

ICT Policy, Research, and Innovation

Perspectives and Prospects for
EU-US Collaboration

SVETLANA KLESSOVA

SEBASTIAN ENGELL

MAARTEN BOTTERMAN

JONATHAN CAVE


IEEE PRESS



IEEE PRESS SERIES ON
TECHNOLOGY MANAGEMENT,
INNOVATION, AND LEADERSHIP

WILEY

ICT Policy, Research, and Innovation

IEEE Press
445 Hoes Lane
Piscataway, NJ 08854

IEEE Press Editorial Board
Ekram Hossain, Editor in Chief

Jón Atli Benediktsson
Xiaoou Li
Saeid Nahavandi
Sarah Spurgeon

David Alan Grier
Peter Lian
Jeffrey Reed
Ahmet Murat Tekalp

Elya B. Joffe
Andreas Molisch
Diomidis Spinellis

ICT Policy, Research, and Innovation

Perspectives and Prospects for EU-US Collaboration

Editors

Svetlana Klessova

*Université Côte d'Azur, CNRS, GREDEG, France
GAC Group, France*

Sebastian Engell

BCI Department, TU Dortmund University, Germany

Maarten Botterman

GNKS Consult, The Netherlands

Jonathan Cave

Department of Economics, University of Warwick, United Kingdom

IEEE Press Series on Technology Management, Innovation, and Leadership




IEEE PRESS
WILEY

Copyright © 2021 by The Institute of Electrical and Electronics Engineers, Inc. All rights reserved.

Published by John Wiley & Sons, Inc., Hoboken, New Jersey.
Published simultaneously in Canada.

No part of this publication may be reproduced, stored in a retrieval system, or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, scanning, or otherwise, except as permitted under Section 107 or 108 of the 1976 United States Copyright Act, without either the prior written permission of the Publisher, or authorization through payment of the appropriate per-copy fee to the Copyright Clearance Center, Inc., 222 Rosewood Drive, Danvers, MA 01923, (978) 750-8400, fax (978) 750-4470, or on the web at www.copyright.com. Requests to the Publisher for permission should be addressed to the Permissions Department, John Wiley & Sons, Inc., 111 River Street, Hoboken, NJ 07030, (201) 748-6011, fax (201) 748-6008, or online at <http://www.wiley.com/go/permission>.

Limit of Liability/Disclaimer of Warranty: While the publisher and author have used their best efforts in preparing this book, they make no representations or warranties with respect to the accuracy or completeness of the contents of this book and specifically disclaim any implied warranties of merchantability or fitness for a particular purpose. No warranty may be created or extended by sales representatives or written sales materials. The advice and strategies contained herein may not be suitable for your situation. You should consult with a professional where appropriate. Neither the publisher nor author shall be liable for any loss of profit or any other commercial damages, including but not limited to special, incidental, consequential, or other damages.

For general information on our other products and services or for technical support, please contact our Customer Care Department within the United States at (800) 762-2974, outside the United States at (317) 572-3993 or fax (317) 572-4002.

Wiley also publishes its books in a variety of electronic formats. Some content that appears in print may not be available in electronic formats. For more information about Wiley products, visit our web site at www.wiley.com.

Library of Congress Cataloging-in-Publication Data:

Names: Klessova, Svetlana, editor.

Title: ICT Policy, Research, and Innovation : Perspectives and Prospects
for EU-US Collaboration / edited by Svetlana Klessova, Sebastian Engell,
Maarten Botterman, Jonathan Cave.

Description: Hoboken, New Jersey : Wiley/IEEE Press, [2019] | Series: IEEE
Press series on technology management, innovation, and leadership |
Includes bibliographical references and index.

Identifiers: LCCN 2020025362 (print) | LCCN 2020025363 (ebook) | ISBN
9781119632528 (hardback) | ISBN 9781119632542 (adobe pdf) | ISBN
9781119632559 (epub)

Subjects: LCSH: Technology and state–International cooperation. |
Information technology–Research–International cooperation. |
Telecommunication policy–International cooperation. | Information
technology–Government policy–European Union countries. | Information
technology–Government policy–United States.

Classification: LCC T49.5 .I155 2019 (print) | LCC T49.5 (ebook) | DDC
338.9/26–dc23

LC record available at <https://lcn.loc.gov/2020025362>

LC ebook record available at <https://lcn.loc.gov/2020025363>

Cover Design: Wiley

Cover Images: Compass Rose Vector Logo Template Illustration Design, © Sigit Mulyo Utomo/ Getty Images;
Smart city and global network concept; © metamorworks/Getty Images

Set in 9.5/12.5pt STIXTwoText by SPI Global, Pondicherry, India

Printed in the United States of America.

10 9 8 7 6 5 4 3 2 1

Disclaimer

All contents attributed in this book to co-editors, authors, or other contributors represent their personal views and do not represent official positions of the institutions with which they are or were affiliated.

Contents

List of Contributors	<i>xviii</i>
Editor Biographies	<i>xx</i>
Acknowledgments	<i>xxi</i>
List of Acronyms	<i>xxiv</i>

A Note from the Series Editor 1

1	Collaboration in a Globally Networked Knowledge Society	3
	<i>Svetlana Klessova, Maarten Botterman, Jonathan Cave, and Sebastian Engell</i>	
1.1	ICT Topics in Focus	6
1.1.1	5G	6
1.1.2	Internet of Things	7
1.1.3	Cyber-Physical Systems	7
1.1.4	Big Data	8
1.1.5	Cybersecurity	8
1.2	The Policy Aspect	9
1.3	International Collaborations – EU–US Partnerships	11
1.4	About this Volume	14
	References	19
2	Industrial Drivers, Barriers, and Societal Needs: EU and US Perspectives	21
	<i>Haydn Thompson, Daniela Ramos-Hernandez, and Christian Sonntag</i>	
2.1	Introduction and Overview	21
2.2	Industrial Drivers and Societal Needs	23
2.2.1	Smart Cities	23
2.2.1.1	Landscape Analysis	23
2.2.1.2	Industry Interviews	24
2.2.2	Smart Energy and Smart Grid	26
2.2.2.1	Landscape Analysis	26
2.2.2.2	Industry Interviews	28
2.2.3	Smart Transportation	31
2.2.3.1	Automotive and Road	32
2.2.3.2	Rail	35

2.2.3.3	Aerospace	36
2.2.3.4	Maritime	38
2.2.4	Automation	40
2.2.5	Diagnostics and Plant Monitoring	42
2.2.6	Information Technology	43
2.2.7	Wireless and Telecommunications	44
2.2.8	Software Development and Tools	46
2.2.9	Research Organizations and Networks	47
2.2.10	Standardization	48
2.2.11	Recruitment	49
2.2.12	Summary of Key Recommendations	50
2.3	Barriers	51
2.3.1	Cross-Cutting Barriers	51
2.3.1.1	Structural Differences in Funding Environments	51
2.3.1.2	Administrative Overhead and Legal Barriers	52
2.3.1.3	Lack of Clarity of the Benefits of EU–US Collaboration	53
2.3.1.4	Restrictions due to Intellectual Property Protection	54
2.3.1.5	Lack of Joint EU–US Funding Mechanisms and Policies	55
2.3.1.6	Export Control and Privacy Restrictions	55
2.3.1.7	Lack of Awareness and Knowledge	56
2.3.1.8	Lack of Interoperability and Standards	56
2.3.2	Barriers in Smart Cities	56
2.3.3	Barriers in Smart Energy and the Smart Grid	57
2.3.4	Barriers in Smart Transportation	58
2.3.5	Barriers for Large and Small Companies	60
2.4	Concluding Remarks	60
	References	61
3	Research and Innovation Programs as a Mechanism to Support Collaborative Efforts	63
	<i>Svetlana Klessova, Tariq Samad, Margot Bezzi, and Marta Calderaro</i>	
3.1	Introduction	63
3.2	EU Research and Innovation FP	64
3.2.1	Coupling Research and Innovation	64
3.2.2	Collaborative, Interorganizational Projects	65
3.2.3	ICT Priorities and Opportunities in H2020	67
3.2.4	The FP 2021–2027: Horizon Europe	69
3.3	EU–US Collaboration in H2020	70
3.3.1	The EU–US Research and Innovation Collaboration Framework	70
3.3.2	US Participation in the EU Research and Innovation FPs	71
3.3.3	US Industry Participation in the EU ICT-Related Work Programme	71
3.4	US Programs for Collaborative Research	75
3.4.1	The Federal RDI Funding Landscape	75
3.4.2	National Science Foundation (NSF)	76
3.4.3	National Institutes of Health (NIH)	78
3.4.4	Department of Defense (DoD)	79
3.4.5	Department of Energy (DoE)	80

3.4.6	NITRD: A Programmatic Umbrella Covering ICT	81
3.5	Conclusion	82
3.6	Annex 1: About the PICASSO Project	84
	References	87
4	International Context and the Specific Value of EU–US Collaboration	89
	<i>Jonathan Cave and Maarten Botterman</i>	
4.1	Introduction	89
4.2	Advantages of EU–US Collaboration	90
4.2.1	General Aspects	90
4.2.2	Collaboration Along Technology, Market, and Policy Life Cycles	92
4.2.3	Specific Activities to Foster Collaboration	92
4.3	Overview	94
4.3.1	A Summary of Challenges and Opportunities	94
4.3.2	EU–US Comparisons	94
4.3.2.1	A Bit of History	94
4.3.2.2	The Difficulty of Meaningful Comparisons	103
4.3.3	Differences and Cooperation	103
4.4	Collaborative Research and Innovation Priorities and Barriers	103
4.4.1	EU and US Priorities	103
4.4.2	Barriers to Policy-driven R&I Collaboration	104
	References	108
5	Challenges and Potential for EU–US Collaboration at the Intersection of the Internet of Things and Cyber-physical Systems	111
	<i>Christian Sonntag, Sebastian Engell, and Tariq Samad</i>	
5.1	Introduction	111
5.1.1	Internet of Things-Enabled Cyber-physical Systems	111
5.1.2	Objectives of this Chapter	113
5.2	R&I Priorities in the European Union and the United States	114
5.2.1	Cross-Domain Drivers and Needs	115
5.2.2	Enabling Technologies	115
5.2.3	Cyber-physical Systems (CPS)	116
5.2.3.1	R&I Priorities in the European Union	117
5.2.3.2	R&I Priorities in the United States	119
5.2.4	The Internet of Things (IoT)	121
5.2.4.1	R&I Priorities in the European Union	122
5.2.4.2	R&I Priorities in the United States	123
5.2.5	Application Sectors: Drivers and Needs	124
5.2.5.1	Smart Production	124
5.2.5.2	Smart Cities	126
5.2.5.3	Smart Energy	126
5.2.5.4	Smart Transportation	127
5.2.6	Synthesis of the Findings	128
5.3	Technology Themes for EU–US Collaboration	133
5.3.1	Autonomy and Humans in the Loop	134
5.3.1.1	R&I Topics	134

5.3.1.2	Why EU–US Collaboration?	134
5.3.1.3	Relevance to Application Sectors	134
5.3.2	Model-based Systems Engineering	135
5.3.2.1	R&I Topics	135
5.3.2.2	Why EU–US Collaboration?	135
5.3.2.3	Relevance to Application Sectors	135
5.3.3	Trust, (Cyber-)Security, Robustness, Resilience, and Safety	135
5.3.3.1	R&I Topics	135
5.3.3.2	Why EU–US Collaboration?	136
5.3.3.3	Relevance to Application Sectors	136
5.3.4	Integration, Interoperability, Flexibility, and Reconfiguration	136
5.3.4.1	R&I Topics	136
5.3.4.2	Why EU–US Collaboration?	136
5.3.4.3	Relevance to Application Sectors	136
5.3.5	Situational Awareness, Diagnostics, and Prognostics	137
5.3.5.1	R&I Topics	137
5.3.5.2	Why EU–US Collaboration?	137
5.3.5.3	Relevance to Application Sectors	137
5.3.6	Closing the Loop in IoT-enabled CPS	137
5.3.6.1	R&I Topics	137
5.3.6.2	Why EU–US Collaboration?	137
5.3.6.3	Relevance to Application Sectors	137
5.4	Key Recommendations: Enabling EU–US Collaboration for IoT-Enabled CPS	138
5.4.1	Joint EU–US Knowledge Exchange Initiative	139
5.4.2	Joint NSF–EC Program on Autonomous IoT-enabled CPS in Horizon Europe	140
5.5	Conclusions and Outlook	141
	References	142
6	Challenges and Potential for EU–US Collaboration in 5G and Beyond Networks	145
	<i>Yaning Zou, Gerhard Fettweis, Amitava Ghosh, Glenn Ricart, Matti Latva-Aho, and Lucas Scheuven</i>	
6.1	Introduction	145
6.2	R&I Priorities of 5G Networks in the European Union and the United States	146
6.2.1	Cross-domain Drivers and Needs	146
6.2.2	5G and its Enabling Technologies	147
6.2.3	R&I Priorities in the European Union	148
6.2.4	R&I Priorities in the United States	150
6.2.5	Vertical Sectors: Drivers and Needs	152
6.2.5.1	Automotive and Transportation	152
6.2.5.2	Industrial Automation	153
6.2.5.3	Health	154
6.2.5.4	Energy	155
6.2.6	EU–US Research Collaboration in 5G Network	155
6.3	5G Beyond and Technology Themes for EU–US Collaboration	157
6.3.1	Connecting the Last Billions in Unserved Areas	159
6.3.1.1	R&I Topics	159
6.3.1.2	Why EU–US Collaboration?	159

- 6.3.2 Wireless Premises Networks 159
- 6.3.2.1 R&I Topics 159
- 6.3.2.2 Why EU–US Collaboration? 159
- 6.3.3 mmWave Technology Beyond 5G 160
- 6.3.3.1 R&I Topics 160
- 6.3.3.2 Why EU–US Collaboration? 160
- 6.3.4 Spectrum Farming and Harmonization 160
- 6.3.4.1 R&I Topics 160
- 6.3.4.2 Why EU–US Collaboration? 161
- 6.4 Fostering EU–US Collaboration for 5G Beyond: Strategies and Key Recommendations 161
- 6.4.1 Collaboration Strategies in the 5G Beyond Domain 161
- 6.4.2 Collaboration Opportunities in the 5G Beyond Domain 162
- 6.5 Conclusions and Outlook 163
- References 164

7 Big Data Policies and Priorities: A Comparison Between the European Union and United States and Opportunities for Collaboration 165

Vasileios Papanikolaou, Nikos Sarris, Florence D. Hudson, Lea A. Shanley, Andrew S. Hoffman, and Christine R. Kirkpatrick

- 7.1 Introduction 165
- 7.2 R&I Priorities in the European States and the United States 166
- 7.2.1 Big Data Technology Enablers 166
- 7.2.2 EU Priorities and R&I Landscape 167
- 7.2.2.1 The EU Big Data Strategy 168
- 7.2.2.2 EU R&I Priorities 168
- 7.2.3 US Priorities and R&I Landscape 169
- 7.2.3.1 The US Big Data Strategy 171
- 7.2.3.2 The American Artificial Intelligence Initiative 172
- 7.2.3.3 US Research and Innovation Priorities 172
- 7.2.4 Postgraduate Education on Big Data 176
- 7.2.5 Application Sectors 177
- 7.2.5.1 EU Key Application Sectors 177
- 7.2.5.2 US Application Sectors 178
- 7.2.6 Conclusions 179
- 7.2.6.1 Similarities and Differences at the Design and at the Implementation Level 179
- 7.2.6.2 Similarities and Differences in Big Data Technology and Application Domains between the European States and the United States 180
- 7.3 Fostering EU–US Collaboration for Big Data: Opportunities and Key Recommendations 181
- 7.3.1 Collaboration Opportunities 181
- 7.3.1.1 Big Data Ecosystem Opportunities 182
- 7.3.1.2 Standardization and Regulation 183
- 7.3.1.3 Opportunities in Education and Workforce Development 183
- 7.3.1.4 Big Data for Smart Cities 183
- 7.3.1.5 Big Data and the Environment–Food–Energy–Water Nexus 184
- 7.3.1.6 Big Data for Better Health 184

- 7.3.2 Key Recommendations for Enhancing EU–US Collaboration in Big Data Technologies 185
- 7.3.2.1 Big Data EU–US Task Force for Enhancing Collaboration 185
- 7.3.2.2 Joint R&D Projects under the Horizon Europe Umbrella 186
- 7.4 Conclusions and Outlook 186
- 7.4.1 Summary of Recommendations 187
- References 188

8 Cybersecurity and Privacy 191

Jim Clarke, Fabio Martinelli, Artsiom Yautsiukhin, Claudio Caimi, Alberto Terzi, Silviya Nonova, Camille E. Sailer, Jody Serrano, and Yolanda Ursa

- 8.1 Introduction 191
- 8.2 Landscape of Cybersecurity in Europe and the United States 192
- 8.2.1 EU Cybersecurity and Privacy Strategy 192
- 8.2.1.1 NIS Public–Private Platform (NIS Platform) 192
- 8.2.1.2 Contractual Public–Private Partnership (cPPP) 192
- 8.2.1.3 EU Global Strategy for Foreign and Security Policy 193
- 8.2.1.4 European Agenda on Security 193
- 8.2.1.5 Digital Single Market Strategy 193
- 8.2.2 US Cybersecurity and Privacy Strategy 193
- 8.2.2.1 Federal Cybersecurity Research and Development Strategic Plan 194
- 8.2.2.2 National Privacy Research Strategy (NPRS) 195
- 8.2.2.3 International Strategy for Cyberspace 195
- 8.3 Priority Areas for EU–US Collaboration in R&I in CSP 195
- 8.3.1 Cybersecurity Research Domains 197
- 8.3.2 Applications and Technologies 198
- 8.3.3 Sectors 198
- 8.3.4 Expert Analysis of Our Ranking 199
- 8.3.4.1 Cybersecurity Research Domains 199
- 8.3.4.2 Applications and Technologies 199
- 8.3.4.3 Sectors 200
- 8.3.5 Recommended Focus Sectors for Transatlantic Cooperation 200
- 8.3.5.1 Finance 200
- 8.3.5.2 Health Care 200
- 8.3.5.3 Maritime 200
- 8.3.6 Summary of the Analysis of the Three Focus Sectors 201
- 8.4 Innovation Partnerships in CSP 203
- 8.4.1 Strategy 203
- 8.4.2 Multidisciplinary Approach 206
- 8.4.3 Resilience 206
- 8.4.4 Governance 206
- 8.4.5 Cooperation and Sharing 206
- 8.4.6 Reputation 206
- 8.4.7 Innovation 207
- 8.5 Cybersecurity Policies Enabling EU–US Collaboration 207
- 8.5.1 Standards and Certification 207
- 8.5.1.1 EU Policies 207
- 8.5.1.2 US Policies 208

8.5.2	Public–Private Information Sharing	209
8.5.2.1	EU Policies	209
8.5.2.2	US Policies	210
8.6	Recommendations for EU–US Collaboration	210
8.7	Conclusions	212
	References	214
9	The Next Generation Internet Initiative	217
	<i>Glenn Ricart, Jose Gonzalez, Vasilis Papanikolaou, Hubert Santer, Fabrice Clari, Nikos Sarris, Peter Van Daele, and Wouter Tavernier</i>	
9.1	Introduction	217
9.1.1	Technologies and Applications for an Internet of Humans	219
9.1.1.1	Key Application Areas	221
9.1.2	Drivers and Impediments for a Global DSM	221
9.2	Transatlantic Cooperation on NGI	224
9.2.1	State of Collaboration	224
9.2.2	NGI in the United States	226
9.2.2.1	Digital Policies in the United States	227
9.2.3	Funding Mechanisms and Opportunities	229
9.2.3.1	Europe	229
9.2.3.2	United States	230
9.2.4	Initiatives Supporting EU–US Collaboration on NGI	232
9.2.4.1	Transatlantic NGI Projects	232
9.2.4.2	US Clusters and Innovation Hubs	236
9.2.4.3	Initiatives Developing NGI Technologies	238
9.3	Think NEXUS to Support the Transatlantic NGI Alliance	239
9.3.1	Think NEXUS US Workshop 2019	241
9.3.1.1	Science and Technology Expert Group	241
9.3.1.2	Innovation and Entrepreneurship Expert Group	243
9.3.1.3	Policy Expert Group	247
9.4	Conclusions	249
	References	251
10	Privacy and Data Protection Issues	255
	<i>Maarten Botterman and Jonathan Cave</i>	
10.1	Introduction	255
10.2	EU and US Policy Frameworks	256
10.3	Differences in Legal Status of Privacy	257
10.3.1	Europe: GDPR	258
10.3.2	The United States: Case Law Based on the Constitution	259
10.3.3	The EU/US Agreement Privacy Shield	261
10.4	ICT Development Impacts	261
10.4.1	5G Networks	262
10.4.2	Big Data	263
10.4.3	Internet of Things/Cyber-Physical Systems	265
10.5	Conclusions	266
	References	270

11 Information and Communication Technology Security Issues 273*Jonathan Cave, Maarten Botterman, and Dave Farber*

- 11.1 Introduction 273
- 11.2 The Technical Situation 274
- 11.3 The Policy Situation 276
 - 11.3.1 Cybersecurity Risk Cannot be “Minimized” 276
 - 11.3.2 Trust Cannot be “Maximized” 277
 - 11.3.3 Trust and Security are Both Real and Imagined 277
 - 11.3.4 The International Dimension 278
 - 11.3.5 Simplistic Approaches to a Complex Problem 280
 - 11.3.5.1 Data and Its Uses and Abuses 280
 - 11.3.5.2 Definitional Issues 282
 - 11.3.5.3 Identification and Authentication 282
 - 11.3.5.4 Data and Processing Integrity and Quality 285
 - 11.3.5.5 Cybercrime and Cyber-enhanced Crime 287
 - 11.3.5.6 Encryption 288
 - 11.3.5.7 A Dialogue Between Technology and Policy 290
- 11.4 New ICT Developments Impacts 292
 - 11.4.1 5G Networks 292
 - 11.4.2 Big Data 294
 - 11.4.2.1 The Scope of the Issue 294
 - 11.4.2.2 The Accessibility of Big Data 295
 - 11.4.2.3 Data Analytics and AI as Cybersecurity Tools 295
 - 11.4.3 Internet of Things/Cyber-Physical Systems 296
- 11.5 Possible Ways Forward 297
- 11.6 Conclusions 299
 - 11.6.1 5G Networks 299
 - 11.6.2 Big Data 300
 - 11.6.3 IoT and Cyber-Physical Systems 300
 - 11.6.4 Operational Conclusions 301
- References 305

12 Standardization Issues 309*Maarten Botterman, Jonathan Cave, and Avri Doria*

- 12.1 Introduction 309
 - 12.1.1 How ICT Dynamics Affect Standards 310
 - 12.1.2 Implications of Convergence 310
 - 12.1.3 Convergence Is Not Inevitable 311
- 12.2 Standardization as a Collaborative and Competitive Activity 311
 - 12.2.1 Why Address Standards Setting Now? 312
- 12.3 Drivers of ICT Standardization 313
 - 12.3.1 Social Drivers 314
 - 12.3.2 Technology Drivers 315
 - 12.3.3 Economic Drivers 316
- 12.4 Standards Development in Practice 316
 - 12.4.1 Permissionless Innovation 317
 - 12.4.2 Open Standards 317

12.4.3	The Role of Standards Organizations	318
12.4.4	The Role of Governments	318
12.4.4.1	EU Perspective	319
12.4.4.2	US Perspective	320
12.5	Standardization: Focus on Technology Domains	320
12.5.1	5G Networks	320
12.5.2	Big Data	323
12.5.3	Internet of Things/Cyber-Physical Systems	324
12.6	Perspectives Towards the Future	325
12.7	Conclusions	327
	References	328
13	Spectrum Issues	331
	<i>Jonathan Cave</i>	
13.1	Introduction	331
13.1.1	Challenges to Existing Spectrum Policies	333
13.1.2	Implications for Research into Wireless Technologies and Services	333
13.1.2.1	Example: 2.6 GHz Spectrum Auction	334
13.1.3	Availability of Spectrum for Research Purposes	334
13.2	Technology-specific Spectrum Issues	334
13.2.1	5G Networks	334
13.2.1.1	Specific Issues (Tentative)	335
13.2.2	Internet of Things/Cyber-Physical Systems	337
13.2.3	Big Data	339
13.2.3.1	Big Data Traffic Flows over the Electromagnetic Spectrum	339
13.2.3.2	Use of Data Analytics to Allocate Rights and Manage Spectrum Use	340
13.3	Perspectives Towards the Future	340
13.4	Conclusions	341
13.5	Annex A: Some Comments on IoT and CPS from the Spectrum Perspective	342
13.5.1	Internet of Things	342
13.5.2	Cyber-physical Systems	343
13.5.3	Link to Spectrum	343
13.6	Annex B: TV White Space (TVWS)	344
	References	346
14	Digital Communities and EU–US ICT Development Collaboration	349
	<i>Glenn Ricart, Maarten Botterman, and Jonathan Cave</i>	
14.1	Why Focus on Digital Communities?	349
14.1.1	What are Communities?	350
14.1.2	The Effect of “Digitization”	350
14.2	Relation to Other Key Policy Issues	353
14.2.1	Privacy and Data Protection	354
14.2.2	ICT Security	354
14.2.3	ICT Standards	355
14.2.4	Spectrum	355
14.3	Digital Communities, Impacted	356
14.3.1	5G Networks	356

14.3.2	Big Data	357
14.3.3	Internet of Things/Cyber-Physical Systems	357
14.4	Perspectives Towards the Future	358
14.5	Conclusions	360
	References	362
15	Opening Towards a New Reality, Together	365
	<i>Maarten Botterman and Jonathan Cave</i>	
15.1	Introduction	365
15.1.1	Case for Collaboration	366
15.1.2	Most-relevant Issues	367
15.2	Policy Challenges for ICT R&I Collaboration	368
15.3	Privacy and Data Protection	368
15.3.1	Context	368
15.3.1.1	Differences in Legal Status of Privacy	369
15.3.2	ICT Development Impacts	370
15.3.2.1	5G Networks	370
15.3.2.2	Big Data	371
15.3.2.3	The Internet of Things and Cyber-physical Systems	372
15.3.3	Privacy and Data Protection Conclusions	372
15.4	Security	372
15.4.1	Context	373
15.4.1.1	The Technical Situation	373
15.4.1.2	The Policy Situation	374
15.4.2	ICT Development Impacts	377
15.4.2.1	5G Networks	377
15.4.2.2	Big Data	378
15.4.2.3	The Internet of Things and Cyber-Physical Systems	379
15.4.3	Security Conclusions	379
15.5	Standards	380
15.5.1	Context	380
15.5.1.1	How ICT Dynamics Affect Standards	380
15.5.1.2	Implications of Convergence	381
15.5.1.3	Convergence is Not Inevitable	381
15.5.1.4	Standardization as a Collaborative and Competitive Activity	382
15.5.2	Standards Development in Practice	383
15.5.2.1	Permissionless Innovation	384
15.5.2.2	Open Standards	384
15.5.3	ICT Development Impacts	384
15.5.3.1	5G Networks	384
15.5.3.2	Big Data	385
15.5.3.3	Internet of Things/Cyber-Physical Systems	387
15.5.4	Standards Conclusions	387
15.6	Spectrum	389
15.6.1	Context	389
15.6.1.1	Challenges to Existing Spectrum Policies	390
15.6.1.2	Implications for Radio Technology and Service R&I	391

15.6.1.3	Spectrum Availability for Research Purposes	391
15.6.2	ICT Development Impacts	392
15.6.2.1	5G Networks	392
15.6.2.2	Big Data	394
15.6.2.3	Internet of Things/Cyber-Physical Systems	395
15.6.3	Spectrum Conclusions	396
15.7	Future Outlook	397
15.7.1	General Trends	397
15.7.1.1	Overarching Developments	397
15.7.1.2	The Evolving Security Landscape	398
15.7.2	The Role of Communities	399
15.7.2.1	The Future of Digital is Driven by Communities, and Vice Versa	401
15.8	Conclusions and Recommendations	403
15.8.1	General Aspects	403
15.8.1.1	Competition Between Domains	404
15.8.1.2	Coordination Models	404
15.8.2	Key Policy Domains	406
15.8.2.1	Privacy and Data Protection	406
15.8.2.2	ICT Security	408
15.8.2.3	Standardization	409
15.8.2.4	Spectrum	410
15.8.3	Lessons Learned from Digital Communities	411
15.8.4	Strategic Proposals for the Way Forward	412
15.9	Annexes	413
15.9.1	Annex A: Security Considerations	413
15.9.1.1	Data and Its Uses and Abuses	413
15.9.1.2	Definitional Issues	414
15.9.1.3	Identification and Authentication	414
15.9.1.4	Cybercrime and Cyber-Enhanced Crime	414
15.9.1.5	Encryption	415
15.9.1.6	A Dialogue Between Technology and Policy	416
15.9.2	Annex 2: Standards	418
15.9.2.1	Drivers	418
15.9.2.2	Organizational Roles	420
15.9.3	Annex C Spectrum	422
15.9.3.1	IoT and CPS from the Spectrum Perspective	422
15.9.3.2	TV White Space (TVWS)	424
15.9.4	Annex D Future Developments	425
15.9.4.1	Trends	425
15.9.4.2	Digital Communities Perspectives on Policy and Technology Areas	427
15.9.4.3	How Do Communities Relate to the Three Technical Domains?	429
	References	437

Index	439
--------------	-----

List of Contributors

Margot Bezzi

Agenzia per la Promozione della Ricerca
Europea (APRE), Rome, Italy

Maarten Botterman

GNKS Consult, Rotterdam, The Netherlands

Claudio Caimi

Hewlett Packard Italy, Milan, Italy

Marta Calderaro

Agenzia per la Promozione della Ricerca
Europea (APRE), Rome, Italy

Jonathan Cave

Department of Economics, University of
Warwick, Coventry, UK

Fabrice Clari

GAC Group, Sophia Antipolis, France

Jim Clarke

Waterford Institute of Technology,
Waterford, Ireland

Avri Doria

Technicalities, Providence, RI, USA

Sebastian Engell

Department of Biochemical and Chemical
Engineering, Technische Universität
Dortmund, Dortmund, Germany

Dave Farber

Cyber Civilization Research Center, Global
Research Institute (KGRI), Keio University,
Tokyo, Japan

Gerhard Fettweis

TU Dresden, Dresden, Germany

Amitava Ghosh

Nokia, Naperville, IL, USA

Jose Gonzalez

InterInnov, Barcelona, Spain

Andrew S. Hoffman

iHub – Interdisciplinary Hub for Security,
Privacy and Data Governance, Department
of Practical Philosophy, Radboud University,
Nijmegen, The Netherlands
US NSF West Big Data Innovation Hub

Florence D. Hudson

Northeast Big Data Innovation Hub, FDHint,
NSF Cybersecurity Center of Excellence,
Indiana University, Innovation Center,
Bloomington, IN, USA

Christine R. Kirkpatrick

San Diego Supercomputer Center,
University of California San Diego, La
Jolla, CA, USA

Svetlana Klessova

Université Côte d'Azur, CNRS, GREDEG,
Valbonne, France
GAC Group, Sophia Antipolis, France

Matti Latva-Aho

Faculty of Information Technology and
Electrical Engineering, University of Oulu,
Oulu, Finland

Dagmar Marron (Editorial Assistant)

inno TSD, France

Fabio Martinelli

Consiglio Nazionale delle Ricerche,
Rome, Italy

Silviya Nonova

Hewlett Packard Italy, Milan, Italy

Vasileios Papanikolaou

Athens Technology Center, Chalandri, Greece

Daniela Ramos-Hernandez

Haydn Consulting Ltd., Sheffield, UK

Glenn Ricart

US Ignite, Salt Lake City, UT, USA

Camille E. Sailer

European-American Chamber of Commerce,
Seaville, NJ, USA

Tariq Samad

Technological Leadership Institute, University
of Minnesota, Minneapolis, MN, USA

Hubert Santer

GAC Group, Sophia Antipolis, France

Nikos Sarris

Athens Technology Center, Chalandri, Greece

Lucas Scheuvs

TU Dresden, Dresden, Germany

Jody Serrano

Inmark Europa, Madrid, Spain

Lea A. Shanley

Nelson Institute, University of
Wisconsin-Madison, Madison, WI, USA
US NSF South Big Data Innovation Hub

Christian Sonntag

INOSIM Software GmbH,
Dortmund, Germany

Wouter Tavernier

IDLab/Department of Information
Technology (INTEC), iGent, IMEC – Ghent
University, Ghent, Belgium

Alberto Terzi

Hewlett Packard Italy, Milan, Italy

Haydn Thompson

Haydn Consulting Ltd., Sheffield, UK

Yolanda Ursa

Inmark Europa, Madrid, Spain

Peter Van Daele

IDLab/Department of Information
Technology (INTEC), iGent, IMEC – Ghent
University, Ghent, Belgium

Artsiom Yautsiukhin

Consiglio Nazionale delle Ricerche,
Rome, Italy

Yaning Zou

TU Dresden, Dresden, Germany

Editor Biographies

Svetlana Klessova was the coordinator of the PICASSO EU–US initiative “ICT Policy, Research and Innovation for a Smart Society.” She is Director, Research and Innovation Partnerships at GAC Group, France, and doing research in innovation management at the Université Côte d’Azur, CNRS, GREDEG. She is the editor of the open source volume *Innovation Strategy in R&D Projects: A Step by Step Guide* and has authored numerous analytical reports.

Sebastian Engell is a professor of Process Dynamics and Operations at Technische Universität Dortmund, Germany. He obtained several best paper awards and is a co-editor of the Wiley title *Resource Efficiency of Processing Plants: Monitoring and Improvement* (2018) and the editor of the Wiley title *Logistic Optimization of Chemical Production Processes* (2008).

Maarten Botterman is an independent policy analyst, as well as the Chairman of the ICANN Board, Chairman of the IGF Dynamic Coalition of the Internet of Things, Board Member of the Institute for Accountability in the Digital Age, Chairman of the Supervisory Board of the NLnet Foundation, and founder and Director of GNKS Consult.

Jonathan Cave belongs to the Economics Department of the University of Warwick, UK and the UK’s Regulatory Policy Committee. He is also an Associate at GNKS Consult and a Fellow of the Alan Turing Institute, an area editor of the Journal of Cybersecurity and advisor to the Cyber Civilization Research Centre at Keio University.

Acknowledgments

We are grateful for the generous support provided by the European Commission, DG CONNECT, to implement the PICASSO project and for the financial and in-kind support provided by many US-based agencies and organizations, in particular: National Institute of Standards and Technology (NIST), US National Science Foundation (NSF), Woodrow Wilson International Center for Scholars, Big Data Hubs across the United States, the University of Minnesota, and the University of Mississippi. We express our gratitude particularly to Peter Fatelnig, Minister-Counsellor for Digital Economy Policy, Delegation of the European Union to the United States, and to Jean-Yves Roger, the EC project responsible.

Dagmar Marron from inno TSD provided invaluable support as the editorial assistant of the volume, tirelessly taking care of all the details and removing inconsistencies until the last minute.

We are grateful to many further direct and indirect contributors, especially to the PICASSO Expert Group members who volunteered their time to contribute to the PICASSO work during several years, sharing perspectives and jointly authoring or contributing to reports and white papers. The positions of the contributors are indicated as at the time of their last contributions.

5G Networks Expert Group:

- **Gerhard Fettweis (chair)** – Vodafone Chair Professor, TU Dresden, IEEE Fellow, coordinator 5GLab Germany
- **Leif Johansson** – BusDev Manager Northern Europe, European Leaduser Manager RF/Communication, National Instruments, Sweden
- **Deborah Crawford** – Vice President of Research at George Mason University (GMU), USA
- **Olav Queseth** – Project Coordinator METIS I & II, Ericsson, Sweden
- **Amitabha Ghosh** – Head, Radio Interface Group, Nokia, USA
- **David Kennedy** – Director, Project Coordinator EURO 5G, Eurescom, Germany
- **Chengshan Xiao** – Professor, Lehigh University, USA
- **Matti Latva-Aho** – Professor, Head of Telecommunication Laboratory, Oulu University, Finland
- **Meryem Simsek** – Senior Scientist, ICSI/Berkeley & Senior Research Scientist, Intel, USA
- **Expert Group Manager: Yaning Zou** – Research Manager, TU Dresden, Germany

Big Data Expert Group:

- **Nikos Sarris (chair)**, ATC – Athens Technology Centre, Greece, member of Steering Committee Big Data Value Association (BDVA)

- **Sören Auer** – Professor, Head of Enterprise Information Systems group, University of Bonn, Germany
- **Andreas Metzger** – Head of Adaptive Systems and Future Internet Applications, University of Duisburg-Essen, Germany, Deputy General Secretary of the Big Data Value Association (BDVA) and Steering Committee vice chair of the European Technology Platform NESSI
- **David Belanger** – Senior Research Fellow, Stevens Institute of Technology, Co-Leader IEEE Big Data Initiative, USA
- **Michail Bletsas** – MIT, Director of Computing at the MIT Media Lab, USA
- **Wo Chang** – Digital Data Advisor for the NIST Information Technology Laboratory (ITL), USA
- **Ray Walshe** – Assistant Professor at Dublin City University, Ireland, Steering Board member for NetWorld2020 the European Technology Platform for communications networks and services, Chair of Standardisation Group at Big Data Value Association (BDVA)
- **Pantelis Angelidis** – VIDAVO, Professor of eHealth at University of Western Macedonia, Greece
- **Expert Group Manager: Vasilis Papanikolaou**, Athens Technology Centre, Greece

IoT/CPS Expert Group:

- **Sebastian Engell (chair)**, Professor, Head of the Process Dynamics and Operations Group, TU Dortmund, Germany, IFAC Fellow
- **Tariq Samad (co-chair)**, Senior Fellow, Technological Leadership Institute, University of Minnesota, USA
- **Massoud Amin**, Director, Technological Leadership Institute, University of Minnesota, USA
- **Chris Greer**, Director of the Smart Grid and CPS Program Office and National Coordinator for Smart Grid Interoperability, NIST, USA
- **Amit B. Kulkarni**, Global R&D Leader for Wireless and IoT, Honeywell ACS, USA
- **Paul D. Nielsen**, Director and CEO, Software Engineering Institute, Carnegie Mellon University, USA
- **Martin Serrano**, Principal Investigator and Data Scientist, Insight Centre for Data Analytics, Ireland
- **Haydn Thompson**, CEO, THHINK, UK
- **O. Sinan Tumer**, Senior Director, SAP Co-Innovation Labs, SAP Labs LLC, USA
- **Hubertus Tummescheit**, Chief Executive Officer, Modelon Inc., USA, and Co-founder, Modelon AB, Sweden
- **Ovidiu Vermesan**, Chief Scientist, SINTEF, Norway, and chair of WG01 of the Alliance for Internet of Things Innovation (AIOTI)
- **Expert Group Manager: Christian Sonntag**, Head of Innovation, INOSIM Software GmbH, Germany

ICT Policy Expert Group:

- **Maarten Botterman (chair)** – GNKS Consult BV Director, ICANN Chair, IGF DC IoT Chairman, The Netherlands
- **David Farber (co-chair)** – Cyber Civilization Research Center, Keio University, Global Research Institute (KGRI), Japan, IEEE fellow, ACM fellow

- **Jonathan Cave** – Department of Economics, University of Warwick, United Kingdom; Associate, GNKS; Turing Fellow, Alan Turing Institute; Economist Member, UK Regulatory Policy Committee
- **Dan Caprio** – The Providence Group, USA
- **Avri Doria** – Technicalities, USA
- **Ilkka Lakaniemi** – Aalto University, Finland, Chairman of Future Internet Public Private Partnership, Finland Chamber of Commerce
- **Glenn Ricart** – Founder and CTO, US Ignite, USA

We also would like to thank colleagues at the PICASSO project partners, especially Eva Fadil, GAC Group, France, Margot Bezzi, Marta Calderaro and Martina de Sole, APRE, Italy, and Christine Caly, Florida International University, USA, as well as participants of several conferences organized by the project, for their helpful contributions throughout the project.

The co-editors

List of Acronyms

Acronym	Full Text
2D TMD	Two-dimensional Transition Metal Dichalcogenides
3GPP	3rd Generation Partnership Program
4G	4th Generation
5G	5th Generation
5G PPP	5G Infrastructure Public Private Partnership
AAA	Authentication, authorization, accounting
ABC	Administration, Business, and Civil Society
ACARE	Advisory Council for Aviation Research and Innovation in Europe
ACER	Agency for the Cooperation of Energy Regulators
ADAS	Advanced Driver Assist Systems
AFOSR	Air Force Office of Scientific Research
AFR	Automatic facial recognition
AFRL	Air Force Research Laboratory
AI	Artificial Intelligence
AIOTI	Alliance for Internet of Things Innovation
AIS	Automatic Identification System
ALICE	Alliance for Logistics Innovation through Collaboration in Europe
AmI	Ambient intelligence
AMO	Advanced Manufacturing Office
AMP	American Maritime Partnership
Anatel	Brazil's National Telecommunications Agency
ANPR	Automatic number plate recognition
ANSI	American National Standards Institute
API	Application Interface
AR	Augmented Reality
AREA	Academic Research Enhancement Award
ARL	Army Research Laboratory
ARO	Army Research Office
ARPA-E	Advanced Research Projects Agency – Energy
ARRA	American Recovery and Reinvestment Act
ARTEMIS-IA	Advanced Research and Technology for Embedded Intelligence and Systems Industry Association
ASC	Amsterdam Smart City

ASIC	Application-specific Integrated Circuit
ASME	American Society of Mechanical Engineers
AV	Autonomous Vehicle
AWN	Advanced Wireless Networking
AWS	Amazon Web Services
B2B	Business-to-business
B2C	Business-to-customer
BAA	Broad Agency Announcement
BBI	Bio-based Industries
BD	Big Data
BD Hubs	Big Data Regional Innovation Hubs program
BDVA	Big Data Value Association
BDVPPP	Big Data Value Public Private Partnership
BSI	British Standards Institution
BYOD	Bring Your Own Device
C2C	Car to Car
C2C-CC	Car 2 Car Communication Consortium
C2I	Car to Infrastructure
CA	Certificate Authority
CAA	Civil Aviation Authority
CAM	Connected and Automated Mobility
CBM	Cyber confidence Building Measure
CBRS	Citizens Broadband Radio Service
CCPA	California Consumer Privacy Act
CCS	Combined Charging System
CCTV	Closed-circuit television
CDN	Content Delivery Network
CEDR	Conference of European Directors of Roads
CEER	Council of European Energy Regulators
CEN	European Committee for Standardization (Comité Européen de Normalisation)
CENELEC	European Committee for Electrotechnical Standardization
CERDEC	Communications-Electronics Research, Development, and Engineering Center
CERN	Conseil Européen pour la Recherche Nucléaire
CHuman	Computing-enabled Human Interaction, Communication, and Augmentation
CISA	Cybersecurity Information Sharing Act
CISE	Computer and Information Science and Engineering
CLOUD	Clarifying Lawful Use of Overseas Data
CLOUD Act	Clarifying Lawful Overseas Use of Data Act
CN	Core Network
CNPS	Computing-enabled Networked Physical Systems
CNS	Computer and Network Systems
COPPA	Children's Online Privacy Protection Act
COSME	Competitiveness of Enterprises and Small and Medium-sized Enterprises
cPPP	Contractual Public-Private Partnership
CPS	Cyber-Physical Systems
CPS PWG	Cyber-Physical Systems Public Working Group

CPSoS	Cyber-physical Systems of Systems
CPS-VO	CPS Virtual Organization
CPU	Central Processing Unit
CS	Clean Sky
CSA	Coordination and Support Action
CSAAC	Cyber Situational Awareness Analytical Capabilities
CSD	Cyber Security Division
CSDP	Common Security and Defense Policy
CSIRT	Computer Security Incident Response Team
CSP	Cybersecurity and Privacy
CSR	Corporate Social Responsibility
CVE	Common Vulnerabilities and Exposures
CWC	Centre for Wireless Communications
D2D	Device-to-device
DARPA	Defense Advanced Research Projects Agency
DC	Direct Current
DDOS	Distributed Denial of Service
DEP	Digital Europe Programme
DG	Directorate General
DG CONNECT	Directorate General for Communications Networks, Content and Technology
DG MOVE	Directorate General Mobility and Transport
DHS	Department of Homeland Security
DIH	Digital Innovation Hub
DIN	Deutsches Institut für Normung
DISA	Defense Information Systems Agency
DLT	Distributed Ledger Technology
DNS	Domain Name System
DoC	Department of Commerce
DoD	Department of Defence
DoDIN	DoD Information Networks
DoE	Department of Energy
DoS	Department of State
DoT	Department of Transportation
DPD	Data Protection Directive
DREN	Defense Research and Engineering Network
DSA	Dynamic Spectrum Access
DSL	Digital Subscriber Line
DSM	Digital Single Market
DSP	Digital Signal Processor
DTN	Data Transfer Nodes
DTT	Digital Terrestrial Television
e2e	End-to-end
EASA	European Aviation Safety Agency
EC	European Commission
EC3	European Cybercrime Centre
ECDIS	Electronic Chart Display and Information Systems

ECJ	European Court of Justice
ECSEL	Electronic Components and Systems for European Leadership
ECSEL-JU	Electronic Components and Systems for European Leadership Joint Undertaking
ECSSO	European Cyber Security Organization
EDPS	European Data Protection Supervisor
EdW	Education and Workforce
EEA	European Economic Area
EeB	Energy-efficient Buildings
EERA	European Energy Research Alliance
EFTA	European Free Trade Association
EG	Expert Group
EHCS	Enabling R&D for High-capability Computing Systems
EHR	CEN
EIC	European Innovation Council
eIDAS	Electronic Identification, Authentication and Trust Services
EIN	Employer Identification Number
EIP	European Innovation Partnership
EIP – SCC	European Innovation Partnership on Smart Cities and Communities
EISA	Energy Independence and Security Act of 2007
EIT	European Institute of Innovation and Technology
eMBB	enhanced Mobile Broadband
EMSA	European Maritime Safety Agency
EMT	Emergency Medical Technician
eMTC	Enhanced Machine-type Communication
ENISA	European Union Agency for Network and Information Security
ENSG	Electricity Networks Strategy Group
EO	Executive Order
EPI	European Platform Initiative
ERA	European Railway Agency
ERA	European Research Area
ERRAC	European Rail Research Advisory Council
ERTMS	European Railway Traffic Management System
ERTRAC	European Road Transport Research Advisory Council
E-Sign Act	Electronic Signatures in Global and National Commerce Act
ESOs	European Standards Organizations
ETI	Energy Technology Institute
ETNA	European Transport Network Alliance
ETP	European Technology Platform
ETSI	European Telecommunications Standards Institute
EU	European Union
EV4SCC	Electric Vehicles for Smart Cities and Communities
FAA	Federal Aviation Administration
FBMC	Filter-Bank Multi-Carrier
FCC	Federal Communications Commission
FCH	Fuel Cells and Hydrogen

FERC	Federal Energy Regulatory Commission
FET	Future and Emerging Technologies
FFO	Federal Funding Opportunity
FIRE	Future Internet Research and Experimentation
FOA	Funding Opportunity Announcement
FoF	Factories of the Future
FP	Framework Programme
FP7	7th Framework Programme
FSS	Fixed-satellite Service
FTA	Free Trade Agreement
FTC	Federal Trade Commission
FWA	Fixed Wireless Access
FY	Financial Year
GAFA	Google, Amazon, Facebook, and Apple
Gbps	Gigabit per second
GCTC	Global Cities Team Challenge
GDP	Gross Domestic Product
GDPR	General Data Protection Regulation
GE	General Electric
GEANT	Gigabit European Academic Network
GENI	Global Environment for Networking Innovations
GFDM	Generalized Frequency-Division Multiplexing
GGE	Group of Governmental Experts
GHz	Gigahertz
GLIF	Global Lambda Integrated Facility
Global EPIC	Global Ecosystem of Ecosystems Partnership in Innovation and Cybersecurity
GP	General Practitioner
GPS	Global Positioning System
GRP	Global Research Platform
GSM	Global System for Mobile
GSM-A	Global System for Mobile Communications
GSM-A	Groupe Speciale Mobile Association
GSM-R	Global System for Mobile Communications – Railway
H2020	Horizon 2020
H2M	Human-to-machine
HAPS	High Altitude Platform Station
HCA	High-capability computing infrastructure and applications
HD	High-definition
HE	(Homomorphic) Encryption
HES	Higher Education Institutions
HGV	Heavy Goods Vehicle
HIPAA	Health Information Portability and Accountability Act
HMI	Human–Machine Interface
HP F&W	Hewlett Packard William and Flora Hewlett Foundation
HPC	High-performance Computing
HPCMP	High Performance Computing Modernization Program