CONTENTS

EDITORIAL:
Robot Based Automation with Industrial IT - a paradigm shift in industry
by Mr. Lars-Erik Ringström, ABB Sweden ix

EXECUTIVE SUMMARY 1

I INTRODUCTION 11

I.1 Sources and methods 11
I.1.1 New title - extended coverage 11
I.1.2 Data sources and reliability of data 11
I.1.3 Two types of stock data 13
I.1.4 Interpretation of the concepts of shipments, sales and yearly supply 14
I.1.5 Revision of time-series data on the robot stock 14
I.1.6 Data coverage and where to access data for previous years 15
I.2 Multipurpose manipulating industrial robots: definition and classification 17
I.2.1 Definition (ISO 8373) and delimitation 17
I.2.2 Classification by industrial branches 21
I.2.3 Classification by application areas 22
I.2.4 Classification by types of robots 23
I.3 Service robots: definition and classification 25
I.3.1 Provisional definition 25
I.3.2 Provisional classification of service robots by application areas 25

II WORLDWIDE DIFFUSION OF INDUSTRIAL ROBOTS 27

II.1 Shipments (sales) in units 27
II.2 Estimate of the worldwide operational stock of industrial robots 30
II.3 Estimate of the value of the world robot market in 1995-2000 33
II.4 Degree of concentration in the robot industry 33
II.5 Analysis of the effects of the business cycle on investments in industrial robots 36
II.6 The 2000 industrial robot stock, by industrial branches, in relation to value added and employment 39
II.7 Analysis of the development of robot density in selected countries 46
II.7.1 Definition of robot density 46
II.7.2 Measurements of robot density based on the total number of persons employed 46
II.7.3 Measurements of robot density based on the total number of production workers 50
II.8 Analysis of the stock and supply of multipurpose industrial robots in 2000 by major application areas 53
II.9 Analysis of the stock and supply of multipurpose industrial robots in 2000 by major industrial branches 59
II.10 Comparison between the motor vehicle industry and all other industrial branches 64
II.11 Installations of multipurpose industrial robots in 2000 by types of robots 64
II.12 Installations of multipurpose industrial robots with 5 axes or more 70

III PRICES, WAGES AND EMPLOYMENT 73

III.1 Introduction 73
III.1.1 Variables and indicators in selected industrial branches 73
III.1.2 Sources 73
III.1.3 Two types of price data for robotics 73

III.1.4 Outline of the chapter 74
III.2 Producer price indices for industrial robots - methodological overview 74
III.2.1 Characteristics of the pricing of industrial robots 74
III.2.2 Method of survey 75
III.2.3 Method for calculating a quality adjusted price index for industrial robots 75
III.3 Average unit price of robots in robot systems 76
III.4 International PPI for industrial robots 79
III.4.1 Without quality adjustment 79
III.4.2 With quality adjustment 79
III.5 United States - robot price and labour cost indices - wages and employment statistics 81
III.6 Germany - robot price and labour cost indices - wages and employment statistics 84
III.7 Italy - robot price and labour cost indices - wages and employment statistics 87
III.8 France - robot price and labour cost indices - wages and employment statistics 90
III.9 United Kingdom - robot price and labour cost indices - wages and employment statistics 93
III.10 Sweden - robot price and labour cost indices - wages and employment statistics 96
III.11 Republic of Korea - labour cost indices, wages and employment statistics 99

IV THE STRUCTURE OF THE DIFFUSION OF INDUSTRIAL ROBOTS IN INDIVIDUAL COUNTRIES 101

Introduction 101
Australia 102
Austria 108
Benelux 115
Denmark 117
Finland 125
France 133
Germany 145
Hungary 156
Italy 157
Japan 168
Norway 180
Poland 189
Portugal 195
Republic of Korea 198
Spain 210
Sweden 220
Switzerland 229
Taiwan Province of China 231
United Kingdom 239
United States (North America) 251
All other countries 256

V FORECAST OF WORLDWIDE INVESTMENT IN INDUSTRIAL ROBOTS IN THE PERIOD 2001-2004 257

V.1 Determining factors 257
V.2 The world economy - an overview 257
V.3 Assumptions 260
V.4 Forecasts 2001-2004 261
V.4.1 Historical development 261

V.4.2 Forecasts 2001-2004 ... 263
V.4.3 Results in the first half of 2001 ... 267
V.4.4 Comparison between forecasts for previous years and the actual outcome ... 267

VI THE PROFITABILITY OF INDUSTRIAL ROBOTS: ANALYSIS OF CASE STUDIES ... 269

VI.1 Introduction and conclusions ... 269
VI.1.1 Introduction ... 269
VI.1.2 Benefits of Robot Automation ... 269
VI.1.3 Conclusions ... 270
VI.2 Case study 1: Agile six-axis robots: Greater cost-effectiveness for injection moulding
by Mr. Jürgen Warmbold, Martfeld, Germany ... 274
VI.3 Case study 2: Robots servicing injection-moulding machines
by Stäubli, Robotics Division, France ... 277
VI.4 Case study 3: E-business and e-manufacturing at ABB's motor plant
by Mr. Åke Madesäter, ABB Flexible Automation, Sweden ... 279
VI.5 Case study 4: Robots in the 21st century bakery - justifying an automation project
by Mr. Dave Watson, Pepperidge Farm, United States ... 282

VII ROBOTICS AT NESTLÉ ... 285

VII.1 Present use of robotics at Nestlé ... 285
VII.1.1 Introduction ... 285
VII.1.2 Existing systems within Nestlé ... 285
VII.1.3 Justification for robots ... 286
VII.2 Requirement put by Nestlé on robotics ... 287
VII.2.1 Introduction ... 287
VII.2.2 Robotics versus manual operation ... 287
VII.2.3 Robotics versus mechanization ... 287
VII.2.4 Criticism and discussion on existing solutions ... 288
VII.3 How Nestlé sees future robotics use ... 288
VII.3.1 Introduction ... 288
VII.3.2 Expectations concerning robot suppliers ... 288
VII.3.3 Expectations concerning systems integrators ... 289
VII.3.4 Systems for the future ... 289
VII.4 Conclusion ... 289

VIII SERVICE ROBOTS ... 291

VIII.1 Introduction ... 291
VIII.2 Diffusion of service robots ... 291
VIII.3 Major application areas for service robots ... 295
VIII.3.1 Introduction ... 295
VIII.3.2 Cleaning robots ... 295
VIII.3.3 Sewer robots ... 300
VIII.3.4 Wall-climbing robots ... 301
VIII.3.5 Inspection robots, general (power plants, nuclear sites, bridges etc.) ... 303
VIII.3.6 Demolition robots; Servicing and/or dismantling nuclear, chemical, waste, military and other hazardous complexes ... 303
VIII.3.7 Underwater robots (inspection and work class robots) ... 304
VIII.3.8 Domestic robots ... 305
VIII.3.9 Medical robots ... 308
VIII.3.10 Robots for disabled persons; Assistive robots; Wheelchair robots ... 311
VIII.3.11 Courier robots; Mail delivery robots ... 313

VIII.3.12 Mobile robot platforms 314
VIII.3.13 Surveillance robots; Security robots 315
VIII.3.14 Unmanned aerial vehicles 317
VIII.3.15 Guide robots 317
VIII.3.16 Refuelling Robots 320
VIII.3.17 Fire- and bomb-fighting robots 321
VIII.3.18 Robots in the construction industry 322
VIII.3.19 Robots in agriculture and forestry 324
VIII.3.20 Hotel and restaurant robots 325
VIII.3.21 Clean room robots 326
VIII.3.22 Laboratory robots 326
VIII.3.23 Nano robots, micro robots 326
VIII.3.24 Humanoid robots 326
VIII.3.25 Space robots 326
VIII.3.26 Entertainment robots, including toy and hobby robots 327
VIII.3.27 Robots in marketing 327
VIII.3.28 Other types 327

Annex A 333

Table A-1 Total accumulated yearly sales of multipurpose industrial robots in selected countries. Number of units 334
Table A-2 Percentage yearly change in accumulated yearly sales of multipurpose industrial robots in selected countries 335
Table A-3 Estimated operational stock of multipurpose industrial robots at year end in selected countries. Number of units 336
Table A-4 Percentage yearly change in estimated operational stock of multipurpose industrial robots at year end in selected countries 337
Table A-5 Estimated yearly shipments (sales) of multipurpose industrial robots in selected countries. Number of units 338
Table A-6 Percentage yearly change in estimated shipments (sales) of multipurpose industrial robots in selected countries 339

Annex B Measuring service lives of industrial robots - Pilot study 341

1. Introduction 341
2. Method of survey 341
3. Steps taken 341
4. Questions surveyed 342
5. Two stock measures 342
6. Results of the survey 342
7. Conclusions of the survey 346
8. The survival paradox 346