Läänemere eripära (Nord Stream ignores the specific features of the vulnerable Baltic Sea, presentation to the Estonian Parliament on October 27, 2009). Postimees 249 (5729), October 28, 2009, 12–13 (in Estonian).

15. E.Quak. Editorial. Newsletter No 2 of the EU project FOCUS K3D, February 2009.

5.2 Conferences

1. "Glass Performance Days", Tampere, 12–15 June 2009.
   H.Aben. On complete non-destructive residual stress measurement in architectural glass panels and automotive glazing.

2. Symposium "Recent Advances in Mechanics", Athens, 17–19 September 2009.
   H.Aben. Photoelastic tomography as hybrid mechanics.

3. EUROMECH Colloquium 510: Mechanics of Generalized Continua: A hundred years after the Cosserats. UPMC, Paris, France, May 13–16, 2009.
   A.Berezovski, J.Engelbrecht. Generalized thermomechanics with internal variables.
   A.Stulov. Magneto-optical tomography of Cosserat flows.

4. IUTAM Symposium on Recent Advances of Acoustic Waves in Solids. Taipei, May 25–28, 2009.
   J.Engelbrecht, A.Berezovski, M.Berezovski. Deformation waves in microstructured materials: theory and numerics.
   T.Peets. Dispersion analysis of wave motion in microstructured solids.
   A.Ravasoo. Counterpropagating ultrasonic waves for inhomogeneous materials characterization.

5. ISDMM09 — 4th International Symposium on Defect and Material Mechanics. Trento, Italy, July 6–9, 2009.
   A.Berezovski, G.A.Maugin. Jump conditions and kinetic relations at moving discontinuities.

6. 7th EUROMECH Solid Mechanics Conference (ESMC2009), Lisbon, Portugal, September 7–11, 2009.
   M.Rousseau, G.A.Maugin and M.Berezovski. Elements of wave propagation in dynamic materials.
   J.Engelbrecht, A.Ravasoo. Nondestructive characterization of functionally graded materials.
   H.Herrmann. Towards mesoscopic simulation of growth of micro-cracks.
   A.Salupere, L.Ilison. On interaction of solitary waves in granular materials.
   M.Vendelin, M.Kalda, P.Peterson. Mechanoenergetics of actomyosin interaction analyzed by a cross-bridge model.

7. International Conference on Complexity of Nonlinear Waves, Tallinn, Estonia, October 5–7, 2009.
   M.Berezovski, A.Berezovski, J.Engelbrecht. Waves in materials with microstructure: numerical simulation.
   H.Herrmann. Towards a description of twist waves in liquid crystals using mesoscopic continuum physics.
   A.Ravasoo. Nonlinear counterpropagating waves in inhomogeneous materials.
   A.Stulov, D.Kartofelev. Propagation of deformation waves in the piano hammer felt.
   T.Soomere. Applications of soliton interactions in Rogue wave theory and in understanding the impact of Vessel wake.
   K.Tamm, A.Salupere. Emergence of solitary deformation waves in Mindlin-type microstructured solids.
   T.Torsvik. Modeling bottom shear stress for transient wave events.
   I.Zaitseva-Pärnaste. Seasonal and long-term variations of wave conditions in estonian coastal waters.
   I.Didenkulova. Travelling waves in strongly inhomogeneous media.
   N.Delpeche. The generation and dissipation of a solitonic wave that travels in the reverse direction to the flow in the Saint John River Estuary, New Brunswick, Canada.

8. 2nd International Symposium on Computational Mechanics (ISCM II) and 12th International Conference on Enhancement and Promotion of Computational Methods in Engineering and Science (EPMESC XII), Hong Kong – Macau, November 30 – December 3, 2009.
   M.Berezovski, A.Berezovski, J.Engelbrecht. Numerical simulations of one-dimensional microstructure dynamics.

9. 16th International Congress on Sound and Vibration (ICSV16), Krakow, Poland, 5–9 July, 2009.
   A.Braunbrück. Harmonic burst in exponentially graded material.

10. JETC (10th Joint European Thermodynamics Conference) 22–24 June, 2009.
    H.Herrmann. The balance of spin from the point of view of mesoscopic continuum physics for liquid crystals

11. Finno-Ugric International Conference of Mechanics (FUDoM 09), Savoya Palace, Rackeve, Hungary, 23–29 August, 2009.

J.Engelbrecht. Complexity in mechanics.
M.Kutser. Multidisciplinary research – a basis for developmen.
A.Ravasoo. Wave interaction for inhomogeneous materials characterization.

12. The Sixth IMACS International Conference on Nonlinear Evolution Equations and Wave Phenomena: Computation and Theory, The University of Georgia, Athens, USA, March 23–26, 2009.
A.Salupere, M.Vallikivi, Hui-Hui Dai. On propagation of solitary deformation waves in a compressible hyperelastic rod.
K.Tamm, A.Salupere. On propagation of 1D solitary waves in Mindlin-type microstructured solids.
T.Soomere. Shallow-water soliton interactions as a potential source of freak waves and agents of danger from fast ferries.

13. 34th International Acoustical Conference - EAA Symposium, Slovakia, September 28–30, 2009.
A.Stulov, D.Kartofelev. Piano hammer-string interaction: the influence of the elastic parameters of bass hammers on the contact time duration.

14. 12th EUROMECH European Turbulence Conference, Marburg, September 7–10, 2009.
J.Kalda. Origin of the small-scale anisotropy of the passive scalar fluctuations.

15. 14th International Conference Mathematical Modelling and Analysis Daugavpils, Latvia, 27–30 May, 2009.
J.Janno. New uniqueness results for parabolic integrodifferential inverse problems.

16. Chemnitz-RICAM Symposium on Inverse Problems, Linz, Austria, 14–15 July, 2009.
J.Janno. New uniqueness results for parabolic integro-differential identification problems.

17. 3rd Finnish-Estonian Mathematical Colloquium FinEst Math 2009, Tartu, Estonia, 26–28 August, 2009.
J.Janno. Inverse problems for microstructured materials.

18. 17th International Conference on Process Control, Strsbske Pleso, Slovakia, June 9–12, 2009.
Ü.Kotta. Model matching for nonlinear systems not having the state-space realization
M.Tõnso. WebMathematica based tools for continuous-time nonlinear control systems.

19. 12th International Conference on Computer Aided Systems Theory (EUROCAST), Las Palmas de Gran Canaria, Spain, February 15–20, 2009.
Ü.Kotta, M.Tõnso. Realization of continuous-time nonlinear input-output equations: polynomial approach.

20. 3rd IEEE Multi-Conference on Systems and Control, Saint Petersburg, Russia, July 8–10, 2009.
J.Belikov. Model reference control of nonlinear TITO systems by dynamic output feedback linearization of neural network based ANARX models.

21. European Control Conference, Budapest, Hungary, August 23–26, 2009.
Ü.Kotta. Differential rings associated with control systems on regular time scales.

22. IEEE International Conference on Control and Automation, Christchurch, New Zealand, December 9–11, 2009.
J.Belikov. Model Reference Control of Nonlinear MIMO Systems by Dynamic Output

Feedback Linearization of ANARX Models.
V.Kaparin. Necessary conditions for transformation the nonlinear control system into the observer form via state and output coordinate changes.
P.Kotta. Irreducibility and reduction of MIMO nonlinear control systems: unification and extension via pseudo-linear algebra.
Ü.Kotta. Realization problem of SISO nonlinear systems: a transfer function approach.
Ü.Nurges. Reflection coefficient approach to robust state controller design.
S.Nõmm. Supervised training of voting automata for the surgeon's motion recognition during laparoscope surgery.

23. 4th IEEE Conference on Industrial Electronics and Applications (ICIEA), Xi'an, China, May 25–27, 2009.
J.Vain (participated).
S.Nõmm. Hybrid approach to detection of the surgeon's hand motions during endoscope surgery.

24. ICROS-SICE International Joint Conference 2009, Fukuoka City, Japan, 18–21 August, 2009.
S.Nõmm, J.Vain. Human-robot interaction learning using timed automata.

25. Chinese Control and Decision Conference, Guilin, China, 14–22 June, 2009.
Ü.Nurges. A reflection coefficient approach to robust controller design.

26. 21st Nordic Workshop on Programming Theory 2009, Lyngby, Denmark, 14–16 October, 2009.
J.Vain, S.Juurik. Model checking emerging behaviour properties of robot swarms.

27. 3rd Finnish-Estonian Mathematical Colloquium, FinEst Math 2009, Tartu, Estonia, 26–28 August 2009.
T.Mullari. Transformation of nonlinear control system into the observer form: simplification and extension.

28. International Conference "Solitons in their roaring forties". CPNLW09, Coherence and Persistence in Nonlinear Waves, Nice University, 6–9 January, 2009.
T.Soomere, I.Didenkulova, I.Zaitseva-Pärnaste. Interactions of shallow water solitons and their applications.
Nonlinear aspects of tsunami waves. (co-authors E.Pelinovsky, N.Zahibo).

29. Kick-off meeting of the BONUS BalticWay project, Helsinki, 12 January, 2009.
E.Quak, T.Soomere. Baltic Way: Towards using the potential of currents for the benefit of society.

30. Kick-off meeting and conference of the Baltic Sea Research Programme BONUS. Dipoli Conference Centre, Espoo, Finland, 13–15 January, 2009.
E.Quak,T.Soomere. Baltic Way: Towards using the potential of currents for the benefit of society

31. Alexander von Humboldt Foundation Alumni Network Conference "Germany Alumni in Tomorrow's World", Berlin, 21–22 January, 2009.
T.Soomere. Possibilities of strengthening cooperation between German and foreign scientists: experience from Estonia.

32. SEAMOCS, Intense course for young researchers on "Statistical software for climate research", Malta, Sliema, Preluna Hotel and Spa, 16–17 March, 2009.
Interdisciplinary workshop "Effects of climate change: coastal systems, policy implications, and the role of statistics", Malta, Sliema, Preluna Hotel and Spa, 18–20 March, 2009.
T.Torsvik. Ship wakes in Tallinn Bay: experimental and numerical study.
T.Dolphin. BLINKS: Beach LINKs to Sandbanks - Sandbanks, shorelines and coastal photography.
N.Delpeche, T.Soomere, J.H.Clarke, S.Haigh. Internal waves and interfacial mixing in the Saint JohnRiver Estuary, New Brunswick, Canada.
I.Didenkulova. Nonlinear long-wave deformation and runup in a basin of varying depth.
I.Didenkulova, T.Soomere, E.Pelinovsky. Modeling of tsunami waves using waves induced by high-speed ferries in Tallin Bay, Baltic Sea.
L.Kelpšaite, T.Soomere. Energy pollution: The relative influence of wind-waves and vessel-wake energy in Tallinn Bay, Baltic Sea.
D.Kurennoy, T.Soomere. Variability in wakes properties generated by high-speed ferries in Tallinn Bay, Baltic sea.
I.Zaitseva-Pärnaste, Ü.Suursaar, T.Kullas, T.Soomere. Seasonal and long-term variations of wave conditions in the North Baltic Sea.

33. Conference of Control Processes and Stability 09, St. Petersburg Russia, 6–9 April, 2009.
D.Kurennoy. Properties of wakes generated by high-speed ferries in Tallinn Bay (co-author T.Soomere).

34. Conference "Sea and coastal research 2009", Nida Lithuania, 8–10 April, 2009.
L.Kelpšaite. Estimation of wave induced sediment transport at Aega Island, Tallinn Bay (co-author T.Soomere).

35. 10th International Coastal Symposium, Lisbon, 13–18 April, 2009.
D.Kurennoy, K.E.Parnell, T.Soomere. Variability of properties of wakes from high-speed ferries.
T.Torsvik, T.Soomere. Modeling of long waves from high speed ferries in coastal waters.
L.Kelpšaite, K.E.Parnell, T.Soomere. Energy pollution: the relative influence of wind-wave and vessel-wake energy: Tallinn Bay, the Baltic Sea.
T.Soomere, I.Didenkulova, K.E.Parnell. Implications of fast ferry wakes for semi-sheltered beaches, Aegna Island, Baltic Sea.
I.Didenkulova, K.E.Parnell, T.Soomere, E.Pelinovsky, D.Kurennoy. Shoaling and runup of long waves induced by high-speed ferries in Tallinn Bay.
A.Räämet, Ü.Suursaar, T.Kullas, T.Soomere. Reconsidering uncertainties of wave conditions in the coastal areas of the northern Baltic Sea.
I.Zaitseva-Pärnaste, Ü.Suursaar, T.Kullas, T.Soomere. Seasonal and long-term variations of wave conditions in the northern Baltic Sea.
T.J.Dolphin, M.O.Green. Patterns of wave-orbital speed and skin friction under estuarine (fetch-limited) waves.
A.Kask, T.Soomere, T.Healy, N.Delpeche. Sediment transport patterns and rapid estimates of net loss of sediments for "almost equilibrium"beaches (poster presentation).
T.Soomere was the Chair of the session "GIS and Remote Sensing".

36. EGU General Assembly in Vienna, Austria, 19–24 April, 2009.
I.Didenkulova, E.Pelinovsky, T.Soomere. Long Surface Wave Dynamics along a Convex Bottom.

Nonlinear Long-Wave Deformation and Runup in a Basin of Varying Depth (poster presentations).
The 1956 Greek tsunami recorded at Yafo (Israel) and its numerical modeling (co-authors E.Pelinovsky, M.Sladkevich, L.Chubarov, E.Kit, Yu.Shokin, S.Beisel and A.Levin).
Freak waves in Tallinn Bay, the Baltic sea (co-authors D.Kurennoy, T.Soomere).
Modeling of tsunami waves using waves induced by high-speed ferries in Tallinn bay, Baltic Sea (co-authors E.Pelinovsky, T.Soomere).

37. 41st International Liège Colloquium on Ocean Dynamics "Science-based management of the coastal waters", 4–8 May, 2009.
T.Soomere. The implications of frequent high-speed ferry wakes, Tallinn Bay, Estonia (in cooperation with K.E.Parnell and I.Didenkulova).

38. Call 5 EU Information Event at the Jean Monnet Centre in Luxembourg, 11–12 May, 2009.
E.Quak (participated).

39. FOCUS workshop on advanced 3D media in gaming and simulation in Amsterdam, The Netherlands, 16 June, 2009.
E.Quak (participated).

40. Nonlinear evolution equations and dynamical systems (NEEDS 2009) in Sardinia, Italy, May 16–23, 2009.
I.Didenkulova. Non-dispersive traveling waves in strongly inhomogeneous water channels (co-author E.Pelinovsky).

41. Stakeholdes Conferences European Maritime Days, Rome, Italy, 19–20 May, 2009.
T.Soomere (participated).

42. Scientific Conference, United Kingdom, London, House of Lords, 2 July, 2009.
Annual Meeting, 3 July, University College London: FP7 Future and Emerging Technologies network "Global Systems Dynamics and Policies"(GSD).
T.Soomere (participated).

43. 24th International Tsunami Symposium, Novosibirsk, Russia, 14–17 July, 2009.
I.Didenkulova: Is it possible to model tsunami waves with waves induced by high-speed ferries?
Abnormal amplification of long waves in the coastal zone.

44. International Conference "Construction of artificial islands in coastal and offshore areas", Novosibirsk, Russia, 20–25 July, 2009.
L.Kelpšaite. The relative importance of wind-waves and ship-wakes on longshore drift in Tallinn Bay, the Baltic Sea (co-author T.Soomere).
D.Kurennoy. Variability in wake properties generated by high-speed ferries (co-author T.Soomere).

45. V International Workshop "Solitons, collapses and turbulence: achievements, developments and perspectives", Chernogolovka, Russia, August 2–7, 2009.
I.Didenkulova. Non-dispersive traveling waves in strongly inhomogeneous water channels.

46. VI Annual Meeting of Asia Oceania Geosciences Society, SUNTEC, Singapore, August 11–15, 2009.

I.Didenkulova: Runup of random waves on a plane beach;
Long-Wave Runup on Beaches of Complex Geometry;
Conviner of the session "OS09 – Nonlinear Dynamics of the Coastal Zone".

47. 7th Baltic Sea Science Congress 2009, Tallinn, Estonia, 17–21 August, 2009.
I.Didenkulova. Analytical Theory of Nonlinear Long Wave Runup on a Coast;
T.Soomere, K.E.Parnell, I.Didenkulova. Implications of fast ferry wakes for semi-sheltered beaches:
T.Soomere. On the dynamics of almost equilibrium beaches on the North Estonian coast (plenary presentation).
E.Quak, T.Soomere. The BalticWay Project: The Use of Currents for Environmental Management of the Baltic Sea coasts.
N.Delpeche, T.Soomere. Internal waves and Interfacial Mixing in Stratified environments.
D.Ryabchuk, I.Leontyev, V.Zhamoida, M.Spiridonov, E.Nesterova, D.Kurennoy. Submarine terraces of the Eastern Gulf of Finland: results of survey and reconstruction of evolution in Holocene.
I.Zaitseva-Pärnaste. Seasonal and long-term variations of wave conditions in Estonian coastal waters.
A.Räämet. Simulating long-term changes of wave conditions in the northern Baltic Sea.
L.Kelpšaite. The comparison of wind-waves and ship-wakes on the coastal zone in Tallinn Bay, the Baltic Sea (poster presentations).
I.Didenkulova, E.Pelinovsky. Weakly Reflecting Waves in Narrow Bays.
I.Didenkulov, I.Didenkulova, S.Muyakeshin, D.Selivanovsky. Interaction of plankton with wave fields in the sea.
D.Kurennoy, K.E.Parnell. Variability in the properties of long waves generated by high-speed ferries in Tallinn Bay.
T.Soomere and I.Didenkulova were conviners and chairs of the thematic session "Interplay of wave dynamics, marine ecosystem and coastal processes".

48. 19e Congres Francais de Mecanique, Marseille, France, August 24–28, 2009.
I.Didenkulova. Wave turbulence in shallow water;
Strong amplification of water waves at "non-reflecting"beaches.

49. GO-3D Go for Innovations Workshop at the Fraunhofer Institute for Computer Graphics in Rostock, Germany, 31 August, 2009.
E.Quak (participated).

50. FOCUS Workshop on Challenges in 3D Content for Virtual Product Modelling at the Fraunhofer Institute for Computer Graphics in Rostock, Germany, 01 September, 2009.
E.Quak (participated).

51. SEAMOCS Closure Meeting, Toulouse, France, September 8–10, 2009.
T.Soomere. The reaction of "almost equilibrium"beaches on the North Estonian coast to wind waves and ferry wakes.
I.Didenkulova and C.Anderson. Statistical characteristics of long waves nearshore.
I.Didenkulova. Study of freak waves in the coastal zone of the Baltic Sea.
D.Kurennoy. Ship waves.
I.Zaitseva-Pärnaste. Long term variation in wave fields in the Baltic Proper.

52. International Conference "Lithodynamics of bottom contact zone of the ocean", Moscow, Russia, 14–17 September, 2009.
L.Kelpšaite. The relative importance of wind-waves and ship-wakes on longshore drift in

Tallinn Bay, the Baltic Sea (co-author T.Soomere.
D.Kurennoy. Ship wakes measurements in Tallinn Bay (co-author T.Soomere).
I.Zaitseva-Pärnaste. Long term variation in wave fields in the Baltic Proper.

53. Australasian Coasts and Ports Conference, Wellington, New Zealand, 18 September, 2009.
T.Soomere. Using wave and current dynamics to find solutions to the challenges of environmental change;
Chaired the session "Modelling coastal waters".

54. 4th International Student Conference "Biodiversity and functioning of Aquatic Ecosystems in the Baltic Sea Region", Dubingiai, Lithuania, 2–4 October, 2009.
A.Räämet. Wave climate changes in the Baltic Proper 1978–2007 (co-author T.Soomere).

55. Conference FAST 2009: 10th International Conference on Fast Sea Transportation, Athens, Greece, October 5–8, 2009.
T.Soomere. The implications of frequent high-speed ferry wakes, Tallinn Bay, Estonia (co-authors K.E.Parnell and I.Didenkulova).

56. Regional Humboldt Colloquium "Alexander von Humboldt (1769–1859): Werk und Wirkung", Helsinki, 16–17 October, 2009.
T.Soomere (participated).

57. Annual Scientific Seminar of the Institute of Cybernetics, Viinistu, Estonia, 17–18 October, 2009.
D.Kurennoy, N.Delpeche and T.Soomere. Submarine terrances of the Eastern Gulf of Finland: surveys and reconstruction of evolution in the Late Holocene;
Interfacial Mixing in the Saint John River Estuary;
On the dynamics of almost equilibrium beaches.

58. Conference dedicated to the 90 years of Estonian Marine Academy, Tallinn, 23 October, 2009.
T.Soomere. Marine science in Estonia in the present, past and future.

59. Conference "Coping with Uncertainty", Sigtuna, Stockholm, Sweden, November 15–17, 2009.
T.Soomere. Towards the use of currents for reducing anthropogenic risks for the Baltic Sea coasts.
R.Isotamm, B.Viikmäe and T.Soomere. Application of a trajectory model to select areas of high risk of pollution.
R.Isotamm, N.Delpeche. An Empirical Method to Determine a low-risk fairway in the Gulf of Finland.

60. FOCUS 3D Physiological Human Workshop, Zermatt, Switzerland, 29 November – 02 December, 2009.
E.Quak (participated).

61. BalticWay seminar, SYKE, Helsinki, 3 December, 2009.
T.Soomere. Transport patterns in the surface layer of the Gulf of Finland.

62. Workshop on Modelling, mitigation and management of coastal disasters, Venice, Institute of Marine Science (ISMAR, Venice), 7–11 December, 2009.
I.Didenkulova and T.Soomere. Applications of soliton interactions in rogue wave theory and in understanding the impact of vessel wakes;
Tsunami and phenomena similar to tsunami: global and local scales.

63. In Biophysical Society 53rd Annual Meeting, Boston, Massachusetts, USA, 28 February – 4 March, 2009.
D.W.Schryer, P.Peterson, T.Paalme, M.Vendelin. Isotopomeric 13C Labeling of Amino Acids Reveal Compartmentation in Saccharomyces uvarum.
M.Laasmaa, P.Peterson, R.Birkedal, M.Vendelin. 3D ConfocalMicroscope Image Enhancement by Richardson-Lucy Deconvolution Algorithm with Total Variation Regularization.
M.Kalda, M.Vendelin. Mechanoenergetics of Actomyosin Interaction Analyzed by Cross-Bridge Model.
M.Sepp, T.Kaambre, P.Sikk, M.Vendelin, R.Birkedal. Kinetic studies of intracellular compartmentalization in permeabilized rat cardiomyocytes.
M.Vendelin, A.Illaste, R.Birkedal. Anisotropic diffusion of fluorescently labeled Atp in cardiomyocytes determined by raster image correlation spectroscopy.
H.R.Ramay, M.Vendelin. Diffusion restrictions surrounding mitochondria: a mathematical model of heart muscle fibers.
A.Illaste, M.Vendelin. Computational model of citric acid cycle and oxidative phosphorylation in mitochondria.
N.Sokolova, M.Vendelin, R.Birkedal. Rainbow trout cardiomyocytes are compartmentalized despite low density of intracellular membrane structures.

64. In SIAM Conference on Computational Science and Engineering, Miami, Florida, USA, 2–6 March, 2009.
P.Peterson. An efficient Computer Algebra System for Python.

65. In ENUMATH2009.Uppsala University, Sweden, 29 June – 3 July, 2009.
M.Vendelin, M.Kalda, P.Peterson. Mechanoenergetics of actomyosin interaction analyzed by cross-bridge model.

66. In 36th International Congress of Physiological Sciences (IUPS2009), Kyoto, Japan, 27 July – 1 August, 2009.
M.Kalda, M.Vendelin. Mechanoenergetics of actomyosin interaction analyzed by a cross-bridge model.
M.Sepp, T.Kaambre, P.Sikk, M.Vendelin, R.Birkedal. Kinetic studies of intracellular compartmentalization in permeabilized rat cardiomyocytes.
N.Sokolova, M.Vendelin, R.Birkedal. Intracellular diffusion restrictions in trout cardiac fibers and cells.
R.Birkedal, D.Warren, H.Shiels. Adrenergic stimulation of L-type Ca^{2+}current and CICR in trout cardiomyocytes: effects of tissue and temperature.

67. IEEE 31st International Conference on Software Engineering, Vancouver, Canada, May 16–24, 2009.
A.Karpištšenko. (participated).

68. 14th Estonian Winter School in Computer Science, March 1–6, 2009, Palmse, Estonia.
T.Lints. (participated).

69. IEEE Symposium on Intelligent Agents, in IEEE Symposium Series on Computational Intelligence, March 30 – April 2, 2009, Nashville, Tennessee, US.
T.Lints. Relation Learning with Bar Charts.

70. 35th Estonian Spring School in Theoretical Biology: The Theory of Inheritance, May 29–31, 2009, Mesikamäe, Estonia.
T.Lints. (participated).

71. IEEE Estonia Section Workshop, August 19–20, 2009, Toosikõnnu, Estonia .
T.Lints. (participated).

72. 15th Estonian Computer Science Theory Days, October 2–4, 2009, Mäetaguse, Estonia.
T.Lints. (participated).

73. The 13th International Conference ELECTRONICS'2009. 12–14 May, 2009, Kaunas and Vilnius, Lithuania.
A.Udal. (participated).

74. The 11th International Conference on Squeezed States and Uncertainty Relations 2009 ICSSUR2009 and the 4th Feynman Festival FF4. June 22–26, 2009, Olomouc, Czech Rep..
A.Udal. Comparison of uncertainty relations in quantum mechanics and signal processing.

75. Atomistix Toolkit User Meeting & Training Seminar organised by QuantumWise A/S. September 7–8, 2009, Copenhagen, Denmark.
A.Udal. (participated).

76. 8th Estonian Summer School on Computer and Systems Science, ESSCaSS 2009.
R.Pahtma, J.Preden, T.Lints. (participated).

77. NATO RTO SCI-210 Technical Course "Tactical Guided Weapon System Design and Integration", Tallinn, 2009.
R.Pahtma. (participated).

78. TOGAF^{TM} Version 9 – The Open Group Architecture Framework; leaded by The Open Group, Tallinn (certification received), October 2009.
T.Kangilaski. (participated).

79. Nordic ARIS User Group meeting, Stockholm, Sweden, November 2009.
T.Kangilaski. (participated).

80. 2009 International Conference on Industrial Mechatronics and Automation (ICIMA 2009), Chengdu, China, May 16–17, 2009.
I.Astrov. Control of hovering manoeuvres in unmanned helicopter for enhanced situational awareness.

81. 5th WSEAS International Conference on Dynamical Systems and Control (CONTROL'09), La Laguna, Tenerife, Canary Islands, Spain, July 1–3, 2009.
I.Astrov. (participated).

82. ICROS (Institute of Control, Robotics and Systems)-SICE (Society of Instrument and Control Engineers) International Joint Conference 2009 (ICCAS (International Conference on Control, Automation and Systems)-SICE 2009, Fukuoka, Japan, August 18–21, 2009.
I.Astrov. Depth control of an autonomous underwater vehicle in situational awareness a mission.

83. 7th International Conference on Robotics, Vision, Signal Processing and Power Applications (RoViSP'09, Awana Porto Malai, Langkawi) Island, Malaysia, December 19–20, 2009.
I.Astrov. Depth multi-rate control of an autonomous underwater vehicle for enhanced situational awareness.

84. International Conference on Marine and Naval Engineering ICMNE 2009/ 2009 World Congress on Science, Engineering and Technology (WCSET 2009), Oslo, Norway, July 29–31, 2009.
A.Pedai. (participated).

85. 2009 IEEE International Conference on Mechatronics and Automation. (IEEE ICMA 2009), Changchun, China, August 9–12, 2009.
A.Pedai. Enhancing situational awareness through multi-rate control of an autonomous underwater vehicle.

86. 2009 Military Communications Conference (MILCOM 2009), Boston, USA, October .
L.Mõtus, M.Meriste, J.S.Preden. Towards Middleware Based Situation Awareness.

87. Situation Management Workshop (SIMA 2009) in conjunction with MILCOM 2009, Boston, USA.
L.Mõtus, M.Meriste, J.S.Preden. (participated).

88. NATO RTO SCI Symposium on "Intelligent Uninhabited vehicle Guidance Systems", Munich, Germany, July 2009.
L.Mõtus, M.Meriste, J.S.Preden. Vehicle Guidance Systems in NEC context.

89. Electronics and Electrical Engineering, May 2009, Vilnius, Lithuania.
J.S.Preden. (participated).

90. IEEE International Conference on Adaptive Science & Technology, ICAST 2009, December 2009, Ghana Accra.
J.S.Preden. (participated).

91. IEEE 3rd Multi-Conference on Systems and Control, St. Petersburg, Russia, July 2009.
E.Petlenkov, J.Belikov. Dynamic Pole Placement based Control of Nonlinear Discrete Time Systems with Input Delay.
J.Belikov, E.Petlenkov. Model Reference Control of Nonlinear TITO Systems by Dynamic Output Feedback Linearization of Neural Network based ANARX Models.
E.Petlenkov, J.Belikov. NN-ANARX Model based Control of Nonlinear Discrete-Time Systems with Input Delay.

92. IEEE 7th International Conference on Control and Automation, New Zealand, December 2009.
J.Belikov. Model Reference Control of Nonlinear MIMO Systems by Dynamic Output Feedback Linearization of ANARX Models.
E.Petlenkov Neural Network based Dynamic Pole Placement Control of Nonlinear Systems.

93. HYCON-EECI graduate school on Control, Paris, France, January 2009.
J.Belikov. (participated).

5.3 Seminars

5.3.1 Tallinn Seminars on Mechanics (CENS)

1. 12.02 A.Fischer, CENS-CMA, Chemnitz University: Spin Glasses – Prototypes for complex systems;
2. 09.03 A.Stulov: Magneto-optical tomography of Cosserat flows;
3. 16.03 L.Ilison: Solitons and solitary waves in hierarchical Korteweg-de Vries type systems;
4. 27.03 K.Papenfuss, CENS-CMA, Berlin University: Mesoscopic theory of damage and damage parameters of different tensorial order;
5. 06.04 A.Kask: On sediments and morphology of coasts;
6. 07.04 T.Healy, University of Waikato, New Zeeland: Identifying sediment transport pathways in the coastal realm;
7. 13.04 A.Fischer, CENS-CMA, Chemnitz University: State space dynamics in complex systems;
8. 20.04 M.Kree: Mixing of passive scalars from point sources;
9. 27.04 L.Kelpšaité: Long-term dynamic development of coasts;
10. 04.05 H.Aben, L.Ainola, J.Anton, A.Errapart: Theory, technology and application of integral photoelasticity in glass manufacturing;
11. 18.05 K.Tamm: On propagation of 1D solitary waves in Mindlin-type solids;
12. 11.05 D.Kurennoy: Cross-shore sediment transport and coastal profile development
13. 25.05 A.Berezovski: Jump conditions and kinetic relations at moving discontinuities in solids;
14. 12.10 Dr. B.V.Chubarenko, Laboratory for Coastal Systems Study, Atlantic Branch; P.P.Shirshov, Institute of Oceanology: Resuspension in shallow lagoons and its long-term influence;
15. 18.10 M.Patriarca, KBFI: Influence of geography on language competition;
16. 26.10 L.Kelpšaité: Changing properties of wind waves and vessel wakes on the eastern coast of the Baltic Sea;
17. 09.11 M.Berezovski: Waves in materials with microstructure: numerical simulation;
18. 16.11 T.Peets: Dispersion of waves in microstructured materials: optical branches and internal degrees of freedom;
19. 27.11 N.Delpeche: Utilization of a trajectory model to determine areas of reduced risk of pollution in the Gulf of Finland;
20. 30.04 R.Kitt: An update to the econophysics research in CENS;
21. 03.12 H.Aben: Polarized light measures the strength of glass or why glass is not broken;
22. 07.12 D.Kartofelev: Analysis of vibration spectra of piano string;

23. 14.12 H.Herrmann: Mesoscopic Continuum Physics: overview, recent achievements and open questions.

5.3.1.1 Seminars of the Wave Engineering Group

1. 20.01 T.Torsvik: Basic concepts of ship wake properties.
2. 27.01 I.Didenkulova: Is it possible to model tsunami waves by waves induced by high-speed ferries?
3. 12.03 D.Kurennoy: Asymmetry of waves generated by high-speed ferries.
4. 20.11 I.Didenkulova: Global and local tsunamis: observations and theory.

5.3.2 Lectures and seminars outside the home Institute

1. J.Engelbrecht. Complexity in Mechanics. Lagrangian Lecture at the University of Turin, May 7.
2. A.Berezovski. Jump conditions and kinetic relations at moving discontinuities in solids. Applied Mathematics Seminar, Department of Mathematics and Computer Science, Bar-Ilan University, Ramat Gan, Israel, 15 March.
3. A.Berezovski. Jump conditions and kinetic relations at moving discontinuities in solids. Mathematical Colloquium, Holon Institute of Technology, Holon, Israel, 18 March.
4. Ü.Kotta. Transfer Function Approach to the Model Matching Problem of Nonlinear Systems. The Universify of Sheffield, 20 April.
5. Ü.Kotta. Non-Commutative Determinants in Nonlinear Control Theory: Preliminary Ideas. The Universify of Sheffield, 21 April.
6. Ü.Kotta. Nonlinear Control Systems on Time Scales. The University of Birmingham, 28 April.
7. T.Mullari. Transformation the nonlinear system into the observer form: simplification and extension. FinEst Math 2009, Tartu University, 27 August.
8. M.Tõnso. Computer algebra tools for modelling, analysis and synthesis for nonlinear control systems. Institute for Problems in Mechanics of the Russian Academy of Sciences, 17 December.
9. J.Vain. ROBOSWARM: Smart Environment for Interacting Robot Swarm. INNOESTONIA 2009, November 12–13.
10. T.Soomere. Marine hazards for Estonian large cities. Lions Club in the premises of the Estonian Academy of Sciences, 25 February.
11. I.Didenkulova. Runup of long ship waves on a beach. Russian State Hydrometeorological University, Oceanology department, St.Petersburg, 03 April.
12. E.Quak. CENS-CMA project experiences. The seminar on International Research Links at the Estonian Academy of Sciences, 20 May.

13. I.Didenkulova. Waves induced by high-speed ferries in the Baltic Sea: numerical simulation and analysis of experimental data. Geolab UMR 6042 CNRS – UBP, University Blaise Pascal, Clermont-Ferrand, France.

14. I.Didenkulova. Waves induced by high speed ferries in the Baltic Sea: numerical simulation and analysis of experimental data. School of Engineering, University of Warwick, Coventry, UK, 14 October.

15. I.Didenkulova. Analytical theory of long wave runup on a beach. Department of Mathematics, University College London, UK, 19 October.

16. I.Didenkulova. Analytical theory of long wave runup on a beach. Department of Mathematical Sciences, Loughborough University, UK, 21 October.

17. I.Didenkulova. Analytical theory of tsunami wave runup on a beach. Dipartimento di Fisica, Settore Geofisica, University of Bologna, Bologna, Italy, 23 November.

18. I.Didenkulova. Global and local tsunamis: observations and theory. National Institute for Geophysics and Volcanology (INGV), Bologna, Italy, 24 November.

19. T.Soomere. Transport patterns in the surface layer of the Gulf of Finland. BalticWay seminar in the Finnish Environmental Institute, SYKE, Helsinki, Finland, 03 December.

20. T.Soomere. Applications of soliton interactions in rogue wave theory and in understanding the impact of vessel wakes. ISMAR, Venice, Italy, 9 December.

21. T.Torsvik. Modelling of waves generated by high-speed ferries. ISMAR, Venice, Italy, 9 December.

22. I.Didenkulova. Tsunami and phenomena similar to tsunami: global and local scales. ISMAR, Venice, Italy, 10 December.

23. A.Kull, K.Raiend, A.Lehtmets. Model-based TTCN-3 testing experiences from industrial case studies. TTCN-3 User Conf., 3–5 June ETSI, Sophia Antipolis, France.

24. A.Kull. Model-based testing of reactive systems. QA&Test 2009 – 8th Int. Conf. on Software QA and Testing on Embedded Systems, Oct. 21–23, 2009 in Bilbao, Spain.

25. A.Kull, K.Raiend, A.Garg. End-to-End Testing Automation in TTCN-3 environment using Conformiq Qtronic and Elvior MessageMagic. TTCN-3 User Conference Asia 2009, Bangalore, India.

26. J.-S.Preden. Working visit to Microsoft Innovation Centre, Aachen, Germany.

27. J.-S.Preden, M.Meriste, L.Mõtus. Short visit to Department of Aerospace Engineering, Institute of Flight Systems, Universität der Bundeswehr München (UBM), Neubiberg, Germany.

6. Research and teaching activities

6.1. Meetings, events

6.1.1. International Conference on Complexity of Nonlinear Waves October 5–7, Tallinn

Organised by Dr. A.Berezovski Prof. T.Soomere

The conference provided a forum for presentation and discussion of innovative complex models and methods for computer based simulation of dynamical processes in mechanics. Applications from solid mechanics, fluid mechanics, biomechanics, thermomechanics, and material sciences were presented. The Conference marked 10 years of activities of the Centre for Nonlinear Studies - CENS. During the last decade, the complexity of wave fields in solids and fluids has been one of the focal issues in CENS. One of the key speakers at the Conference was Prof. Jüri Engelbrecht, the Head of CENS, who celebrated in 2009 his 70th anniversary.

1. Alan Jeffrey: Quasilinear Hyperbolic Systems, Nonlinear Superposition and Solitons;
2. Gerard A.Maugin: From Phase-transformation Fronts to the Growth of Long Bones;
3. Peter Van: Objectivity and Wave Propagation;
4. Masaharu Kuroda: Complexity of Nonlinear Waves Observed in a Large Array of Fluid-elastic Oscillators;
5. Miguel Onorato: Wave Turbulence in Shallow Water: Theory and Numerical Simulations;
6. John Grue: Scaling Law of Internal Run-up Duration;
7. Sergei Badulin: On the Dominance of Nonlinear Transfer for Wind-driven Seas;
8. Tarmo Soomere: Applications of Soliton Interactions in Rogue Wave Theory and in Understanding the Impact of Vessel Wake;
9. Tomas Torsvik: Modeling Bottom Shear Stress for Transient Wave Events;
10. Inga Zaitseva-Pärnaste: Seasonal and Long-term Variations of Wave Conditions in Estonian Coastal Waters;
11. Franco Pastrone: Hierarchy of Nonlinear Waves in Complex Microstructured Solids;
12. Alexey Porubov: Models for Essentially Nonlinear Strain Waves in Complex Materials;
13. Hui-Hui Dai: Solitary Shock Waves and Periodic Shock Waves in a Compressible Mooney-Rivlin Elastic Rod;
14. Serge dos Santos: Dispersion and Nonlinearity for Single Solitonic Pulse Acoustic Propagation in a Complex Shape Aeronautic Composite Material;
15. Arvi Ravasoo: Nonlinear Counterpropagating Waves in Inhomogeneous Materials;
16. Natalya Kizilova: Numerical Simulation of Wave Propagation in Multilayered Viscoelastic Tubes;
17. Enrique Zuazua: Dispersive Numerical Schemes for Schrodinger Equations;
18. Jiri Plesek: Numerical Stability of Mass Lumping Schemes for Higher Order Finite Elements;
19. Mihhail Berezovski: Waves in Materials with Microstructure: Numerical Simulation;

20. Manfred Braun: On Periodic Waves Governed by the Extended Korteweg-deVries Equation;

21. Anatoli Stulov: Propagation of Deformation Wave in the Piano Hammer Felt Material;

22. Andras Szekeres: Waves in Thermoelastic and Plastic Solids;

23. Henrik Kalisch: A Study of Dispersive Effects in Hydraulic Jumps;

24. Kert Tamm: Emergence of Solitary Deformation Waves in Mindlin-type Microstructured Solids;

25. Dmitri Tseluiko: Solitary Pulse Interaction Theory for the Generalized Kuramoto-Sivashinsky Equation;

26. Alexander Dyachenko: About Shape of Freakon;

27. Ira Didenkulova: Travelling Waves in Strongly Inhomogeneous Media;

28. Nicole Delpeche: The Generation and Dissipation of a Solitonic Wave that Travels in the Reverse Direction to the Flow in the Saint John River Estuary, New Brunswick, Canada;

29. Heiko Herrmann: Towards a Description of Twist Waves in Liquid Crystals Using Mesoscopic Continuum Physics;

30. Christina Papenfuss: Mesoscopic and Macroscopic Description of Material Damage and Magnetization;

31. Jaan Kalda: Turbulent Mixing of Passive Scalars: Evolution of Discontinuity Fronts and Material Lines;

32. Jüri Engelbrecht: On Complexity and Beyond.

6.1.2. Complex Systems: growth and emergent behaviour October 9, Academy House 6, Kohtu str., Tallinn

This seminar discusses various aspects of complex systems (natural and artificial) related to the ways and possibilities of controlling their growth, and/or the resulting behaviour. The authors, all involved in SAGECCO project, have suggested exploiting knowledge and properties of growing biological systems to engineer complex systems using similar growth processes, as the way to find vanishingly small regions of their phase space where they can exist and function as expected. Such growth to (dynamic analogue of) an attractor automatically provides repair (elimination of deviation from the desired growth trajectory) and homeostasis.

The following presentations demonstrate the scope and variety of problems and approaches that are to be dealt with in order to gain the ability to (partially) control the growth of complex systems.

1. Jüri Engelbrecht, (Estonian Academy of Sciences, Vice-President);

2. Susan Stepney, Department of Computer Science, University of York, U.K.: Computation and Growth;

3. Paul Valckenaers, Department of Mechanical Engineering, Katholieke Universiteit Leuven, Belgium: Integrate-ability, mirroring the real-world and context-driven coordination and control;

4. Farhad Arbab, Centre for Mathematics and Computer Science, Centrum Wiskunde and Informatica, the Netherlands: Growth through dynamically reconfigurable coordination;
5. Julian Miller, Department of Electronics, University of York, U.K: Truly complex programs cannot be written by humans;
6. Leo Mõtus, Research Lab for Proactive Technologies, Department of Computer Control, Tallinn University of Technology, Estonia: Towards behaviour verification in self-organising and in networked/integrated systems.

6.1.3. IoC Fall Seminar 2009: AGENDA at VIINISTU, Saturday, October 17, Estonia

1. Mari Kalda: Mechanoenergetics and single heart cell;
2. Mervi Sepp: Secrets in the cell: coupling between PK and ATPases;
3. Niina Sokolova: Intracellular diffusion restrictions in trout cardiomyocytes;
4. David Schryer: A systems biology study of yeast metabolism using multiple isotopomeric datasets;
5. Ardo Illaste: Calcium handling in cardiac myocytes derived from human embryonic stem cells;
6. Martin Laasmaa: Confocal Microscope Image Enhancement;
7. Hena Ramay: Sparks to Waves: Calcium dynamics in cardiac cells;
8. Tanel Peets: Waves in microstructured solids – dispersion and internal degrees of freedom;
9. Dmitri Kartofelev: The influence of the elastic parameters of piano bass hammers on the hammer-string contact time duration;
10. Maksim Säkki: Scaling and universality in financial time-series;
11. Andres Braunbrück: Finite burst in functionally graded materials;
12. Dmitry Kurennoy: Submarine terrances of the Eastern Gulf of Finland: surveys and reconstruction of evolution in the Late Holocene;
13. Nicole Delpeche: Interfacial Mixing in the Saint John River Estuary;
14. Bert Viikmäe: Application of a trajectory model to select areas of high risk of pollution in the Baltic Sea;
15. Andrus Räämet: Wave climate changes in the Baltic Sea 1970–2007;
16. Tarmo Soomere: On the dynamics of “almost equilibrium”beaches on the North Estonian coast.

6.1.4. Meetings and events in CENS

The week of open doors at the Laboratory of Wave Engineering, Institute of Cybernetics. At the end of January - in the beginning of February (26 January – 04 February 2009), the Wave Engineering Laboratory celebrated its establishing by inviting several guest scientists to give seminars and by organising a series of planning and foresight study meetings. The event was organised in cooperation of Marie Curie projects CENS-CMA and SEAMOCS.

Prof. Kevin Parnell (James Cook University, Australia) and Dr. Tomas Torsvik stayed in Tallinn during the entire event. Dr. Daria Ryabchuk (Saint Petersburg) visited the laboratory on 29–30 January 2009 and Dr. Luigi Cavaleri on 2–4 February. Prof. Zhijun Li and Prof. Matti Leppäranta visited the lab shortly on 29 January. The event offered various possibilities for scientists from different countries and communities to meet members of the Estonian team, to exchange ideas about further joint research, and to discuss with each other in informal atmosphere. The most important outcome are the decisions to perform extensive field studies of ship waves in Tallinn Bay in June 2009 in the planning meeting of the field work session (28 January) and to start preparation of a pan-Europan project focussing on tsunami-like flooding of low-lying cities like Venice, Saint Petersburg, Pärnu or Rostock in the foresight study meeting on possibilities of modelling of tsunami flooding in Venice and similar areas (03 February).

The Wave Engineering Laboratory team (A.Terentjeva, K.Beloussova) contributed to the planning and organization of the intense course for young researchers on "Statistical software for climate research"(Malta, Preluna Hotel and Spa, 16–17 March 2009) and in the interdisciplinary workshop "Effects of climate change: coastal systems, policy implications, and the role of statistics"(Malta, Preluna Hotel and Spa, 18–20 March 2009). The themes for the workshop are facts and uncertainties of climate change and its effects on coastal systems and marine safety, and the use of modern statistical tools to address some of these important issues.

Measurements of properties and runup of ship-induced waves (June–July 2009)

The Tallinn team organised a series of field works, targeted to measurements of properties of ship wakes in Tallinn Bay and runup features of ship-induced long waves in the vicinity of Pikakari Beach (Katariina jetty, western coast of the interior of Tallinn Bay) and, for a shorter time, at the island of Aegna. The studies comprised of high-resolution water surface profiling, measurements of near-bottom currents in shallow water, electronic measurements of runup heights, recording of beach profile changes, identification of ship's type, speed and distance to the study site, visual observations of the overall appearance of the ship wave systems, video recordings of the runup details, GPS-recordings of several tracks of fast ferries, and studies of wave-induced changes of the optical properties of sea water.

The entire team, including PhD students at the Department of mechanics Andrus Räämet and Andres Kask, MSc student Inga Zaitseva-Pärnaste (ESR to Sheffield in Aug-Oct. 2009), and several guests (prof. Kevin Parnell, dr. Ants Erm, dr. Tomas Torsvik, among others) took part in the planning and practical organisation of the experiment and performing field measurements.

Intense course "TRACMASS - A Lagrangian Trajectory code"course was held by Anders Anbo (Uppsala University and Meteorological Institute, Stockholm University) in the Institute of Cybernetics at Tallinn University of Technology on 14–24 July 2009. Nicole Delpeche participated in the entire course while Inga Zaitseva-Pärnaste and Loreta Kelpšaite took part in the basic training.

7th Baltic Sea Science Congress 2009 (Tallinn, Estonia, 17–21 August 2009)

1. T.Soomere was a chair member and a co-organiser.
2. T.Soomere and I.Didenkulova were conveners and chairs of the thematic session "Interplay of wave dynamics, marine ecosystem and coastal processes"(20–21 August).
3. The IoC SEAMOCS team organised (jointly with the FP7 network GSD) the workshop "Global System Dynamics and Policies"held in the Estonian Academy of Sciences on 18 August 2009 and an accompanying workshop/panel discussion of young scientists in the Institute of Cybernetics on 19 August 2009 (to be amended).
4. The IoC SEAMOCS team was the co-organiser of the International Conference on Complexity of Nonlinear Waves (Tallinn, Estonia, 5–7 October 2009) – described elsewhere in the report.

6.1.5. Meetings and events organised elsewhere

1. I.Didenkulova was convener of the session "OS09 - Nonlinear Dynamics of the Coastal Zone"in the VI Annual Meeting of Asia Oceania Geosciences Society (SUNTEC, Singapore, August 11–15, 2009).
2. E.Quak organized the Workshop Industry Challenges in Geometric Modeling, CAD and Simulation 2009 (Darmstadt, Germany, March 12–13, 2009.
3. E.Quak organized the Forward Looking Session 2009 to discuss future research issues at the Joint SIAM (Society for Industrial and Applied Mathematics)/ACM (Association for Computing Machinery) Conference on Geometric and Physical Modeling (San Francisco, California, USA, October 5–8, 2009).
4. E.Quak organized and moderated the Panel Discussion on Future Research Trends at the Conference on Geometric and Physical Modeling (San Francisco, California, USA, October 5–8, 2009).

6.2 International cooperation

- University of Waikato: stay of Bryna Flaim in Tallinn in December 2008-February 2009, training towards the use of the coastal engineering software CEDAS;
- Collaboration with the University of Bergen: T.Torsvik, Dept. of Mathematics, Uni of Oslo: Prof. G.Pedersen, and Inst. of Applied physics: Prof. E.N.Pelinovsky in the framework of the EEA grant EMP41 "Shoaling and runup of long waves generated by high-speed ferries"(2008–2010;
- Swedish Meteorological and Hydrological Institute (Norrköping), Laser Diagnostic Instruments (Tallinn), Danish Meteorological Institute, Department of Meteorology, Univ. of Stockholm, Institute for Coastal Research, GKSS Geesthacht, Finnish Institute of Marine Research, and Leibniz Institute of Marine Sciences at the University of Kiel in the framework of the pan-Baltic **BONUS-169 project BalticWay:** The potential of currents for environmental management of the Baltic Sea maritime industry (2009–2011);

- Collaboration between I.Didenkulova and (1) Dept of Mathematics, University of Oslo: Prof. J.Grue, (2) Institut de Recherche sur les Phenomenes Hors-Equilibre (IRPHE), Marseille, France: Prof. Ch.Kharif, (3) University of Antilles and Guyane, Guadeloupe: Prof. N.Zahibo, (4) University of Bologna, Italy: Prof. S.Tinti, (5) Geolab UMR 6042 CNRS-UBP, University Blaise Pascal, Clermont-Ferrand, France: Dr.Raphael Paris, (6) University of Warwick, Coventry, UK: Dr. P.Denissenko;

- Collaboration with the MC Transfer of Knowledge network CENS-CMA: exchange of senior scientists between IoC and University of Oslo; stay of Dr. H.Herrmann (Berlin/Chemnitz), Prof. K.Parnell (Australia), Dr. T.Dolphin (Norwich, UK) in Tallinn;

- Collaboration with the Finnish Environmental Institute and University of Helsinki: Physical oceanography of the Gulf of Finland and the Baltic Sea (K.Myrberg, M.Leppäranta), Planetary Boundary Layers (S. Zilitinkevich);

- Collaboration with the GKSS Geesthacht (H.Günther): Pre-operational modelling of wave regime in the Gulf of Finland, Implementation of WaMoS in the Baltic Sea.

- Laboratory of Photoelasticity of the Institute of Cybernetics participatesin an informal academic cooperation on the topic "Stress field in locally plastically deformed glass". Head of the team is Prof. C.R.Kurkjian from the university of Southern Mayne (USA). The other participants are Prof. R.Oldenbourg (Marine Biology Laboratory, Woods Hole, USA) and Nippon Electric Glass (Japan).

- Collaboration with the Academic partners:

  – Centrum Wiskunde and Informatica (Netherlands); Katholieke Universiteit Leuven (Belgium); Leeds University (U.K.); Microsoft Research at Redmond (USA); Microsoft Innovation Centre, Aachen (Germany); University of York (U.K.).

- Collaboration with the Industrial partners:

  – Bestnet Ltd; ELIKO; ELI Military Simulations; Elvior OÜ; IB Krates; Smartdust Solutions Ltd.

6.3 Teaching activities

6.3.1 CENS seminars for graduate students

1. Continuum physics – H.Herrmann

6.3.2 Courses:

1. A.Salupere – courses in TUT:
   - Statics
   - Continuum Mechanics
   - Theory of Elasticity
   - Special Topics in Mechanics
   - Seminars and Special Seminars for MSc and PhD students

2. A.Braunbrück – courses in TUT:
   - Technical Mechanics I
   - Technical Mechanics II

3. R.Kitt – courses in TUT:
   - Taking risks as an opportunity to earn profits

4. M.Randrüüt – courses in TUT:
   - Technical mechanics I (EMD0011)
   - Technical mechanics II (EMD0012)

5. J.Vain, M.Kääramees, J.Ernits – courses in TUT:
   ITI8110 Preparation of Scientific Papers

6. E.Rüstern, Ü.Nurges, A.Riid – courses in TUT:
   ISS0022 Advanced Automatic Control Systems

7. Ü.Nurges – courses in TUT:
   ISS0030 Modeling and Optimization

8. E.Rüstern, Ü.Nurges – courses in TUT:
   ISS9030 Control of Dynamic Systems

9. J.Vain – courses in TUT:
   ITI9120 Advanced Topics in Computer Science
   ITI9190 Formal Verification
   ITX8025 Formal Methods in System Design
   ITI9100 Special Course on Hybrid Systems

10. S.Nõmm, M.Tõnso – courses in TUT:
    YMR0063 Algebraic Methods in Nonlinear Control Systems Theory
    YMR0064 Computer Algebra in Nonlinear Control Systems Theory

11. S.Nõmm, Ü.Kotta, J.Vain – courses in TUT:
    ITX8017 Nonlinear Control Systems: Computational Aspects
    ITX8018 Modern methods in nonlinear control systems and computer algebra systems

12. S.Nõmm – courses in TUT:
    ISS9410 Introduction to control systems on time scales

13. J.Vain – courses in Technical University of Denmark:
    - Model based testing and verification of embedded systems, Doctoral course

14. T.Soomere – courses in TUT:
    - Coastal processes
    - Wave dynamics

15. T.Soomere – a series of lectures in the Open University, in TUT in the framework of the course “Port and Coastal Engineering II”:
    2 lectures: Theory of surface waves and vessel wakes
    2 lectures: Modeling of sediment transport in Estonian beaches;
    2 lectures: Marine-induced hazards in the context of Estonian cities

16. T.Soomere – a series of lectures to the summer school on Physical Oceanography of the Baltic Sea, Tvärminne, May 11-16, 2009:
    2 lectures Wave motions in the Baltic Sea
    2 lectures Coastal processes in the Baltic Sea

17. E.Quak – a series of lectures to the summer school on Physical Oceanography of the Baltic Sea, Tvärminne, May 11–16, 2009

18. T.Soomere – external assessor of an application for a docentship in the Helsinki University.

19. T.Naks and R.Savimaa: lectures:
    – Introduction to Real-time Software Engineering

20. T.Naks supervision of course projects:
    – Real-time systems

21. L.Mõtus: course:
    – Software dynamics
    – Multi-Agent Systems

22. L.Mõtus: courses for PhD students for individual study, e.g.:
    – Foundations of Multi-agent System

23. R.Serg: supervises practical exercises in Computer Networks

24. A.Udal: (together with Prof. V.Kukk, Dep. of Computer Control) course:
    – ASIC design and nanoscale information technology

6.3.3. Participation in other events, transfer of knowledge:

1. E.Quak was part of a workshop on IRSES project proposals in the EU FP7 PEOPLE program organized by the Norwegian Research Council (NFR), March 17, 2009.

2. I.Didenkulova visited the University of Sheffield, Dept. of Mathematics, for 01 May – 31 September 2009.

3. E.Quak was part of a workshop on IAPP project proposals in the EU FP7 PEOPLE program organized by the Norwegian Research Council (NFR), May 5, 2009.

4. T.Soomere, lectures to the summer school on Physical Oceanography of the Baltic Sea (Tvärminne, Finland, May 11–16, 2009): "Wave motions in the Baltic Sea"(2 academic hours) and "Coastal processes in the Baltic Sea"(2 academic hours).

5. I.Didenkulova visited the Geolab UMR 6042 CNRS-UBP, University Blaise Pascal (Clermont-Ferrand, France) in the framework of collaboration with Dr. Raphael Paris, where she worked on the problem of tsunami, induced by volcanic eruptions (29 August – 15 September 2009).

6. E.Quak visited Larry Schumaker, Stevenson Professor of Mathematics at Vanderbilt University, Nashville, Tennessee, USA, for research on the use of bivariate splines in image compression as part of the ESTSpline project (October 1 – November 16, 2009).

7. I.Didenkulova visited University of Bergen (Bergen, Norway) in the framework of collaboration with Dr. T.Torsvik, where she worked on the problem of modelling of ship induced wave runup (30 October – 3 November 2009 and 20–28 December 2009).

8. E.Quak was part of a workshop on ITN project proposals in the EU FP7 PEOPLE program organized by the Norwegian Research Council (NFR), November 23, 2009.

9. I.Didenkulova visited University of Bologna (Bologna, Italy) in the framework of collaboration with Prof. S.Tinti, where she worked on the analytical theory of breaking wave runup on a beach (22 November – 5 December 2009).

10. I.Astrov – Chairman of the session 4 at ICIMA 2009, the 2009 International Conference on Industrial Mechatronics and Automation, May 16–17, 2009, Chengdu, China.

11. I.Astrov – Chairman of the "Vehicle II"session 1B06 at ICCAS (International Conference on Control, Automation and Systems)-SICE 2009, the ICROS (Institute of Control, Robotics and Systems)-SICE (Society of Instrument and Control Engineers) International Joint Conference 2009, August 18–21, 2009, Fukuoka, Japan.

12. I.Astrov – Chairman of the session "Control, Robotics and Mechatronics 2"session CRM 2 at RoViSP 2009, the 7th International Conference on Robotics, Vision, Signal Processing and Power Applications, December 19–20, 2009, Langkawi Island, Malaysia.

13. I.Astrov – Member of the International Programme Committee at CSIE 2009, the 2009 World Congress on Computer Science and Information Engineering, March 31 – April 2, 2009, Los Angeles, USA.

14. I.Astrov – Member of the International Programme Committee at IMETI 2009, the 2nd International Multi-Conference on Engineering and Technological Innovation, July 10–13, 2009, Orlando, USA.

15. I.Astrov – Member of the International Advisory Committee at TIC-STH 2009, the 2009 IEEE (Institute of Electrical and Electronics Engineers) Toronto International Conference - Science and Technology for Humanity, September 26–27, 2009, Toronto, Canada.

16. I.Astrov – Member of the International Programme Committee at ACIT 2010, the IASTED (International Association of Science and Technology for Development) International Conference on Automation, Control, and Information Technology, June 15–18, 2010, Novosibirsk, Russia.

17. I.Astrov – Member of the International Programme Committee at IMETI 2010, the 3rd International Multi-Conference on Engineering and Technological Innovation, June 29 – July 2, 2010, Orlando, USA.

18. A.Pedai – Chairman of session "AUV Control – I"MP1-10 at ICMA 2009, the 2009 IEEE International Conference on Mechatronics and Automation, August 9–12, 2009, Changchun, China.

19. L.Mõtus – Member International Programme Committee, 7th International Conference on Software Engineering, Research, Management, and Applications (SERA 2009).

20. L.Mõtus – Member International Programme Committee, 30th IFAC Workshop on Real-time Programming.

21. L.Mõtus – Member, Programme Committee, Symposium on "Intelligent Uninhabited vehicle Guidance Systems", NATO RTO SCI.

22. L.Mõtus – Organiser, International seminar on "Complex Systems: growth and emergent behaviour", Tallinn, October 2009.

6.4. Visiting fellows
For shorter period

1. Dr. P.Van (Budapest). Exchange program between Estonian and Hungarian Academies of Sciences, October 3–17.
2. Dr. A.Szekeres (Budapest). Exchange program between Estonian and Hungarian Academies of Sciences, October 3–17.
3. Dr. N.Kizilova (Kharkov). Exchange program between Estonian and Ukrainian Academies of Sciences, October 3–10.
4. Dr. A.Porubov (St.-Petersburg). Exchange program between Estonian and Russian Academies of Sciences, October 3–10.
5. Malgorzata Wyrwas, Bialystok University of Technology, September 15–26.
6. Prof. Kevin Parnell (James Cook University, Australia), 19 January – 05 February 2009, in the framework of studies of properties and runup of ship-induced waves.
7. Dr. Daria Ryabchuk (Saint Petersburg), 29–30 January 2009, visiting the week of open doors of the SEAMOCS Tallinn team and the laboratory of wave engineering.
8. Dr. Luigi Cavaleri (ISMAR, Venice), 2–4 February 2009 in the framework of the foresight study meeting on the possibilities of modelling of tsunami flooding in Venice and to present the seminar paper Predictability of extreme storms and floods in the Adriatic Sea and Venice (03.02.2009).
9. Prof. Terry Healy (University of Waikato, New Zealand) visited the IoC team on 6–8 April 2009 in the framework of planning of joint activies for 2009–2010, and to present the seminar paper "Identifying sediment transport pathways in the coastal realm"(07.04.2009).
10. Anders Anbo (Uppsala University and Institute of Meteorology, Stockholm University), 13–24 July 2009, performed training of the BalticWay team members in TRACMASS trajectory modeling code.
11. Prof. Dr. Jan Harff (University of Greifswald, Germany and University of Szczecin, Poland), 17–21 August 2009, the first opponent and a member of the scientific committee for the defence of PhD thesis of A.Kask.
12. Dr. Sergei Badulin (P.P.Shirshov Institute of Oceanology, Moscow, Russian Academy of Scienced), 1–8 October 2009, the first opponent and a member of the scientific committee for the defence of PhD thesis of L.Kelpšaite.
13. Dr. Boris Chubarenko (Atlantic Branch of the P.P.Shirshov Institute of Oceanology, Kaliningrad, Russian Academy of Sciences), 6–13 October 2009, the first opponent and a member of the scientific committee for the defence of PhD thesis of D.Kurennoy.
14. Farhad Arbab (Centre for Mathematics and Computer Science, Centrum Wiskunde and Informatica), The Netherlands – seminar on "Complex Systems: Growth and emergent behaviour", a lecture.
15. Johannes Helander (Architect and Chief Scientist at Microsoft Innovation Centre), Aachen, Germany – consultations.

16. Gabriel Jakobson (Chief scientist Altusys Corp, IEEE Communication Society, Board of Governors, USA) – consultations and a lecture.

17. Julien Miller (Dept. of Electronics, University of York, U.K.) – seminar on "Complex Systems: Growth and emergent behaviour", a lecture.

18. Susan Stepney (Dept. of Computer Science, York University, U.K.) – seminar on "Complex Systems: Growth and emergent behaviour", a lecture.

19. Paul Valkenaers (Dept. of Mechanical Engineering, Katholieke Universiteit Leuven, Belgium) – seminar on "Complex Systems: Growth and emergent behaviour", a lecture.

For longer periods

1. H.Herrmann (postdoc Research Fellow, Feodor Lynen grant, Alexander von Humboldt Foundation).

2. I.Didenkulova. Experienced Researcher supported by the Marie Curie RTN network SEAMOCS, 1 September 2007 – 31 October 2009.

3. L.Kelpšaite. Early Stage Researcher supported by the Marie Curie RTN network SEAMOCS, 15 November 2007 – 31 October 2009.

4. D.Kurennoy. Early Stage Researcher supported by the Marie Curie RTN network SEAMOCS, 15 November 2007 – 31 October 2009, for 1 September 2008 – 30 April 2009 supported by Marie Curie TK network CENS-CMA.

5. N.Delpeche. Early Stage Researcher supported by the Marie Curie RTN network SEAMOCS, 1 October 2008 – 31 October 2009.

6. Dr. T.Dolphin (Norwich, UK), 22 September 2008 – April 2009 in the framework of joint coastal studies and wave research, supported by the Marie Curie ToK project CENS-CMA), incl. participation at the Malta meeting and Lisbon conference; with the main focus on joint coastal studies and wave research.

7. B.Kathryn Flaim (University of Waikato, Hamilton, New Zealand), 2 December 2008 – 20 February 2009, in the framework of the Marie Curie RTN project SEAMOCS training program: training of early stage and experienced researchers in coastal management and towards the use of the CEDAS analysis and modeling system.

8. Dr. T.Torsvik (University of Bergen, Norway), 29 December 2008 – 8 February 2009 and 12–21 June 2009, in the framework of cooperation within the CENS-CMA network and EEA grant EMP41, incl. in the framework of the measurement program of vessel wakes in Tallinn Bay.

9. Prof. K.E.Parnell (James Cook University, Australia), 01 June – 04 July 2009 in the framework of field studies of properties and runup of ship-induced waves; supervised the field measurements & field training programme in summer 2009.

6.5 Graduate studies
Department of Mechanics and Applied Mathematics:
Promoted:

1. MSc:

M.Kree	Statistical topography of turbulent mixing (supervisor J.Kalda).
D.Kartofelev	Sound generation mechanisms in grand pianos (supervisor A.Stulov).
M.Laasmaa	The Analysis of Richardson-Lucy Deconvolution Algorithm with Application to Microscope Images (supervisors M.Vendelin, P.Peterson).

1. PhD:

L.Ilison	Solitons and Solitary Waves in Hierarchical KdV-type Systems (supervisor A.Salupere).

In progress:

1. PhD:

M.Berezovski	Numerical simulation of front tracking in inhomogeneous solids (supervisor J.Engelbrecht).
T.Peets	Dispersion in microstructured solids (supervisor J.Engelbrecht).
M.Randrüüt	Evolution and existence of nonlinear waves in microstructured solids (supervisors J.Engelbrecht and A.Salupere).
K.Tamm	Deformation waves in microstructured solids (supervisor A.Salupere).
D.Kartofelev	Piano string vibration: the role of bridge impedance (supervisor A.Stulov).
A.Illaste	Mathematical model of mitochondrial energy metabolism (supervisor M.Vendelin).
D.Schryer	^{13}C impulse labeling studies with Saccharomyces cerevisiae (supervisor M.Vendelin).
M.Kalda	Mechanoenergetics of a single cardiomyocyte (supervisor M.Vendelin).
M.Sepp	Estimation of diffusion restrictions in cardiomyocytes using kinetic measurements (supervisor M.Vendelin).
N.Sokolova	Role of the Na+/Ca2+-exchanger in excitation-contraction coupling and energetics in rainbow trout cardiomyocytes (supervisor R.Birkedal).
N.Jepihhina	Heterogeneity of energetic parameters in cardiomyocytes (supervisor M.Vendelin).
M.Laasmaa	Studies of the relationship between excitation-contraction coupling and energetics on trout cardiomyocytes (P.Peterson, R.Birkedal).
J.Branovets	Structural and energetic modifications in cardiomyocytes from mice with modified creatine kinase system (supervisor R.Birkedal).

2. MSc:

M.Vallikivi	Deformation waves in hyperelastic rods (supervisor A.Salupere).

Laboratory of Wave Engineering:
Promoted:

1. Diploma (Estonian Marine Academy):
   - K.Kartau. Beach processes and human activity in Valgerand (supervisor T.Soomere).
   - R.Värv. Digital bathymetry for the near shore of the North Estonian Coast (supervisor T.Soomere).
   - O.Tribštok. Hydrographical works by the example of Raahe port (supervisor I.Zaitseva-Pärnaste).
2. MSc:
   - I.Zaitseva-Pärnaste Long-term variations of wave fields in the Estonian coastal waters (supervisor T.Soomere).
3. PhD:
   - A.Kask Lithohydrodynamic processes in the Tallinn Bay area (supervisor T.Soomere).
   - L.Kelpšaite Changing Properties of Wind Waves and Vessel Wakes on the Eastern Coast of the Baltic Sea (supervisors T.Soomere, I.Lill (Department of Building Production)).
   - D.Kurennoy Analysis of the Properties of Fast Ferry Wakes in the Context of Coastal Management (supervisor T.Soomere).

In progress:

1. PhD:
   - I.Zaitseva-Pärnaste Wave climate changes of the Baltic Sea and their economical consequences (supervisor T.Soomere).
   - A.Räämet Spatio-temporal variability of the Baltic Sea wave fields in changing climate conditions (supervisor T.Soomere, promotion expected 2010).
   - N.Delpeche Using improved understanding of the circulation pattern in the Gulf of Finland to minimize coastal pollution (supervisor T.Soomere, expected defence 2012).
2. MSc: K.Kartau; R.Värv; O.Tribštok.

Control Systems Department:
Promoted:

1. MSc:
   A.Kanarbik. Home automation expert system: living environment configuration example for humans with special needs (supervisor J.Vain)
2. A.Kull. Model-Based Testing of Embedded Systems (cosupervisor J.Vain).
3. D.Pavlov. Bankruptcy Prediction Using Neural Networks: Case for Estonian Companies (cosupervisor S.Nõmm.

In progress:

1. PhD:

M.Tõnso.	Computer algebra tools for modelling, analysis and synthesis for nonlinear control systems (supervisor Ü.Kotta).
V.Kaparin.	Transformation of the nonlinear state equations into the observer form (supervisor Ü.Kotta).
J.Belikov.	Identification and control of complex nonlinear multi input multi output systems based on methods of artificial intelligence (supervisor E.Petlenkov).
A.Anier.	Motion recognition via abstract interpretation (supervisor J.Vain).
M.Markvardt.	Test data generation methods for input validation (supervisor J.Vain).
S.Avanessov.	Robust adaptive output controller (cosupervisor Ü.Nurges).
K.Haavik.	(supervisor J.Vain).
K.Sarna.	(supervisor J.Vain).

Laboratory for Proactive Technology:
Promoted:

1. PhD:

A.Kull.	Model-Based Testing of Reactive Systems (supervisors M.Veanes (Microsoft Research, Redmond, USA), J.Lilius (Embedded Systems Laboratory, Åbo Akademi, Turku, Finland).

In progress:

1. PhD:

R.Pahtma	Physical modelling as complementary tool for studying emergent behaviour and self-organisation

6.6 Distinctions

Fellows:

1. H.Aben, L.Ainola, J.Anton, A.Errapart – State Research Award for innovative research "Theory, technology and instruments for integrated photoelasticity and applications in glass industry".
2. H.Aben – N.Alumäe medal from the Estonian Academy of Sciences for his research in photoelasticity.
3. I.Didenkulova – Plinius Medal 2010 by the European Geosciences Union in recognition of her outstanding contributions to solve complex problems of oceanography and coastal engineering by applying nonlinear wave theory to marine natural hazards, including tsunamis, freak waves and storm waves.
4. T.Soomere – Diploma of the Estonian Society for Nature Protection for informing the public and leaders of Estonia, and for ravishing them to protect the Baltic Sea.

5. Estonian Council of Environmental NGOs (non-govermental organizations) elected the 2009 Environmental Deed to be I.Puura's and T.Soomere's initiative in drawing attention to possible negative environmental influences of the future Nord Stream gas pipe.
6. A.Ravasoo – best TTU research paper in technical sciences.
7. J.Kalda – best TTU research paper in natural sciences.
8. J.Engelbrecht – the Lagrangian Lecture in the University of Turin.
9. T.Soomere was elected into Academia Europaea.
10. J.Engelbrecht was reelected to President of ALLEA.
11. J.Engelbrecht was reelected to Vice-President of the Estonian Academy of Sciences.
12. T.Soomere was elected to Head of the Informatics and Engineering Division of the Estonian Academy of Sciences.

Students:

1. L.Ilison – 3rd Prize in National Students Research Contest 2009 in natural and technical sciences (in PhD subgroup).
2. M.Kree – 3rd Prize in National Students Research Contest 2009 in natural and technical sciences (in MSc subgroup).
3. L.Kelpšaite, prize for the best poster in the section "Conference of Baltic Oceanographers", 7th Baltic Sea Science Congress, 17–21 August 2009, Tallinn.
4. D.Kurennoy, prize for the best poster "Ship wakes measurement in Tallinn Bay"in the International conference "Lithodynamics of bottom contact zone of the ocean"(Moscow, Russia, 14–17 September 2009).
5. I.Zaitseva-Pärnaste, MSc thesis "Long-term variations of wave fields in the Estonian coastal waters"won the II prize of the national competition of student's scientific work by the Estonian Academy of Sciences.
6. J.Belikov – Tallinn UT 1st Prize for research students (MSc subgroup).

6.7 Other activities

6.7.1 Participation on programme committees, reviewing papers:

J.Engelbrecht:

2006 – . . .	ALLEA, ESF, EASAC;
2009	Expert Groups at the Ministry of Education and Research;
May 25–28, 2009	IUTAM Symp. on Recent Advances of Acoustic Waves in Solids, Taipei – Programme Committee;
Aug. 23–29, 2009	FUDoM 09, Rackeve – Programme Committee.

A.Berezovski:

Oct. 5–7, 2009	chairman of International Conference on Complexity of Nonlinear Waves, Tallinn, Estonia;
2009	reviewing papers for ZAMM – Z.Angew. Math. Mech., Int. J. of Fracture, Proc. Est. Acad. Sci.

Ü.Kotta:

–	Nonlinear Control Systems (NOLCOS) 2010;
–	UKACC International Conference on Control 2010 Coventry University, Coventry, UK.

T.Soomere:

2008 – 2009	Member of the expert group of the Ministry of Environment for estimating the content of the environmental impact assessment of the Nord Stream gas pipeline;
2007 – . . .	member of steering committee of the Baltic Sea Science Congress 2009;
2005 – . . .	member of the CBO (Conference of Baltic Oceanographers) steering committee;
2004 – . . .	member of the Scientific Council of the Laboratory of Multiphase Flows at TUT;
2003 – . . .	member of the Scientific Council of the Institute of Cybernetics at TUT.

J.Vain:

–	Nordic Workshop on Programming Theory (NWPT), October 14–16, Lyngby, Denmark;
–	Nordic workshop and doctoral symposium on DEpendability and Security, April 27, Linköping, Sweden.

E.Quak

2009	Vice-chair of the Mathematics-Engineering panel for the evaluation of Marie Curie Industry-Academia Partnerships and Pathways proposals in the EU FP7 People program;
2009	Evaluator of the ComplexityNet call, representing the Estonian Academy of Sciences;
2009	Member of the Program Committee, FOCUS Workshop on advanced 3D media in gaming and simulation in Amsterdam, The Netherlands, June 16;
2009	Member of the Program Committee, Workshop 3D Physiological Human Zermatt, Switzerland, November 29 – December 2;
2005 – . . .	Contact point Special Interest Group on Geometric Modeling, CAD, Evolving Interfaces and Surfaces of the European Consortium for Mathematics in Industry (ECMI).

6.7.2. Participation in journal editorial boards:

1. J.Engelbrecht, Applied Mechanics Reviews.
2. J.Engelbrecht, Applied Mechanics, (Kiev).
3. J.Engelbrecht, J. Theor. Appl. Mech., (Warsav).
4. J.Engelbrecht, Estonian J. Engineering.
5. Ü.Kotta, Abstract and Applied Analysis, Hindawi Publishing Corp.
6. Ü.Kotta, Proceedings of Estonian Academy of Sciences.
7. T.Soomere, Estonian J. Engineering.
8. T.Soomere, J. of Marine Systems.

6.7.3. Participation in professional organizations:

1. A.Salupere, IUTAM contact.
2. Ü.Kotta, IFAC technical committee for nonlinear systems, member.
3. S.Nõmm, IFAC contact person in Estonia.
4. T.Soomere, contact for the ESF Marine Board.

6.7.4. Other:

1. J.Kalda, member of the Advisory Board of the International Physics Olympiads; member of the Directing Committee of the 43rd International Physics Olympiad; member of the Jury of the Estonian Physics Olympiads.
2. Ü.Kotta, FP7-PEOPLE-COFUND-2009 project evaluator, Brussels, Belgium, March 23–27.
3. J.Vain, reviewer of Saulius Pushinskas PhD thesis "Capturing Behavioral Requirements and Testing Against Them by Means of Live Sequence Charts", Aalborg University, Denmark.
4. J.Vain, reviewer of Abdul Haseeb PhD thesis "Interoperability infrastructure and Incremental learning for unreliable heterogeneous communicating Systems", Lic., KTH - Stockholm, Sweden 2009.

6.7.5 Science and Politics:

1. T.Soomere, presentation "Nord Stream: challenges for the Baltic Sea marine sciences"for the joint meeting of the Parliament Commission on foreign affairs and Commission on environment (06.04.2009).
2. T.Soomere presented the paper "Nord Stream: challenges for the Baltic Sea marine sciences"for the meeting of the Estonian govermental maritime commission (27.05.2009).
3. T.Soomere participated in the official meeting of Estonian experts and official representatives with Finnish representatives and Nord Stream experts, organised by the Finnish Ministry of Environment (Helsinki, Finland, 25.06.2009).

4. T.Soomere participated in the meeting of the Environmental Steering Panel of the European Academies Scientific Advisory Council (EASAC) (London, Royal Society).

5. T.Soomere presented the paper "Nord Stream: hard knots of hydrodynamics"for the joint meeting of the Estonian parliament Environment Committee, Foreign Affairs Committee, Economic Affairs Committee (15.10.2009).

6. T.Soomere presented the paper "Nord Stream in the unique and vulnerable environment of the Baltic Sea"to the extraordinary Plenary Session of the Parliament of Estonia and answered questions of Parliament members (27.10.2009).

7. T.Soomere participated in the Plenary Meeting of the European Science Foundation Marine Board in Rome, 18–19.05.2009.

8. E.Quak participated in the consultation workshop on The Future of Networked Immersive Media, organized by the EC Networked Media Systems Unit (Brussels, Belgium, September 24, 2009) and give a presentation on future 3D shape representations.

9. T.Soomere participated in the meeting of the Environmental Steering Panel of the European Academies Scientific Advisory Council (EASAC) (London, Royal Society, 06.05.2009 and London, Royal Institution of Great Britain, 4.11.2009).

6.7.6. Media reflections

1. K.Kaljund, "T.Soomere and his black box of waves". The Club of Smarts, the popular science journal, 4(28), April 2009, 44–47, (in Estonian).

2. Interview of to the leading radio channel Kuku Raadio in Estonia about breaking developments in the process of the Environmental Impact Assessement of the planned NordStream pipeline in the Baltic Sea, broadcast in Meretund (Marine Hour) 21.02.2009.

3. A comment by T.Soomere about topics discussed on the extended meeting of the Commission of Marine Sciences of the Estonian Academy of Sciences, broadcast in the Kuku Raadio Meretund 28.02.2009.

4. Anonymous, Scientist think the gas pipeline may be dangerous to the sea. Editorial, Postimees (The Postman, the leading dailiy newspaper), 57 (5537), 11.03.2009, p. 1 (in Estonian).

5. Madis Filippov, The environmental impact assessment of the Nord Stream pipeline ignores the specific features of the Baltic Sea, based on the interview with T.Soomere, Postimees, 57 (5537), 11.03.2009, p. 4.

6. T.Soomere, citation from Postimees 11.03.2009 concerning environmental issues of the planned gas pipeline in the Baltic Sea. The Club of Smarts, the popular science journal, 4(28), April 2009, 12 (in Estonian).

7. Comment of T.Soomere to state radio channel "Vikerraadio"(broadcast "Huvitaja"- addressing popular science issues) on the environmental risks connected with the construction and operation of the Nord Stream gas pipeline in the Baltic Sea, 12.03.2009.

8. Discussion of T.Soomere and E.Lippmaa about potential environmental risks to Estonia connected with planned NordStream, the radio channel Kuku Raadio, an one-hour broadcast within a series of popular science broadcasts "Kukkuv Õun", 12.04.2009.

9. Madis Filippov, Nord Stream environmental reports are extremely superficial, reflects an interview with T.Soomere, The Postman, 17.06.2009, p. 6 (in Estonian).

10. A longer comment by T.Soomere about the outcome of the 7th Baltic Sea Science Congress held in Tallinn on 17–21 August and co-organised by the IoC SEAMOCS team; broadcast by the Kuku Raadio Marine Hour on 22.08.2009.

11. A comment of T.Soomere in the framework of discussions of the environmental impact assessment of Nord Stream for the Estonian national TV (broadcast in the program for extended news and comments "Aeg luubis", 25.10.2009).

12. Madis Filippov, Finland tends to say "yes"to the Nord Stream pipeline, reflects an interview with T.Soomere, The Postman, 247(5727), 26.10.2009, p. 6 (in Estonian).

13. Comments of T.Soomere in the cases of presentation of the paper "Nord Stream in the unique and vulnerable environment of the Baltic Sea"about the Nord Stream environmental impact assessment to the extraordinary Plenary Session of the Parliament of Estonia (Riigikogu, 27.10.2009), broadcast in all national and private TV channels (TV2, TV3, Russian TV news etc.), and in radio channels on 27–28 October.

14. Interview of T.Soomere by phone to the central news' broadcast "Aktuaalne Kaamera"of the national TV channel: comments to the answers of the Nord Stream research team to critics of the environment impact assessment (the national TV channel, Aktuaalne Kaamera, 28.10.2009).

15. A citation from the presentation of T.Soomere to the extraordinary Plenary Session of the Parliament of Estonia (27.10.2009) appeared as "the word of the day"of the leading daily newspaper "The Postman", 250(5730), 29.10.2009, p. 13.

16. Broadcast of the almost full version of the presentation of T.Soomere to the extraordinary Plenary Session of the Parliament of Estonia (27.10.2009) in the national radio channel, broadcast Reporter's Hour; broadcast twice: 14:05 and 19:05.

17. A longer comment by T.Soomere reflecting the basic message of the address given on the occasion of 90th anniversary of the Estonian Marine Academy; broadcast by the Kuku Raadio Marine Hour, 31.10.2009.

18. Interview of T.Soomere by phone about co-operation of Estonian and Italian (Venice) scientists in the framework of tsunami studies and about problems connected with climate changes, 11.12.2009.

7. Summary

Ten years is not a long period but for a research centre it is long enough to formulate its main goals. Whether it has succeeded or not, is for peers to decide.

CENS celebrated its 10th anniversary in 2009. The overview on 1999–2009 is given in the Annex, Springer published a book on "Applied Wave Mathematics", an International Conference on Complexity of Nonlinear Waves was organized, etc. These are visible events and we are proud of them.

The essence is, however, more important. We deal with analysis, synthesis and control of complex systems. The results are promising (see Section 2 on recent studies) and we have many young people. The member of permanent fellows and visitors from other contries is growing. It was not a surprise for us that H.Aben and his team got the Estonian State Research Award for innovative research in 2009, the most prestigious Research Award in Estonia.

Annexes

1. CENS 1999 – 2009, overview.
2. CENS–CMA project, summary.
3. Marie Curie Action.
4. “Applied Wave Mathematics” by Springer, contents.
5. Highlights CENS 1999 – 2009.

1. CENS 1999 – 2009

The Institute of Cybernetics (IoC) was founded in 1960 within the Estonian Academy of Sciences. Its legendary first director Nikolai Alumäe understood the importance of computer science and control theory but did not forget mechanics, his own field of studies. The needs of mechanics were then one of the driving forces to foster computational methods. So the Department of Mechanics and Applied Mathematics (the present name), shortly DMAM, can look back over almost 50 years in its history. Photoelasticity has always been a topic in the DMAM because of the importance of this powerful method in the analysis of residual stresses. In other fields of studies, however, there has been a shift of focus - from the theory of shells, stability and vibration, the attention was turned step-by-step to the fast-moving front of science in nonlinear dynamics. This opened up new areas of research with surprising ideas and has stimulated many young researchers to join the research teams in DMAM of the Institute of Cybernetics, which since 1997 is part of Tallinn University of Technology (TUT).

About ten years ago it became clear that the research had to be organised in a more flexible way, which could enhance the synergy between strong teams united by basic ideas. The natural concept was to invite other teams sharing similar understandings and working in related fields to join forces and to stress the importance of international co-operation. This was the starting point in 1999 to found the Centre for Nonlinear Studies (CENS) within the IoC. The founders were DMAM with the Laboratory of Photoelasticity of the IoC, the Biomedical Engineering Centre of TUT and the Chair of Geometry of the Institute of Pure Mathematics at the University of Tartu. The idea was to bring under one umbrella the scientific potential in Estonia engaged in interdisciplinary studies of complex nonlinear processes. It was extremely important that CENS invited an International Advisory Board to guide and monitor its activities.

The principles of CENS can be formulated briefly: to be at the frontier of science, to participate in international research, to react to national interests, to keep a good research atmosphere and to disseminate knowledge. The spearheads of research were:

- nonlinear waves in solids: complexity of wave motion in solids, solitonics, coherent wave fields, mechanics of microstructured materials, acoustodiagnostics;
- nonlinear integrated photoelasticity: stress field tomography (tensor tomography) and complexity of interference fringes;
- fractality and biophysics: turbulent diffusion, statistical topography and flooding, econophysics, complexity in biophysics, in silico modelling of cardiac mechanics and cell energetics;
- water waves: marine physics, multimodal waves, wave-wave and soliton interactions, anomalies of wave fields, ship wakes, extreme waves, coastal processes;
- nonlinear signal processing: analysis of physiological signals (EKG, EEG), applications in cardiology and brain research;
- geometric methods: Lie-Cartan methods, flows of vector fields on tensor fields.

The synergy between the fields has brought about a new quality of the activities. All the studies are characterized by a strong influence of nonlinearities, a wide range of scales (in space and time), and essential interaction between the constituents of processes. The results are described in the CENS Annual Reports (http://cens.ioc.ee) over the period 1999–2008. The lists of refereed papers became steadily longer, several monographs and textbooks have been published together with special issues of international and national journals. It would take too

much space here to list all the activities (a summary of best results is given in the Annual Report 2007) but it is worth to mention that 9 fellows of CENS received Estonian Science Awards during the 10 years of CENS, there are 4 fellows of the German Alexander von Humboldt Foundation working in CENS, one Wellcome Trust fellow, etc. In 2002, the Estonian Ministry of Education and Research has included CENS into its list of 10 Centres of Excellence in Research in Estonia (2002–2007).

The decade of research in CENS coincides with a growing interest in the world in complexity and our research is clearly at the frontier of science. Indeed, the study of complex systems investigates collective properties of processes in systems, which are intrinsically nonlinear. While the origins of complexity lie in nonlinear dynamics and physics, today's complexity research is spreading into the medical, economic, and social sciences, as well as into key theories and enabling technologies of the artificial world. The studies listed above formed an excellent basis for complexity studies, and CENS has used this basis to develop its structure and topics in a flexible way. In 2008, CENS was reorganised and includes now three larger units: besides DMAM also the Department of Control Systems (DCS) of the Institute of Cybernetics and the Laboratory of Proactive Technologies (LPT) of TUT. There are now three subunits within DMAM beside its main body: the Laboratory of Photoelasticity, the Laboratory of Systems Biology and the Laboratory of Wave Engineering. The new topics and structures provide better synergy between analysis, synthesis and control. The main spearheads of research from 2008 on are: nonlinear dynamics and complex systems, proactivity and situation awareness, and complex nonlinear control systems. CENS is also the leading centre in Estonia for the EU's Complexity-NET, which unites efforts of 11 European countries.

CENS is an international node of research. For example in 2008, out of around 50 researchers in CENS, 17 were from abroad, representing 12 different countries. Presently CENS has about 30 graduate students, including 3 PhD students and 5 post-docs from abroad. The number of international grants and projects is growing. As one of those projects, the Marie Curie Transfer of Knowledge Development Scheme CENS-CMA (Cooperation of Estonian and Norwegian Scientific Centres within Mathematics and its Applications) linked CENS to the Centre of Mathematics for Applications (CMA) at the University of Oslo, to be described in some detail below. Centres within Mathematics and its from CENS to work in Oslo and foreign researchers not only from Norway but from other countries to work in Tallinn (for periods from 3 months to 2 years). So the CENS-CMA fellows in Tallinn Other projects like the EU Research and Training Network SEAMOCS and a Wellcome Trust grant, etc., have also enhanced the capacity of CENS considerably.

Where do we stand now? Have we followed the main goals formulated at the launching of CENS? Yes, we are well placed according to the international standards in research such as cell energetics, mechanisms of interaction, solitons and turbulent diffusion, analysis of phase-transformation fronts and photoelastic tomography, just to list some results. Several applications are important for Estonia, let it be warnings to diminish the influence of waves from fast ferries in Tallinn Bay, the analysis of risks in financial time series, advice to cardiologists to understand the heart rate variability and the explanation of the influence of microwaves on the nervous system, the optimization of piano scales, etc. We have many graduate students, even though in CENS there is no direct obligation for teaching. The many international and national meetings organised by CENS follow the best practice of research communication. The dissemination of results to the wider public is constantly improving, for example the story of CENS is described in a booklet "The Beauty of a Complex World"(in Estonian), which has been distributed to all Estonian high schools. All that is a result of the good research climate in CENS.

There should always be a look forward. The new ideas for the next decade include linking mesoscopic physics to continuum mechanics, the analysis of emergent behaviour in pervasive computing systems, the unification of discrete- and continuous-time control systems, enlarging

the range of applications of the analysis of time-series using physical methods in various fields of sciences, determining optimal ship routes based on the analysis of oil pollution transport, and so on (for more details, see our Annual Report 2008). All these studies are spiced with nonlinearity, emergence, irreversibility and multilevel approaches over space and time scales. These core complexity studies are carried on in CENS despite the small size of the scientific community in Estonia. By placing ourselves into the large European Research Area, we can overcome the problems of critical mass, and make CENS an international node of complexity studies.

Returning to the starting years of the Institute of Cybernetics, the attitude towards research was set up by Nikolai Alumäe: "Take a difficult problem to solve, then you have something to think about. And if you think then you are a happy person". These ideas have been followed and in 2009 CENS is full of happy people including many young researchers.

2. The CENS–CMA Project

Brief Summary

The aim of the CENS-CMA project is aptly summarized by its full title: "Cooperation of Estonian and Norwegian Scientific Centers within Mathematics and its Applications". The Centre for Nonlinear Studies (CENS) was founded in 1999 within the Institute of Cybernetics at Tallinn University of Technology as an umbrella for the scientific potential in Estonia engaged in interdisciplinary studies of complex nonlinear processes. The Centre of Mathematics for Applications (CMA) at the University of Oslo in Norway was established in 2003 as an international research centre in mathematics, with emphasis on problems arising from modern scientific computing.

Apart from the large number of peer-reviewed publications authored during the project, for more in-depth scientific information we also gladly refer to the upcoming volume "Applied Wave Mathematics - Selected Topics in Solids, Fluids, and Mathematical Methods", to be published by Springer, as an outcome of the project. The book contains twelve tutorials intended for non-specialist researchers and students, written by CENS and CMA scientists and visiting project fellows, to highlight the importance of applied mathematics in the studies of wave phenomena.

A total of 130.5 researcher months were realized as fellowships: 9 outgoing fellows (7 seniors and 2 Post Docs) were sent from Tallinn to Oslo. In total 12 incoming fellows were recruited for stays in Tallinn: 5 seniors from Norway, Hungary, Germany, Australia, and Ukraine, and 7 experienced researchers from the USA, Germany (2), Norway, France, UK, and Russia.

Apart from project fellowships that complemented established CENS research activities, thus strengthening existing and creating new international ties, there was also very significant impact through project fellows that contributed to the development of two new research groups at CENS in synergy with national and other EU initiatives: the Laboratory of Systems Biology and the Wave Engineering Laboratory.

Another major goal of the project was to further develop the skills in obtaining international research funding, and specifically to help define and start a new international research project with a broad partner consortium under the leadership of CENS. The latter goal was achieved through a successful application to the EC-sponsored BONUS-169 initiative. The

project BalticWay (The potential of currents for environmental management of the Baltic Sea maritime industry) started in January 2009, as one of only 16 chosen from 149 applications. BalticWay has 8 partners from 5 Baltic Sea countries, and it is being coordinated by the new Wave Engineering group of CENS, making it the only one of the 16 BONUS projects to be led by a team from the new member states.

Research results where presented at international conferences both in Europe (for example in Bulgaria, Finland, France, Germany, Greece, Lithuania, Malta, Poland, Portugal, Sweden, Switzerland, UK, and Ukraine) and beyond (for example Australia, Hong Kong, India, New Zealand, USA). Project fellows also contributed to stands and presentations at large-scale EC events.

Two international summer schools (with approximately 50 participants each) were held in Tallinn (in July 2006 "Application of 3D Shapes", in cooperation with the IST Network of Excellence in shape modelling AIM@SHAPE, and in August/September 2007 "Waves and Coastal Processes", in collaboration with the SEAMOCS Marie Curie Research and Training Network. In addition two large-scale field experiments in Tallinn Bay on the environmental impact of fast ferry waves were initialized, one held in June/July 2008. The next one was held in June 2009, with participants from 9 different countries, including Australia, and Trinidad and Tobago, including several former project fellows.

The work of some of the fellows was covered in newspaper articles; fellows gave public lectures, and the summer school on coastal processes was covered in a 15-minute feature of the popular science program "Bionina"of the Estonian national broadcasting company ETV (a version with English subtitles can be requested from the Wave Engineering Lab).

List of keywords

applied wave mathematics; waves in inhomogeneous solids; deformation waves; acoustodiagnostics; nonlinear acoustics; turbulent compressible flows; fractality; solitons; Korteweg-de Vries equations; Boussinesq equations; Kadomtsev-Petviashvili equarions; pseudospectral method; discrete spectral analysis; finite element methods for wave equations of Maxwell type; scalar conservation laws with spatially discontinuous flux functions; mesoscopic theory; internal variables; non-equilibrium thermodynamics; liquid chrystals; ferrofluids; twist waves; systems biology; diffusion in cardiac muscle cells; energetic parameters in cardiomyocytes; waves in fluids; wave engineering; waves and coastal processes; long ship waves; shallow water bodies; measurement of ship-induced waves; numerical modelling of ship waves; waves from high-speed vessels; long sea wave runup; reducing coastal pollution by a proper choice of the fairway; environmental management of the Baltic Sea; semi-persistent sub-surface current patterns; current-induced pollution propagation; BONUS project BalticWay; SEAMOCS RTN project; shape modelling; geometric design, computer-aided design (CAD); geometric modelling; AIM@SHAPE NoE project; SAGA ITN project; applications of 3D shapes; industrial challenges workshops.

Web sites

CENS web site: http://cens.ioc.ee;
CMA web site: http://www.cma.uio.no;
Laboratory of Systems Biology at CENS: http://sysbio.ioc.ee;
Wave Engineering Laboratory at CENS: http://cens.ioc.ee/cens/research-teams/waves-in-fluids;
The BalticWay BONUS project:
http://www.bonusportal.org/research_projects/research_projects/balticway/;
The book "Applied Wave Mathematics – Selected Topics in Solids, Fluids, and Mathematical Methods": http://www.springer.com/math/dyn.+systems/book/978-3-642-00584-8.

Project achievements Scientific and technological highlights
The scientific contributions in the project through the work of incoming and outgoing fellows can be split into three different categories: (i) complementing established CENS research activities; (ii) contribution to the development of a recently established research group, the Laboratory of Systems Biology, led by Marko Vendelin; (iii) initializing a whole new research group, the Wave Engineering Laboratory, led by Tarmo Soomere; the latter two in synergy with national, EU and other funding initiatives.
(i) Obviously most outgoing fellows contributed here through their work at the partner institution CMA in Oslo, strengthening existing ties and generating new ones with members of CMA and the whole Norwegian scientific community. Their research covered established topics of strong interest for CENS, such as waves in inhomogeneous materials, solitons as solutions of nonlinear partial differential equations, acoustodiagnostics, nonlinear acoustics, turbulent compressible flows, and fractality. Contributors here were also the incoming senior fellows O.Chechkin (Ukraine, turbulent fluids), P.Van (Hungary, mesoscopic thermodynamics), C.Papenfuss (Germany, internal variables in mesoscopic theory) and the incoming Post Doc fellows H.Herrmann (Germany, waves in mesoscopic continuum physics) and A.Fischer (Germany, complex microstructured materials). Among the numerous papers produced by project fellows, one could highlight one that originated by collaboration in Tallinn, namely "Internal variables and dynamic degrees of freedom"by P.Van (incoming fellow), A.Berezovski (outgoing fellow), J.Engelbrecht (scientist-in-charge) in the Journal of Non-Equilibrium Thermodynamics, 33/3, 2008, 235–254. According to the publisher's online statistics, incorporating articles going back more than 10 years, this paper belongs to the 20 most downloaded articles of this eminent journal, currently ranked at No. 13.
(ii) Following a personal Intra-European Marie Curie fellowship and re-integration grant, M.Vendelin established the Systems Biology Laboratory at CENS in August 2007 with funds from a Wellcome Trust grant and the Estonian Ministry of Education and Research. The CENS-CMA project supported this effort through three fellowships, as well as travel funds and the purchase of experimental equipment. P.Peterson was a senior fellow in Oslo, while H.Renay (recruited from the USA, diffusion in cardiac muscle cells) and N. Béraud (France, energetic parameters in cardiomyocytes) stayed as Post Docs in Tallinn, and had the opportunity to present their achievements to the scientific community at major conferences in the subject area, namely the Annual Biophysical Meetings in the USA in 2007 and 2009, respectively.
(iii) Coastal engineering was not studied for decades in Estonia because of a soviet policy that considered the coasts military territory that had to be closed to civilians as much as possible. Consequently no research and education in this field was considered necessary for Estonians. Starting from zero after the re-establishment of independence in 1991, it became one of the tasks for CENS to rebuild coastal engineering knowledge, research and education in Estonia. While waves in fluids had been studied at CENS for a decade already, it became now possible to combine national funding, PhD fellowships funded by the Marie Curie Research Training Network SEAMOCS (Applied Stochastic Models for Ocean Engineering, Climate and Safe Transportation), and fellowships for experienced and senior researchers from the CENS-CMA project to give this activity a real boost, finally resulting in establishing the Wave Engineering Laboratory as a new research unit of CENS in January 2009. The CENS-CMA project provided an outgoing senior fellowship for T.Soomere, now leader of the new lab, for a total of 12 months, an incoming senior fellowship for K.Parnell (recruited from Australia, measurement of ship-induced waves), incoming Post Doc fellowships for T.Torsvik (Norway, modelling of ship waves) and T.Dolphin (recruited from UK, measurement of ship-induced waves). An experienced researcher, D.Kurennoy (Russia), was recruited as a PhD student to work on wake properties of high-speed ferries. He is expected to obtain his PhD from Tallinn University of Technology later in 2009. The incoming senior fellow E.Quak (also CMA, recruited from Nor-

way, geometric modelling) also contributed to setting up the new lab. The knowledge and activities of the incoming fellows were vital for successfully carrying out two large-scale field experiments in Tallinn Bay on the environmental impact of fast ferry waves, one held in June/July 2008 (for an overview see the paper K.Parnell et al., "Far-field vessel wakes in Tallinn Bay", Estonian Journal of Engineering 14, 273-302). The next one was held in June 2009, with participants from 9 different countries, including Australia, and Trinidad and Tobago, and several former project fellows contributing again. The CENS-CMA project also sponsored several trips to present results of the work in waves in fluids, and contributed to the purchase of important equipment.

The count of project-related peer-reviewed publications is currently at 61, with some still submitted or in preparation. For additional in-depth scientific information, we gladly refer to the upcoming book "Applied Wave Mathematics – Selected Topics in Solids, Fluids, and Mathematical Methods", edited by the project fellows E.Quak and T.Soomere, to appear at Springer in September 2009, as an outcome of the project. The book contains twelve tutorials intended for non-specialist researchers and students, written by CENS and CMA scientists and visiting project fellows, to highlight the importance of applied mathematics in the studies of wave phenomena.

Communicating the results to the scientific community, students and young researchers, as well as the general public, was a specific goal of the project right from the start. Research results where presented at international conferences both in Europe (for example in Bulgaria, Finland, France, Germany, Greece, Lithuania, Malta, Poland, Portugal, Sweden, Switzerland, UK and Ukraine) and beyond (for example Australia, Hong Kong, India, New Zealand, USA). Project fellows also contributed to stands and presentations at large-scale EC events such as the conference Communicating European Research (CER 2005) in Brussels and the EU IST Event 2006 in Helsinki.

Two international summer schools (with approximately 50 participants each) were held in Tallinn: in July 2006 "Application of 3D Shapes", organized by project fellow E.Quak, in cooperation with the IST Network of Excellence in shape modelling AIM@SHAPE (http://www.aimatshape.net), and in August/September 2007 "Waves and Coastal Processes", organized by project fellow T.Soomere, in collaboration with the SEAMOCS RTN.

It certainly helped the general publicity of the project that T.Soomere was staying as a project fellow in Oslo when he was elected "Estonia's Person of the Year 2005"by the major Estonian newspaper "Postimees"for predicting, warning against and later explaining the effects of the storm Gudrun, one of the severest storms in the Baltic Sea area in recent history. Apart from that, the work of some of the fellows was covered in newspaper articles; fellows gave public lectures, and the summer school on coastal processes was covered in a 15-minute feature of the popular science program "Bionina"of the Estonian national broadcasting company ETV (a version with English subtitles can be requested from the Wave Engineering Lab). Other activities included an invited lecture on best project practices at the official launch conference for FP7 in Estonia, an interview for the Norwegian Research Council's newsletter on EU research opportunities, and the initiation of a cooperation of Estonia and Norway concerning the International Physics Olympiads for school children.

Teaching and training activities

The CENS team in Tallinn and its training partner CMA in Oslo held regular meetings for networking, transfer of knowledge and coordination of the project activities. The first such CENS-CMA seminar was actually already held in Tallinn in 2004 as part of the joint preparation of the CENS-CMA project proposal. The second CENS-CMA seminar was held in Oslo in May 2005 and marked the project launch, with a project overview presentation, and scientific presentations by CENS members, and representatives of CMA and its partner institution for industrial appli-

cations, the Norwegian applied research institute SINTEF (www.sintef.no). The meeting was scheduled to include the attendance of the Abel Prize Ceremony (http://www.abelprisen.no/en/), where the 3rd Abel Prize was awarded to the applied mathematician Peter Lax, and the Abel Prize Lectures to honour the laureate. The third CENS-CMA seminar in Tallinn in May 2006 featured lectures for students of Tallinn University of Technology, given by G.Pedersen (Oslo), E.Quak (incoming project fellow) and T.Soomere (outgoing project fellow). The fourth CENS-CMA event, the workshop "Applied Wave Mathematics", was held in Palmse (Estonia) in October 2007, attended by 16 members of the CENS and CMA teams (including 8 project fellows) and about the same number of foreign visitors. It featured 6 scientific presentations by members of CENS and CMA (including 2 project fellows) and by visitors from France and Russia, as well as a project assessment by the Steering Committee and a presentation on Marie Curie project opportunities in FP7 by the attending EC Scientific Officer Dr. Marcela Groholova, who also interviewed some of the project fellows present about their experiences in the project. The event thus served as a midterm project review, and also as a concertation meeting with the SEAMOCS Marie Curie Research and Training Network, in which CENS is also involved, and which held its midterm meeting and a workshop "Waves and Wave Climate Changes"at the same venue right before our meeting. With the remaining course of the project set after this review meeting, no formal CENS-CMA seminars were organized in the remaining 18 months of the project, yet networking and steering activities continued through personal meetings in Oslo and Tallinn.

It goes without saying that the project fellows contributed regularly to the official seminar lecture series at CENS and CMA, respectively. Both the new CENS research groups, the Systems Biology Lab and the Wave Engineering Lab, have now also established their own seminar series intended for students, to which the incoming project fellows have contributed. Even before the Systems Biology Lab was formally established, the fellows Renay, Herrmann and Quak contributed presentations in 2006 to the graduate student seminar "Statistical Thermodynamics of Nonequilibrium Processes". The wave engineering group started its series of seminars for students in coastal engineering in autumn 2007, with incoming fellows Parnell, Dolphin, Torsvik, Kurennoy, Herrmann and Quak contributing. As a research event, a project workshop "Thermodynamics of Slow and Fast Dynamical Processes"was held at CENS in March 2007, again with several incoming and outgoing fellows contributing, organized by the incoming fellows Papenfuss and Herrmann.

The already mentioned volume "Applied Wave Mathematics - Selected Topics in Solids, Fluids, and Mathematical Methods", edited by the project fellows E.Quak and T.Soomere, to appear at Springer in September 2009, is intended to provide educational material for seminars and lectures. The contributors are the fellows A.Berezovski (Waves in inhomogeneous solids), A.Ravasoo (The perturbation technique for wave interaction in prestressed material), C.Papenfuss (Dynamics of internal variables from the mesoscopic background for the example of liquid chrystals and ferrofluids), H.Herrmann (Towards a description of twist waves in mesoscopic continuum physics), P.Van (Weakly nonlocal non-equilibrium thermodynamics – variational principles and second law), T.Soomere (Long ship waves in shallow water bodies), T.Torsvik (Modelling of ship waves from high-speed vessels), and A.Salupere (The pseudospectral method and discrete spectral analysis); the CMA members Snorre Christiansen (Foundations of finite element methods for wave equations of Maxwell type) and Nils Henrik Risebro (An introduction to the theory of scalar conservation laws with spatially discontinuous flux functions); the CENS member (and former SEAMOCS fellow) I.Didenkulova (New trends in the analytical theory of long sea wave runup), and the project's scientist-in-charge J.Engelbrecht (Deformation waves in solids).

The original project plan foresaw – besides the Estonian-Norwegian project workshops – at least one summer school as a major project event in research training. Finally the project

(through the activities of project fellows and the use of relevant training funds) contributed strongly to four such training events. Two international summer schools (with approximately 50 participants each) were held in Tallinn: in July 2006 "Application of 3D Shapes", organized by project fellow E.Quak, in cooperation with the IST Network of Excellence in shape modelling AIM@SHAPE (http://www.aimatshape.net/event/tallinn06-ss/), and in August/September 2007 "Waves and Coastal Processes", organized by project fellow T.Soomere, in collaboration with the SEAMOCS RTN. In addition two large-scale field experiments in Tallinn Bay on the environmental impact of fast ferry waves were initialized, one held in June/July 2008, and one after the project end in June 2009, with participants from 9 different countries, including Australia, and Trinidad and Tobago, involving several former project fellows.

Apart from application-related international invited speakers from a large variety of countries who were invited for the school events and experiments, the project also organized some individual lecture series, most prominently by: Thomas Grandine, the leader of the geometry team in the Mathematics and Engineering Analysis Group of the Boeing Company (USA), and Peter Deuflhard (Germany), the head of the Zuse Institut Berlin for Scientific Computing and co-founder of the research centre MATHEON-Mathematics for Key Technologies.

Another important aspect of the project considered management training for CENS. The outgoing project fellows were able to experience first-hand the administrative structures and procedures at CMA in Oslo. This will be beneficial for at least two of them, who have since taken up new administrative duties: T.Soomere as leader of the new unit Wave Engineering Laboratory since January 2009, and A.Salupere, who was elected as the new Director of the Institute of Cybernetics from June 2009.

The fellows in Tallinn and local personnel contributed to several project proposals, with quite some success, as the following examples show. The two incoming fellows eligible for FP7 re-integration grants because of their longer fellowships, namely E.Quak (24 months) and H.Herrmann (18 months), both were successful in getting them. H.Herrmann secured a Feodor Lynen Fellowship from the German Alexander von Humboldt Foundation to stay at CENS for at least two more years, and the CENS-CMA fellow T.Torsvik and the SEAMOCS fellow I.Didenkulova secured a European Economic Area (EEA) networking grant involving Estonia, Norway & Russia. A major project goal concerning the transfer of management knowledge was in fact to put CENS in a position to not just participate, but actually to lead a major European research effort. The successful achievement of that goal is addressed below in more detail.

Transfer of Knowledge

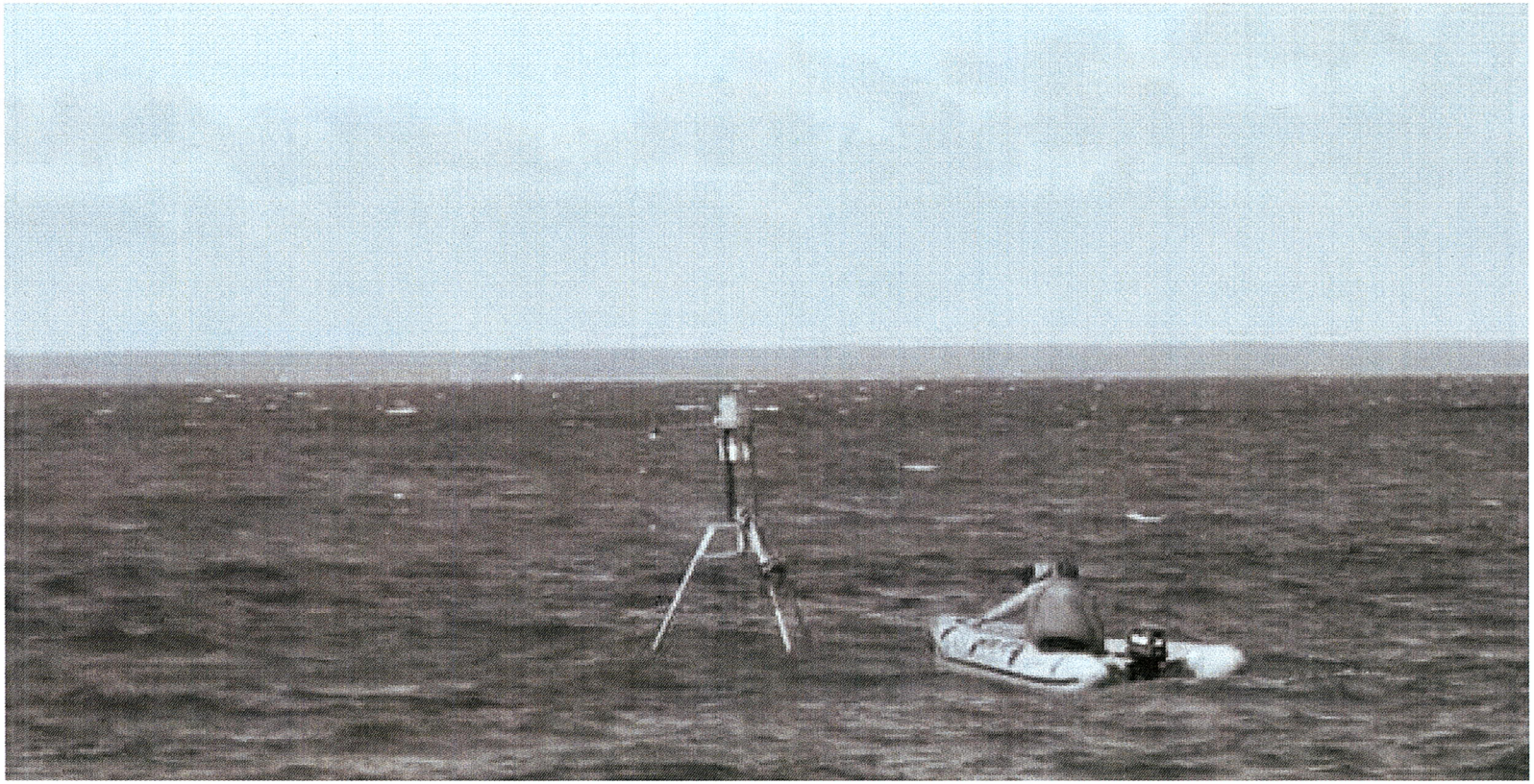
As the knowledge transfer activities between CENS and CMA, and the scientific community as a whole, have been addressed before, we will here give a summary of industry-related activities. The senior incoming fellow E.Quak, recruited from the Norwegian applied research institute SINTEF, was asked to address these issues specifically, also after his fellowship was over when he stayed on at CENS, taking over a managing role for the project in its final year to ensure its successful conclusion.

- Together with the training partner CMA in Oslo, CENS now sponsors an annual series of workshops on industry challenges in Geometric Modelling, Computer-Aided Design, and Simulation, held annually in Darmstadt, Germany, co-organized with Darmstadt University of Technology and the Fraunhofer Institute for Computer Graphics;
- The 2006 summer school "Applications on 3D Shapes"– in collaboration with the FP6 Network of Excellence AIM@SHAPE – focussed on practical applications;
- The 2007 summer school "Waves and Coastal Processes"– in collaboration with the RTN SEAMOCS – emphasized practical coastal engineering topics;

- Contribution to exhibition stands on shape modelling issues at the EU conferences “Communicating European Research (CER) 2005”in Brussels, Belgium, November 2005 and the “IST Event 2006”in Helsinki, Finland, November 2006;
- Organization of an industry challenges minisymposium at the European Conference on Mathematics for Industry (ECMI), in Madrid, Spain, July 2006;
- Organization of an eScience collaboration tool minisymposium at the 6th International Congress on Industrial and Applied Mathematics (ICIAM), in Zurich, Switzerland, July 2007;
- Organization of a forward looking session on industrial problems at the 10th SIAM (Society for Industrial and Applied Mathematics) Conference on Geometric Design and Computing, in San Antonio, Texas, USA, in November 2007;
- A foresight paper “Design for Change”by E.Quak and J.Gravesen (Technical University of Denmark) on future developments in the Computer-Aided Design (CAD) industry, published in the April 2008 issue of SIAM News, the newsletter of SIAM (Society for Industrial and Applied Mathematics), circulated to its ca. 12 000 members;
- A new CAD-related FP7 Initial training Network SAGA (http://www.saga-project.eu), in which CMA is a partner and to which CENS is also contributing, has two industrial partners from France (Missler Software) and Norway (Kongsberg SIM);
- Invited lecture series on industry-related problems (by T.Grandine (Boeing) and P.Deuflhard (ZIB), see also above);
- In Norway, the certification company Det Norske Veritas (DNV) is a collaboration partner, especially through the RTN SEAMOCS of which CENS is also a part;
- An article “Right fairway may reduce coastal pollution”by T.Soomere for the professional shipping community journal “Scandinavian Shipping Gazette”;
- The new BalticWay project is targeted at industrial problems and includes LDI (Laser Diagnostics Instruments) as an SME from Estonia among its partners;
- T.Soomere and the Wave Engineering Lab have recently taken on a substantial role in the Estonian response team concerning the construction of the Nordstream pipeline in the Baltic Sea.

Future research projects: The outgoing fellows from CENS are collaborating back in Tallinn, anyway. As described before, the incoming fellows had a big role in planning

- New field experiments;
- The BONUS project BalticWay;
- An EEA networking project linking Norway, Estonia and Russia;
- A Humboldt Foundation Feodor Lynen Fellowship;
- 2 FP7 reintegration grants.



CENS-CMA

As the Estonian coastline continues to attract more tourists, increasing numbers of scientists are trying to understand its complex environment. The country's coastline represents a new frontier in scientific research, being the focus of several new collaborations. A Marie Curie-sponsored project between the Centre for Nonlinear Studies in Tallinn and the Centre of Mathematics for Applications in Oslo is taking forward the science of coastal engineering.

Coastal research on the crest of a wave

The extensive Estonian coastline is home to more than a thousand islands, many of which host nature reserves and draw in visitors from all over the world. Understanding the impact of construction in the coastal zone and of heavy shipping traffic is crucial for the preservation of the region's natural resources and for ensuring that efforts to develop the area are sustainable. Little is known of the region's particular coastal environment because, in the past, Soviet policy kept civilians from accessing the coastline for military reasons. For decades, coastal research and education were discouraged, and science stagnated.

When Estonia regained its independence in 1991, researchers got back to work building a comprehensive knowledge base in an effort to better understand the complex interactions between ship wakes, waves, beach erosion and other factors along Estonia's vast coastlines.

Rebuilding coastal engineering knowledge, research and education is a monumental task, but researchers at the Centre for Nonlinear Studies (CENS), founded in 1999 within the Institute of Cybernetics at Tallinn University of Technology, took up the challenge.

Internationalising wave science

Supported by a Marie Curie Transfer of Knowledge scheme, CENS joined forces with the University of Oslo's Centre of Mathematics for Applications (CMA) in Norway for a research programme in applied wave mathematics.

The Transfer of Knowledge scheme financially supported visiting Fellows' extended research stays at both CENS in Tallinn and the CMA in Oslo. These fellowships could last anywhere between two months and two years, and were granted to either 'experienced' researchers (usually postdocs with between 4 and 9 years of research experience) or 'senior' researchers (with 10 years of research experience or more).

At work on the CENS-CMA project

The research visitors provided valuable contributions to CENS and CMA wave studies. The collaborations were characterised by strong teamwork and a readiness to share experience and resources.

Coastal research in the limelight

Research on marine waves and coastal processes became one of the focal points of the CENS-CMA project, covering about one-third of the fellowship months, and resulting in the establishment of the Wave Engineering Laboratory in January 2009.

Dr Tarmo Soomere, a member of the Estonian Academy of Sciences, was one of the first CENS Fellows to study at the CMA in Oslo. During the project he was elected 'Estonia's Person of the Year 2005' by the newspaper *Postimees* for predicting and explaining the effects of the storm Gudrun, one of the most severe storms to hit the Baltic Sea in recent history. The Marie Curie project, he says, opened up the scientific community in Estonia and helped scientists to communicate with the public about their research.

'Longer stays in such centres are an almost mandatory experience for everybody who wishes to be successful in cutting-edge science,' asserts Dr Soomere. 'This is particularly important for the younger generation of researchers who tend to focus on a narrow range of problems or a single object of study.'

The benefits of communicating effectively with the public can be reaped when lead researchers are able to organise research in their own communities, explains Dr Soomere. 'This is exactly my case: *the experience gathered as a CENS-CMA Fellow turned out to be indispensable in launching both the teaching and research of port and coastal engineering in Tallinn,*' he adds, referring to the new Laboratory of Wave Engineering in the Institute of Cybernetics, of which he took on the task of leader.

Good news travels fast ... and far

The project enjoyed the attention of the press: some of the Fellows' work was covered in newspaper articles. Other grant recipients gave public lectures, which were well received, and the partners conducted a summer school on coastal processes.

The school was covered in a 15-minute feature on the popular science television programme *Bionina*, produced by the Estonian national broadcasting company ETV.

The CENS-CMA research collaboration also welcomed scientists from further afield: Dr Kevin Parnell, based at the James Cook University in Australia, spent three months as a Senior Fellow in Tallinn.

'The time I spent at the CENS department in Tallinn enabled me to research vessel wakes and their environmental effects,' says Dr Parnell. *'I was able to foster collaborations in a part of the world where it is uncommon for Australians to conduct research.* I am now applying the knowledge I gained to projects in Australia and New Zealand, where issues related to vessel wakes in confined coastal waters remain. It also led to my undertaking further collaborative projects in Estonia.'

Project acronym ■ **CENS-CMA**
Full project title ■ **Cooperation of Estonian and Norwegian scientific centers within mathematics and its applications**

Type of grant ■ **Transfer of Knowledge**
Budget ■ **EUR 853 333**
Duration of project ■ **01-05-2005 - 30-04-2009**
Scientific discipline ■ **Mathematics**

Lead partner ■ **Tallinn University of Technology**
Centre for Nonlinear Studies (CENS)
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Other partners ■ **Training partner**
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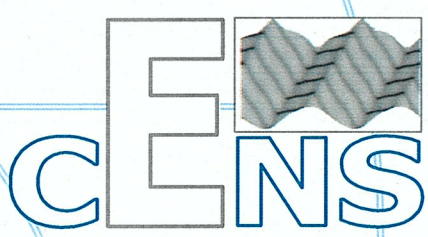
University of Oslo
P.O. Box 1053 Blindern
NO-0316 Oslo
Tel. +47 22 85 58 88
http://www.cma.uio.no

4. Applied Wave Mathematics: Selected Topics in Solids, Fluids, and Mathematical Methods. Eds. ***E.Quak, T.Soomere***, Heidelberg, Springer, 2009, 471 p.

Contents

Founded in 1999, the idea of CENS was to bring under one umbrella the scientific potential of Estonia in interdisciplinary studies of

complex nonlinear processes



Centre for Nonlinear Studies
Institute of Cybernetics
at Tallinn University of Technology
(IoC at TUT)
Akadeemia 21
12618 Tallinn Estonia

Initiators:

Department of Mechanics and Applied Mathematics (IoC at TUT)
Biomedical Engineering Centre (TUT)
Chair of Geometry, Institute of Pure Mathematics (University of Tartu)

Main international programmes/ projects/grants:

ESF NATEMIS
FP6 WIND-CHIME
FP6 SEAMOCS
MC ToK CENS-CMA
EU IST AIM@SHAPE
Complexity-NET
Marie Curie
Wellcome Trust
A.v.Humboldt Foundation
COST

Topics up to 2007:

- nonlinear waves in solids
- nonlinear integrated photoelasticity
- fractality and biophysics
- water waves and coastal engineering
- nonlinear signal processing
- geometric approach

Partners from:

France
Italy
Germany
Hungary
Czech Republic
Norway
Russia

CENS 1999-2009

more information: see Annual Reports at http://cens.ioc.ee

New challenges:

from 2008, CENS expanded the activities beyond **analysis** and will include also the studies in **synthesis** and **control** of complex nonlinear systems

The focal points are:

- complexity of nonlinear wave motion in solids
- complexity of water waves
- complexity in biophysics
- complexity of stress analysis
- fractality in nature
- complexity in software intensive systems
- nonlinear control theory

The units from 2008 on:

Department of Mechanics and Applied Mathematics (IoC at TUT)
- Laboratory of Photoelasticity
- Laboratory of Systems Biology
- Laboratory of Wave Engineering

Department of Control Systems (IoC at TUT)
Laboratory for Proactive Technologies (TUT)

International Advisory Board:

R.Grimshaw (UK)
G.A.Maugin (France)
H.K.Moffatt (UK)
G.Nicolis (Belgium)
F.Pastrone (Italy)
G.Stepan (Hungary)
V.Saks (France/Estonia)
D.van Campen (the Netherlands)

In 2003-2007 CENS was acknowledged as an Estonian Centre of Excellence in Research

Best results up to 2007 – see overleaf

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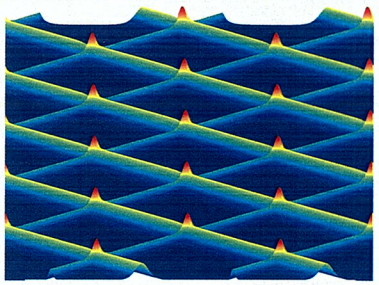
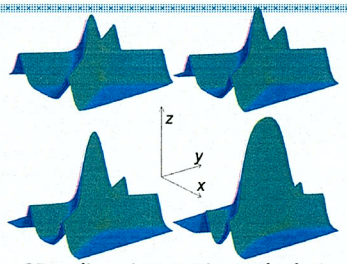
Best results up to 2007 place CENS to the frontier of science:

Nonlinear waves in microstructured material

- a novel approach to calculating the stress-driven phase-transitions fronts based on elaborated thermodynamically consistent finite volume method
- hierarchical mathematical models for describing the wave propagation in micro-structured materials (FGMs, composites, granular materials)



Interaction of single solitons



2D soliton interaction calculations

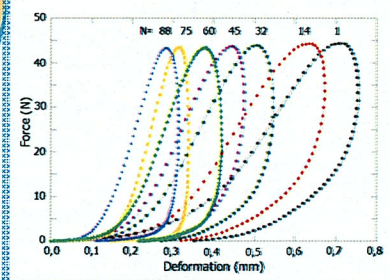
Solitons & water waves

- mechanisms of soliton emergence for complicated dispersion and long-time behaviour with establishing the patterns of trajectories
- properties of interaction for surface waves in shallow water, with possible application to extreme waves, and experiments with ship wake waves

Nonlinear integrated photoelasticity

- method of photoelastic tomography for 3D stress analysis in transparent specimens

Stresses in an optical fibre preform



Dynamics of piano hammers

- novel mathematical model for the impact of piano hammers and spectral analysis of strings

Force-compression characteristics for a set of piano hammers

Acoustodiagnostic method of non-destructive testing

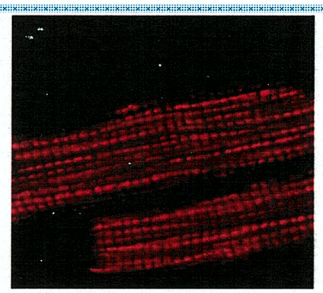
- algorithms for nonlinear acoustodiagnostics for stress analysis and NDT of material properties

Analysis of physiological signals

- microwave effects on EEG established with special attention to low-level radiation on human alpha and theta rhythms

Geometric approach

- methods of mathematical physics derived by using the tensor representations of linear groups and the universal structure of jet space



Representative confocal image of cardiomyocytes labelled with Mitotracter red

Cell energetics & cardiac mechanics

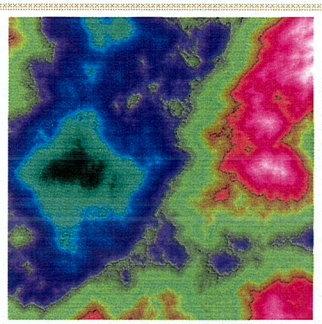
- novel mathematical models for cardiac contraction and related cell energetics with testing in Grenoble, Paris and Tallinn have resulted in molecular cell energetics – a new field in biocomplexity

Fractality of time series

- theoretical explanation of the multi-fractality of the passive scalar field in smooth chaotic flows
- novel scaling models for the time series of asset prices and stock markets with specific multi-scaling properties

Fractality in nature

- fractal analysis of heart rate variability and the properties of multi-scaling
- fractal analysis of geological landscapes (four-vertex model) and the scaling exponents



The model of gradient-limited surfaces

CENS

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