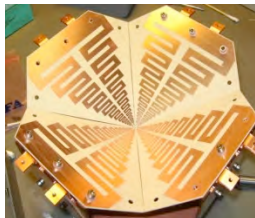


<h1 style="margin: 0;">Final Report of ESoA course: Reflector and Lens Antennas</h1>	Type:
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Gothenburg, Sweden, 5 - 9 December 2011



Coordinator



P.-S. KILDAL (CHALMERS)

Involved institutions



### SUMMARY

The course is divided in five parts:

- Mon: Peter Meincke from TICRA will present design and analysis techniques for reflector antennas. TICRA is recognized as the world-leader of commercial reflector antenna software, which will serve to illustrate the presentation by means of examples.
- Tue: Per-Simon Kildal and Jian Yang will contribute to the course with reflector and feed antenna designs and design methods that have been described in more than 30 journal articles and several patents, by him and his coworkers. The lectures will cover: cylindrical reflector and line feed for EISCAT, small L-band reflector with beam-forming ring feed for satellite terminal, dual reflector feed system for radio telescope in Arecibo, hat feed for radio link antenna, and recent decade bandwidth Eleven feed for radio telescopes and satellite communications.
- Wed: Marianna Ivashina will contribute to the course with antenna designs and design methods that have been described in 30 papers by her and her coworkers. The lectures will cover: design of a wide-band Focal Plane Array (FPA); effects of strong array element coupling on system analysis and optimization; Vivaldi element FPA system as a practical demonstrator of the innovative FPA technology for New Generation Radio Telescopes.
- Thu: Stefano Maci will present high frequency methods used to analyze reflection, diffraction and scattering from reflector antenna surfaces, such as geometrical optics, geometrical theory of diffraction, incremental theory of diffraction, and shadow boundary Integral techniques.
- Fri: Ronan Sauleau will review the lens antenna technologies and applications for millimeter and sub-millimeter wave applications. The lectures will cover: 1) the analysis, the synthesis and the optimization of dielectric focusing systems using HF and full-wave techniques 2) the design of homogeneous / multi-shell, axis-symmetric / arbitrarily-shaped lenses (integrated lens antennas, dielectric lenses, dome antennas).

### Speakers

Name	Organization	Title
Per-Simon Kildal	CHALMERS University of Technology, Sweden	Prof.
Stefano Maci	University of Siena, Italy	Prof.
Peter Meincke	Ticra Commercial Foundation, Denmark	
Marianna Ivashina	CHALMERS University of Technology, Sweden; and The Netherlands Institute for Radio Astronomy (ASTRON)	Dr.
Ronan Sauleau	IETR, Rennes, France	Prof.
Jian Yang	CHALMERS University of Technology	Dr.
Dirk de Villiers	Stellenbosch University (invited)	Dr.
Rob Maaskant	CHALMERS University of Technology (invited)	Dr.

## 1. CVs of Lecturers



Per-Simon Kildal (IEEE M'82-SM'84-F'95) has been Professor at Chalmers University of Technology, Gothenburg, Sweden since 1989. He has authored an antenna textbook, and more than 110 journal articles and letters in IEEE or IET journals. He has designed two very large antennas, including the Gregorian dual-reflector feed of Arecibo radiotelescope. He has invented several reflector antenna feeds that has been used in successful industrial products such as Ericsson's MINILINK. The latest feed invention is the so-called "Eleven antenna" for use in future radio telescopes. He is the originator of the concept of soft and hard surfaces, recently resulting in the gap waveguide, a new low-loss metamaterial-based transmission line advantageous in particular above 30 GHz. His research group has pioneered the reverberation chamber into an accurate measurement tool for antennas and wireless terminals subject to Rayleigh fading, being commercialized in the spinoff company Bluetest AB. Prof Kildal received two best paper awards for articles published in the IEEE Transaction on Antennas and Propagation, and he is the recipient of the 2011 Distinguished Achievements Award of the IEEE Antennas and Propagation Society.



Dr. Meincke has been with TICRA since 2008, where he has worked on several aspects of reflector antenna analysis. Before joining TICRA, Dr. Meincke served as associate professor at the Technical University of Denmark (DTU), where he was teaching and conducting research in the areas of electromagnetic theory, inverse problems, high-frequency and time-domain scattering, antenna theory, and microwave imaging. In spring and summer of 1998, he was visiting the Center for Electromagnetics Research, Northeastern University, Boston, MA, while holding a Postdoctoral position from DTU. Dr. Meincke won the first prize award in the 1996 IEEE Antennas and Propagation Society Student Paper Contest in Baltimore, MD, for his paper on uniform physical theory of diffraction equivalent edge currents and received the 2000 RWP King Paper Award for his paper "Time-domain version of the physical theory of diffraction" published in IEEE Transactions on Antennas and Propagation, February, 1999.



Jian Yang (M'02-SM'10) received the B.S. degree from the Nanjing University of Science and Technology, Nanjing, China, in 1982, and the M.S. degree from the Nanjing Research Center of Electronic Engineering, Nanjing, China, in 1985, both in electrical engineering, and the Swedish Licentiate and Ph.D. degrees from the Chalmers University of Technology, Gothenburg, Sweden, in 1998 and 2001, respectively.

From 1985 to 1996, he was with the Nanjing Research Institute of Electronics Technology, Nanjing, China, as a Senior Engineer. From 1999 to 2005, he was with the Department of Electromagnetics, Chalmers University of Technology as a Research Engineer. During 2005 and 2006, he was with COMHAT AB as a Senior Engineer. From 2006, he has been an Assistant Professor at the Department of Signals and Systems, Chalmers University of Technology. From 2010, he has been titled as Associate Professor. His research interests include ultra-wideband antennas and UWB feeds for reflector antennas, UWB radar systems, UWB antennas in near-field sensing applications, hat-fed antennas, reflector antennas, radome design, and computational electromagnetics.



Dr. Marianna Ivashina, received her PhD in Electrical Engineering in 2001. From 2001 to 2010, she was with the Netherlands Institute for Radio Astronomy (ASTRON) and since 2011, she is a senior antenna scientist at Onsala Space Observatory (Chalmers). Her main research interests are (i) antenna systems including phased array feeds (PAFs) and UWB single pixel feeds for reflector antennas; (ii) methods for the analysis and optimization of the overall antenna-receiver system. She has published over 70 international journal and conference papers, and received 12 scientific distinctions and paper awards. The results of her PAF research have led to novel technology antenna systems (APERTIF and ASKAP). Accordingly, she was involved in the development of APERTIF during 2008-2010, acted as an external reviewer at the Preliminary Design Review of the Australian SKA Pathfinder ASKAP in 2009, and has been as a *Guest Editor for the IEEE Transactions on Antennas and Propagation*.



**Stefano MACI** (S 98, F 2004) received his laurea degree (cum laude) in Electronic Engineering from the University of Florence, Italy. Since '98 he is with the University of Siena (UNISI), Italy, where he presently is a Full Professor. At UNISI, he is the Director of the PhD School of Engineering, head of the Laboratory of Electromagnetic Applications (LEA), Faculty representative of the International Affair Board, and member nominated by the Rector of the Board for the UNISI Research Program. His research interests include EM theory, antennas, high-frequency methods, computational electromagnetics, and metamaterials. He was a co-author of an Incremental Theory of Diffraction for the description of a wide class of electromagnetic scattering phenomena at high frequency, and of a diffraction theory for the analysis of large truncated periodic structures. He was responsible and international coordinator of several research projects funded by the European Union (EU), by the European Space Agency (ESA-ESTEC), by the European Defence Agency, and by various European industries. He was the founder and presently is the Director of the European School of Antennas (ESoA), a post-graduate school that comprises 30 courses on antennas, propagation, and EM modelling through 150 teachers coming from 30 European research centres. He is member of the Finmeccanica

Stefano Maci was Associate Editor of IEEE Transactions on EMC, two times Guest Editor of IEEE Transaction on Antennas and Propagation (IEEE-TAP), Associate Editor of IEEE-TAP. He is presently a member of the IEEE AP-Society AdCom, a member of the Board of Directors of the European Association on Antennas and Propagation (EuRAAP), a member of the Executive Team of the IET Antennas and Propagation Network, a member of the Technical Advisory Board of the URSI Commission B, a member of the Italian Society of Electromagnetism. He was recipient of several national and international prizes and best paper awards, and he is principal author or co-author of 110 papers published in international journals, (among which 70 on IEEE journals), 10 book chapters, and about 350 papers in proceedings of international conferences.



**Ronan Sauleau** (M'04–SM'06) graduated in electrical engineering and radio communications from the Institut National des Sciences Appliquées, Rennes, France, in 1995. He received the Agrégation degree from the Ecole Normale Supérieure de Cachan, France, in 1996, and the Doctoral degree in signal processing and telecommunications and the “Habilitation à Diriger des Recherches” degree from the University of Rennes 1, France, in 1999 and 2005, respectively.

He was an Assistant Professor and Associate Professor at the University of Rennes 1, between September 2000 and November 2005, and between

December 2005 and October 2009. He has been a full Professor in the same University since November 2009. His current research fields are numerical modelling (mainly FDTD), millimeter-wave printed and reconfigurable (MEMS) antennas, lens-based focusing devices, periodic and non-periodic structures (electromagnetic bandgap materials, metamaterials, reflectarrays, and transmitarrays) and biological effects of millimeter waves. He has received seven patents and is the author or coauthor of more than 110 journal papers and more than 240 publications in international conferences. Prof. Sauleau received the 2004 ISAP Conference Young Researcher Scientist Fellowship (Japan) and the first Young Researcher Prize in Brittany, France, in 2001 for his research work on gain-enhanced Fabry-Perot antennas. In September 2007, he was elevated to Junior member of the "Institut Universitaire de France". He was awarded the Bronze medal by CNRS in 2008.



Dirk de Villiers received the B.Eng and Ph.D. degrees in electrical and electronic engineering from the University of Stellenbosch, Stellenbosch, South Africa in 2004 and 2007 respectively. During 2005 to 2007 he spent several months as visiting researcher at the University of Antwerp in Antwerp, Belgium.

From 2008 to 2009 he was a post-doctoral fellow at the University of Stellenbosch working on antenna feeds for the South African SKA program. He is currently a senior lecturer at the University of Stellenbosch, and his main research interests include reflector antennas as well as the design of wideband microwave components.



Rob Maaskant was born in the Netherlands on April, 14th, 1978. He received his MSc degree (*cum laude*) in 2003, and his PhD degree (*cum laude*) in 2010, both in Electrical Engineering from the Eindhoven University of Technology. From 2003-2010 he was employed as an antenna research scientist at the Netherlands Institute of Radio Astronomy (ASTRON). He is currently a postdoctoral researcher at the Chalmers University of Technology, Sweden, for which he received a Rubicon postdoctoral fellowship from the Netherlands Organization for Scientific Research (NWO). He won the 2nd best paper prize (best team contribution) at the 2008 ESA/ESTEC workshop, Noordwijk, and has been awarded the prestigious prize of the best PhD project in 2010 of the TU/e Electrical Engineering Department. His PhD has resulted in 13 journal papers, 18 conference papers, and he is holder of 5 patents or patent applications. He is the primary author of the CAESAR software; an advanced integral-equation based solver for the analysis of large antenna array systems, which is currently being used by several international research institutions. He has also received the prestigious "Young Researcher" grant from the Swedish Research Council (VR) in 2011.

He is currently a postdoctoral researcher at the Chalmers University of Technology, Sweden, for which he received a Rubicon postdoctoral fellowship from the Netherlands Organization for Scientific Research (NWO). He won the 2nd best paper prize (best team contribution) at the 2008 ESA/ESTEC workshop, Noordwijk, and has been awarded the prestigious prize of the best PhD project in 2010 of the TU/e Electrical Engineering Department. His PhD has resulted in 13 journal papers, 18 conference papers, and he is holder of 5 patents or patent applications. He is the primary author of the CAESAR software; an advanced integral-equation based solver for the analysis of large antenna array systems, which is currently being used by several international research institutions. He has also received the prestigious "Young Researcher" grant from the Swedish Research Council (VR) in 2011.

## 2. Lecture program

The lecture program is given below.

Day	Monday	Tuesday	Wednesday	Thursday	Friday
08:30 – 10:00	Peter Meincke Ticra	Per-Simon Kildal Chalmers	Marianna Ivashina Chalmers	Stefano Maci UNISI	Ronan Sauleau IETR
10:00 – 10:30	Coffee break				
10:30 – 12:15	Peter Meincke Ticra	Per-Simon Kildal Chalmers	Marianna Ivashina Chalmers	Stefano Maci UNISI	Ronan Sauleau IETR
12:15 – 13:15	Lunch break at Einstein				
13:15 – 15:00	Peter Meincke Ticra	Jian Yang, Chalmers	Group works	Stefano Maci UNISI	Ronan Sauleau IETR
15:00 – 15:30	Coffee break				
15:30 – 17:00	Peter Meincke Ticra	Discussions	Group works	Stefano Maci UNISI	Ronan Sauleau IETR

Monday: Analysis and design of single and dual reflector antennas (Meincke)

Hour	Topic
08:30 - 09:30	Introduction to reflector antennas
09:30 - 11:00	Analysis methods (PO, PTD, UGTD)
11:00 - 12:15	Radiation from apertures
13:15 - 14:00	Cross polarization in single offset reflectors
14:00 – 15:00	Dual reflectors
15:00 – 17:00	Compensated dual offset reflectors

Tuesday: Large reflector antennas and feeds

Hour	Topic
08:30-12:00	Characterization of large symmetrical paraboloids and feeds (Prof Kildal)
	Characterization of cylindrical and spherical reflector antenna (examples EISCAT VHF and ARECIBO tri-reflector system) (Prof Kildal)
13:15-14:30	Design of multi-port feeds for reflector antennas: Logperiodic (Dr Yang)
	Synthesis and diffraction analysis of feeds for South African MeerKAT radio telescope (invited lecture by Dr Dirk De Villiers)
14:30-15:00	
15:00-17:00	Discussions

Wednesday: Multi-beam focal-plane array feeds. After lunch self study and group works

Hour	Topic
08:30-11:15	Design of Focal Plane Array (FPA) feeds for reflector antennas:
	Beamforming methods for maximum efficiency/sensitivity (Dr Ivashina)
	Effects of strong array element coupling on system analysis (Dr Ivashina)
	Modeling the FPA beams using physics-based basis functions (Dr Ivashina)
11:15-12:15	Analysis of reflector – feed interaction effects (Dr Maaskant)
13:15-14:15	• Self study, read papers about subefficiencies characterizing feeds and reflectors; and effects of strong array element coupling on system analysis
14:15-16:00	Discussions in 2 groups
	• 1 group on subefficiencies of wideband single-beam feeds • 1 group on efficiencies of multi-beam focal plane array feeds.
16:00-17:00	Plenary presentations and discussions

Thursday: Rays and beams

Hour	Topic
09:00-11:00	Part 1: Ray and incremental theories Background, Ray theory, Incremental
11-12 & 13-14:30	Part 2: Beam representations Gaussian beams and complex source, Conical beams
15:00-17:00	Part 3: Multi-reflector systems Domain decomposition, Scattering matrix approach

Friday: Lens antennas

Hour	Topic
08:00-14:45	General introduction: Reflector antennas, Horn antennas & Lenses
	Part 1: Introduction on lens antennas: Lens antenna technologies
	Part 2: Methods of analysis of lens antennas: High-frequency techniques, Decomposition techniques, Numerical techniques, Range of validity of GO/PO
	Part 3: Lens antennas: Basic theory & Applications
	Part 4: Integrated Lens Antennas (ILAs): Fundamentals, Performance (emitting and receiving modes) & Applications
	Part 5: Shaped ILAs Synthesis techniques (3D, nearly-axis symmetric, axis symmetric) & Applications
	Part 6: Optimization of ILAs: Local & global approaches
	Part 7: Advanced topics: Compact lenses, Broadband lenses, Multiple beam lenses, Reconfigurable lenses
	General conclusions
Work group and test	

### 3. Participants and grants



**Fig. 1** Photo of the in Professor Maci's lecture.

**Table X.I Participants**

	Name (first/last)	Organisation	Country	Fee	Submitted exam
	<b>Students:</b>				
1	Thierry Gilles	Royal Military Academy	Belgium	440	
2	Marko Bosiljevac	Zagreb University	Croatia	Grant 440	
3	Yoann Letestu	Radio Frequency Systems	France	1100	1
4	Mehran Pour Mousavi	Institute for Technical Electronics	Germany	440	1
5	Anton Patyuchenko	German Aerospace Center	Germany	440	1
6	Manushanker Balasubramaian	Fraunhofer FHR	Germany	Grant 440	1
7	Heiko Gulan	Karlsruhe Inst of Technology	Germany	440	1
8	Marta Arias-Campo	IMST GmbH	Germany	440	1
9	Andrea Giacomini	SATIMO	Italy	1100	1
10	Iman Vakili	Lund university	Sweden	440	1
11	Per Jacobsson	Arkivator	Sweden	1100	1
12	André Young	Stellenbosch University	South Africa	Grant 440	1
13	Daniel Rodrigo	Universitat Politecnica de Catalunya	Spain	440	1
14	Jose Luis Gomez-Tornero	Universitat Politecnica de Cartagena	Spain	440	1
15	Enrique Nova	Universitat Politècnica de Catalunya	Spain	440	1
16	Anton Somov	Inst of Radio Astronomy - National Academy of Sciences	Ukraine	Grant 440	1
17	Hasan Raza	Chalmers, scholarship holder	Pakistan	grant 440	1
19	Wan-chun Liao	Chalmers, international Master student	Taiwan	grant 440	1
20	Ahmed Hussain	Chalmers	Sweden	440	1
21	Oleg Lupikov	Chalmers	Sweden	440	1
22	Aidin Razavi	Chalmers	Sweden	440	1
	<b>Lecturers:</b>				
1	Jian Yang	Chalmers	Sweden		
2	Per-Simon Kildal	Chalmers	Sweden		
3	Peter Meincke	Ticra	Denmark		
4	Ronan SAULEAU	Rennes	France		
5	Stefano Maci	Siena	Italy		
6	Rob Maaskant	Chalmers	Sweden		
7	Marianna Ivashina	Chalmers	Sweden		
8	Dirk De Villiers	Stellenbosch University	South Africa		
	<b>Sum</b>			<b>11220</b>	<b>19</b>

## 4. Logistic arrangements

### 4.1. Venue

All lectures were given in the room shown in Fig. 1 in the Electrical Engineering building at Chalmers.

## 4.2. Lodging and transportation

The participants arranged their own lodging, mainly in the recommended youth hostel, which is within walking distance from Chalmers.

## 4.3 Lunches and social dinner

Complementary lunches were given in the lunch restaurant Einstein at Chalmers. There were two coffee breaks per day. The complementary social dinner was organized on Thursday 8 December at restaurant Mykonos.

## 5. Course management

### 5.1. Material given to the students

All the students received paper copies of the slide presented by the speakers, as well as some important journal papers. The electronic material was uploaded at a web page and made available for all participants.

### 5.2. Group assignments and computer exercises

See the program in Section 1.

### 5.3. Credits, exams and their outcome

After the course was over we arranged an exam via email. The exam had 60 questions and the students should mark the correct answer(s) among 3 or 2 alternative answers. They got score of 1 point for each question if their answers matched completely the correct template. Each wrong mark gave  $-1/3$  point if there were 3 alternative answers, and  $-1/2$  point if there were 2 alternatives. Thus, the maximum score on each question was 1 (if all alternatives were correctly marked) and the minimum -1 (if all alternatives were wrongly marked). 19 of the participants submitted the exam, and they had between 40 % (24 points) and 89 % (53.3 points) of full score (60 points). The grades were given as follows: Grade A > 80%, grade B > 60%, grade C > 40%.

The course represents the equivalent of 1 week of study, giving 2 ECTS credit units.

The results are given below:



Names	Affiliation	Country	Submitted exam	Total number of correct answers - wrong answers	Grade	% correct total	% correct Meincke	% correct Kildal	% correct Ivashina	% correct Maci	% correct Sauleau	% correct total
Superstudent, max score				60		100	100	100	100	100	100	100
Oleg Lupikov	Chalmers	Sweden	1	53.3	A	89	100	83	58	100	100	89
Daniel Rodrigo	Universitat Politecnica de Catalunya	Spain	1	52.7	A	88	100	90	75	83	89	88
Andrea Giacomini	SATIMO	Italy	1	52.0	A	87	100	67	83	100	100	87
Enrique Nova	Universitat Politècnica de Catalunya	Spain	1	51.3	A	86	100	83	75	83	89	86
André Young	Stellenbosch University	South Africa	1	44.0	B	73	89	83	58	67	67	73
Anton Somov	Inst of Radio Astronomy om Nat	Ukraine	1	43.3	B	72	100	67	67	33	89	72
Marta Arias-Campo	IMST GmbH	Germany	1	40.7	B	68	56	67	42	33	100	68
Per Jacobsson	Arkivator	Sweden	1	40.0	B	67	100	77	33	50	67	67
Ahmed Hussain	Chalmers	Sweden	1	39.3	B	66	78	67	75	17	78	66
Hasan Raza	Chalmers	Sweden	1	39.3	B	66	78	67	75	17	78	66
Iman Vakili	Lund university	Sweden	1	39.3	B	66	100	67	58	17	78	66
Mehran Pour Mousavi	Institute for Technical Electronics	Germany	1	39.3	B	68	78	67	75	17	85	68
Anton Patyuchenko	German Aerospace Center	Germany	1	38.7	B	64	100	50	58	50	78	64
Aidin Razavi	Chalmers	Sweden	1	37.0	B	61	56	67	83	17	67	61
Manushanker Balasubramanian	Fraunhofer FHR	Germany	1	32.0	C	53	56	33	67	33	78	53
Wan-chun Liao	Chalmers	Sweden	1	31.3	C	49	56	40	42	33	67	49
Jose Luis Gomez-Tornero	Universitat Politecnica de Catalunya	Spain	1	30.0	C	50	78	37	58	67	44	50
Yoann Letestu	Radio Frequency Systems	France	1	29.3	C	49	78	50	42	17	56	49
Heiko Gulan	Karlsruhe Inst of Technology	Germany	1	24.0	C	40	67	27	42	42	44	40
Marko Bosiljevac	Zagreb University	Croatia		no								
Thierry Gilles	Royal Military Academy	Belgium		no								
Average % score on all students			19			70	84	67	64	47	82	70

#### 5.4. Evaluation of the course from the students, detected strong and weak points

The standard ACE evaluation form was distributed to the students for submission to one of the PhD students at Chalmers by email after the course was over, and 16 students completed it. The PhD student processed the submitted forms, treating them anonymously. The average scores on each question in the form are given in Table 2 below.

The students had also written some suggestions for improving the course. These were:

- 1 - Provide written answers and comments to group work questions, could be a good summary...
- 2 - Allocate more time, effort and care for group work
- 3 - Some of the slides (actually very few) are not easy to read, resolution is too low for some charts and graphs...
  1. I expected the course to cover also Potter horn feeds.
  2. The class about numerical methods was mainly focused to explain very specific details of the different methods. I would have preferred a general description of the methods and a more practical approach like: When use each method?
  3. It would be useful to cover practical designing for instance with some examples of finding a right reflector architecture given a list of specifications.
    1. A good and thorough presentation of asymptotic methods is necessary for this course. Meincke did a good job, but Macis presentation was too unorganized and cluttered with equations without explanation.
    1. In my opinion, Maci should give a more general overview about the subject, and not such a detailed explanation, which only people who have studied mathematics could maybe understand. I don't think it is useful to approach it on that way.

## ESoA Course on Reflector and Lens Antennas

### Evaluation form (Legend: 1 Poor; 2 Fair, 3 Average, 4 Good, 5 Excellent)

#### Teaching Evaluation

Day	Monday	Tuesday			Wednesday		Thursday	Friday
	Peter Meincke	P.-S. Kildal	Jian Yang	Dirk de Villiers	Marianna Iwashina	Rob Maaskant	Stefano Maci	Ronan Sauleneau
Teacher:								
Answer the following by grading 1-5, see explanation above:								
Instructor is knowledgeable about the subject	4.5	4.7	4.3	4.3	4.4	4.3	4.6	4.6
Instructor is prepared	4.4	4.4	4.3	4.4	4.3	4.3	4.2	4.3
Instructor encourages participation	4.2	4.3	4.0	3.9	4.4	3.9	3.8	4.1
Instructor answers students' questions	4.4	4.5	4.2	4.5	4.5	4.4	4.4	4.4
Instructor is enthusiastic about teaching	4.0	4.6	4.3	4.3	4.5	4.1	4.3	4.3
Instructor's fluency in English	4.5	4.4	3.7	4.6	4.3	4.4	4.4	4.3
Interest of material	4.3	4.5	4.4	4.3	4.2	4.2	3.6	4.5
Relevance of material	4.4	4.6	4.4	4.4	4.3	4.1	3.7	4.6
Using teaching aids (overheads, videos, handouts)	4.3	4.1	3.9	3.9	3.9	4.0	3.9	4.1
How pertinent were the course objectives to the target audience?	4.3	4.6	4.2	4.1	4.1	4.2	3.7	4.4
How well do you feel the course objectives were met?	4.3	4.3	4.1	4.1	4.1	3.9	3.3	4.2
How well do you feel about the level of detail of the course documents?	4.1	4.2	4.4	4.0	4.1	4.1	3.7	4.3
Answer Yes or No on these questions:								
Did the lecturer present too much material in the time allocated?	1	0	0	0	1	1	13	9
Did the lecturer present too little material in the time allocated	0	0	0	0	0	0	0	1
Should the lecturer get more time for his part?	3	3	2	3	2	1	7	11
Should the lecturer get less time for his part?	0	0	0	0	0	1	2	2
Did you understand the material presented?	16	16	16	16	16	15	4	15
Did the teacher present anything that is useful and important for any practical application?	15	16	16	14	16	16	14	15
Did you learn anything that could be useful for you?	16	16	16	14	15	14	11	14
Did you get enough time for questions and discussions?	13	16	16	14	15	16	15	12
Would you have taken the course if you before you registered knew what you now know about its content and teachers?	16	16	16	15	16	15	12	15
Will you benefit from what you learnt in the course in your own research or development?	15	14	14	9	11	11	11	12
Logistical support (grade 1 to 5)								
How would you rate the letter of invitation in providing you with the information you needed to make your plans for participation in this training course?								4.125
How well was the registration/check-in process organised, staffed and located								4
How would you rate the lodging accommodations for this course?								3.938
How would you rate the quality and variety of the meals served?								4.188
The classroom is comfortable and inviting								3.875
Desks and tables provide adequate work space								3.688
Evaluation for group work assignments (grade 1 to 5)								
Quality of assignments								4
Questions are closely related to the theories presented and provide hand-on practice with the theories								4.188
Enforces understanding of important concepts								4.25
Encourages critical thinking and demonstrates pros and cons of specific issues								4.063
Instructions are given at appropriate detail								4
Evaluation of exam								
Was the exam relevant for the course?	15 Yes							
Was the exam useful for you?	15 Yes							
Is it necessary with exams on such short courses?	11 Yes							

## **6. Financial management**

Management was performed by Prof Kildal's secretary at Chalmers University of Technology. The registration fees were 440 € for PhD students (even those from Chalmers). The three industrial participants paid 1100€ each. The course was granted 6 NEWFOCUS scholarships of 440€, and these were given to the students as indicated by Table 1.