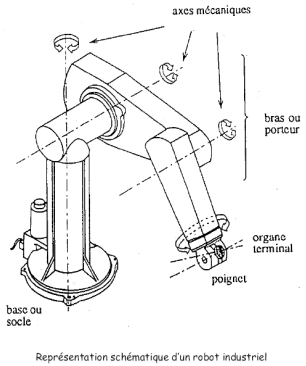
Robotics lecture

- Lecture organization (57h)
  - 16h lecture
  - 9h tutorial
  - 32h lab



Représentation schématique d'un robot industriel

Contact
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Robotics lecture

What do you know about Robotics?

Robotics lecture

NASA definition:

Robotics is the study of robots. Robots are machines that can be used to do jobs. Some robots can do work by themselves. Other robots must always have a person telling them what to do

General definition:

A science that deals with techniques and methods allowing to design, model, control and program robots.

Lecture content (UE robotics)

- Description : This lecture comprises two parts. The first one focuses on the basic notions of conventional robotics, in particular serial industrial robots (introduction to robotics, FKM, IKM…). The second part deals with the advanced notions of robotics related to dynamic modeling and robot control (dynamic modeling, control, trajectory generation…)

- Objectives :

✓ Acquire the basic notion of robotics,
✓ Define, integrate and exploit a robot within a production environment,
✓ Implement innovative robotics applications,
✓ Acquire the basic notions for the design of innovative robots kinematics.

Lecture content (UE robotics)

Part I (general robotics, 9h lecture, 6h tutorial, 16h lab)

- Introduction to robotics: definitions, robots typologies and types of applications,
- Vocabulary and terminology of robotics,
- Forward and inverse kinematics models,
- Velocity kinematics model.

Part II (advanced robotics, 7h lecture, 3h tutorial, 16h lab)

- Dynamic modeling,
- Robot control and trajectory generation,
- Accuracy and repeatability, tool measurement and calibration.

Reference

1- Wisama Khalil et Etienne Dombre, "**Modélisation identification et commandes des robots**", 2 eme edition, Hermès, 1999.

2- Mark W. Spong, Seth Hutchinson, and M. Vidyasagar, "**Robot Dynamics and Contro**l" Second Edition, 2004.

Etymology

Robot

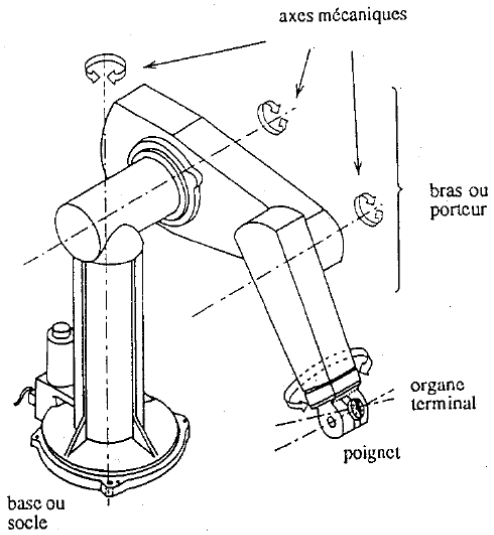
From czech "robota" (forced work, corvee)

(from bulgarian, robu = servant)

work = rabota (russian), arbeit (German)

Definition

Robot is an articulated structure with several parts. Each part is actuated with a motor and controlled by a computer.



Représentation schématique d'un robot industriel

Robot is a programmable mechatronics machine equipped with perception (encoders, position sensor, vision sensors, camera, force and torque sensors), interpretation (unite control and algorithm) and action mechanisms (actuators: motors) that allow to act on the physical environment.

Definition

Norme ISO 8373

Robot industriel pour la manipulation:

*« robot pour **manipulation programmable** de **trois axes ou plus**, à **usage multiple**, contrôlé **automatiquement**, **reprogrammable**, qui peut être **mobile** ou **fixe** lors de son utilisation automatique. »*

ISO 8373 norm

Industrial robot for manipulation:

*« **programmable robot** for manipulation having **three axis or more**, with a **multiple use**, **automatic control** and can be **fix** or **mobile** during its automatic use.*

Definition

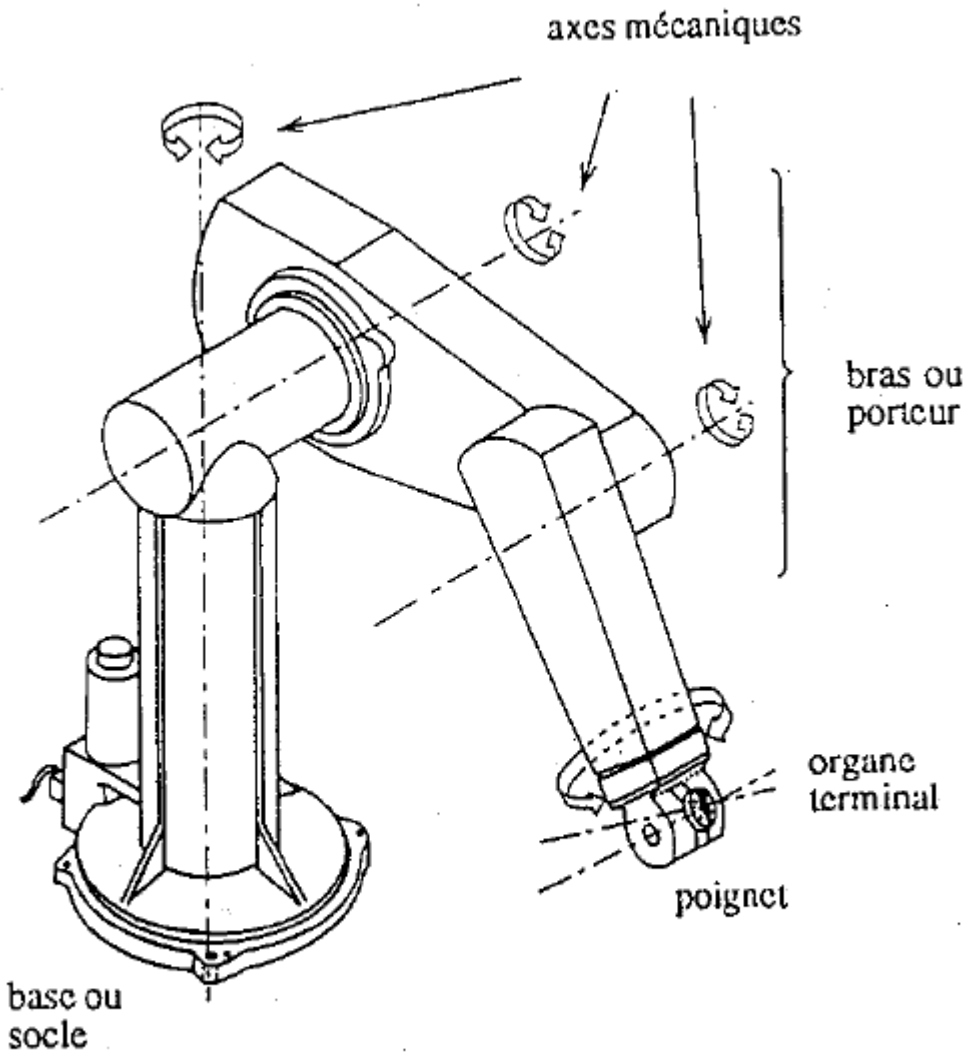
Robot de service :

*«robot **mi ou totalement autonome** accomplissant des **services** utiles au **bien-être de l'homme** et aussi utilisés sur du matériel, à l'exception des tâches industrielles.»*

Service robot:

*« **Sub or totally autonomous** robot achieving **services** for **human care** and can be combined with mobile platform, except industrial tasks.»*

Vocabulary



Représentation schématique d'un robot industriel

-Base (base)
-Robot arm (porteur)
-Wrist (poignet)
-Active link (liaison active)
-Passive link (liaison passive)
-configuration coordinates (coordonnées articulaires)
-Operational coordinates (coordonnées opérationnelles)

Usual industrial robots configurations

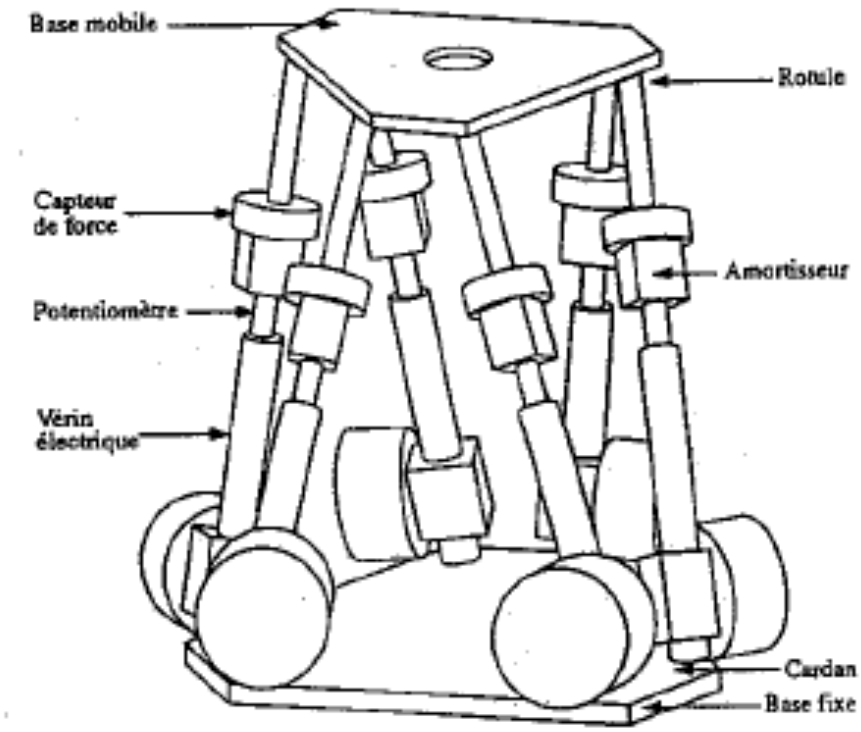


Plate-forme de Stewart

Robot with open kinematics
(**Serial robots**)

Robot with cloosed kinematics
(**Parallel robots**)

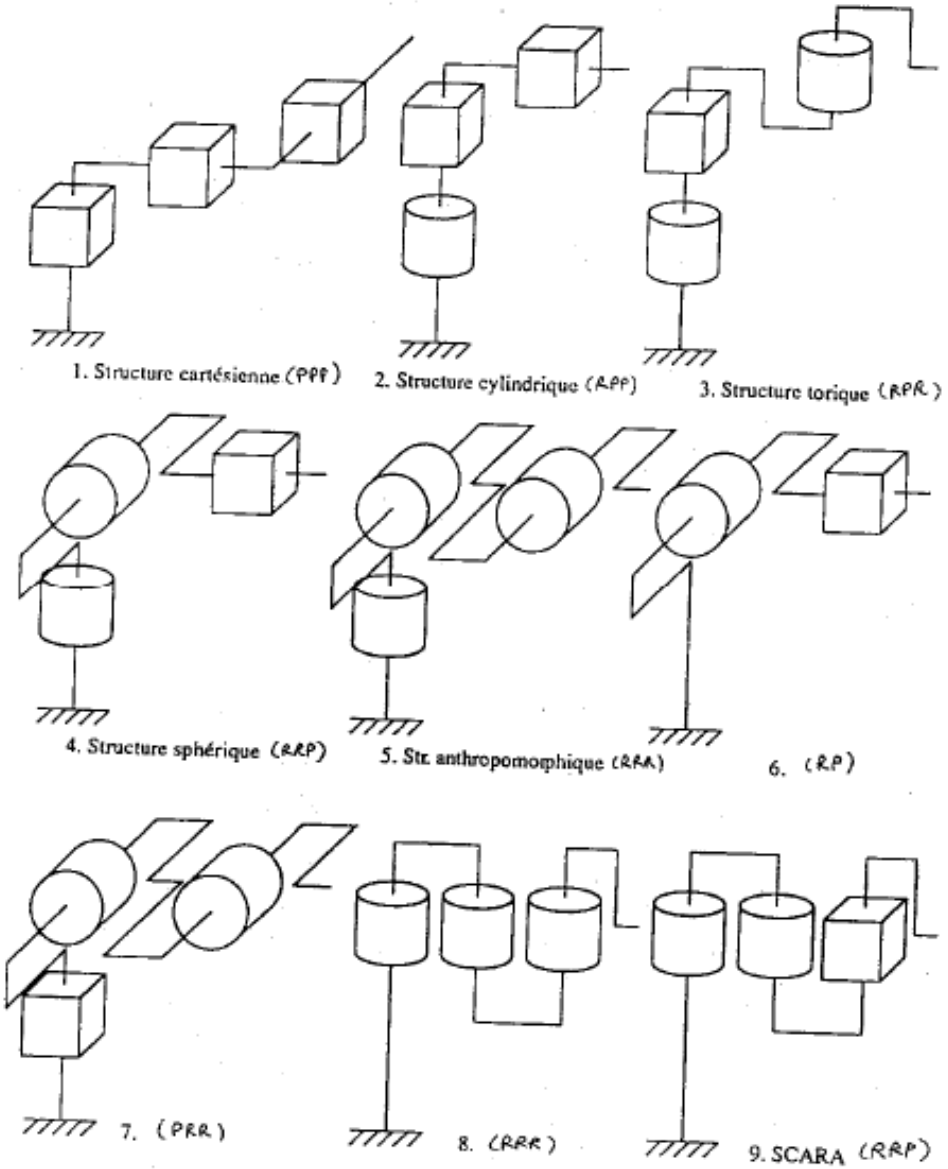
Serial robots

STÄUBLI TX90

COBRA s350

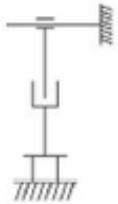
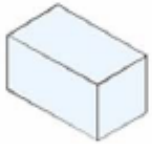
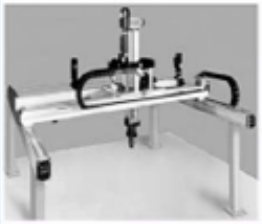
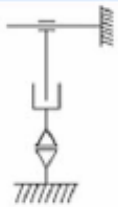
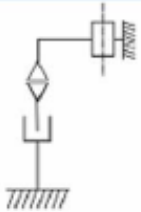
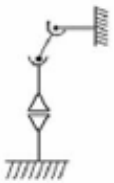
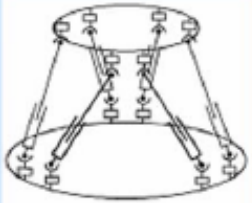
Serial robot : Open kinematics mechanism where the end effector is connected to the base with a series of rigid links. Each link is connected the the previous link through a one degree of freedom articulation (revolute or prismatic joint).

Holder with open kinematic chain



(R : rotoïde, P : prismatique)

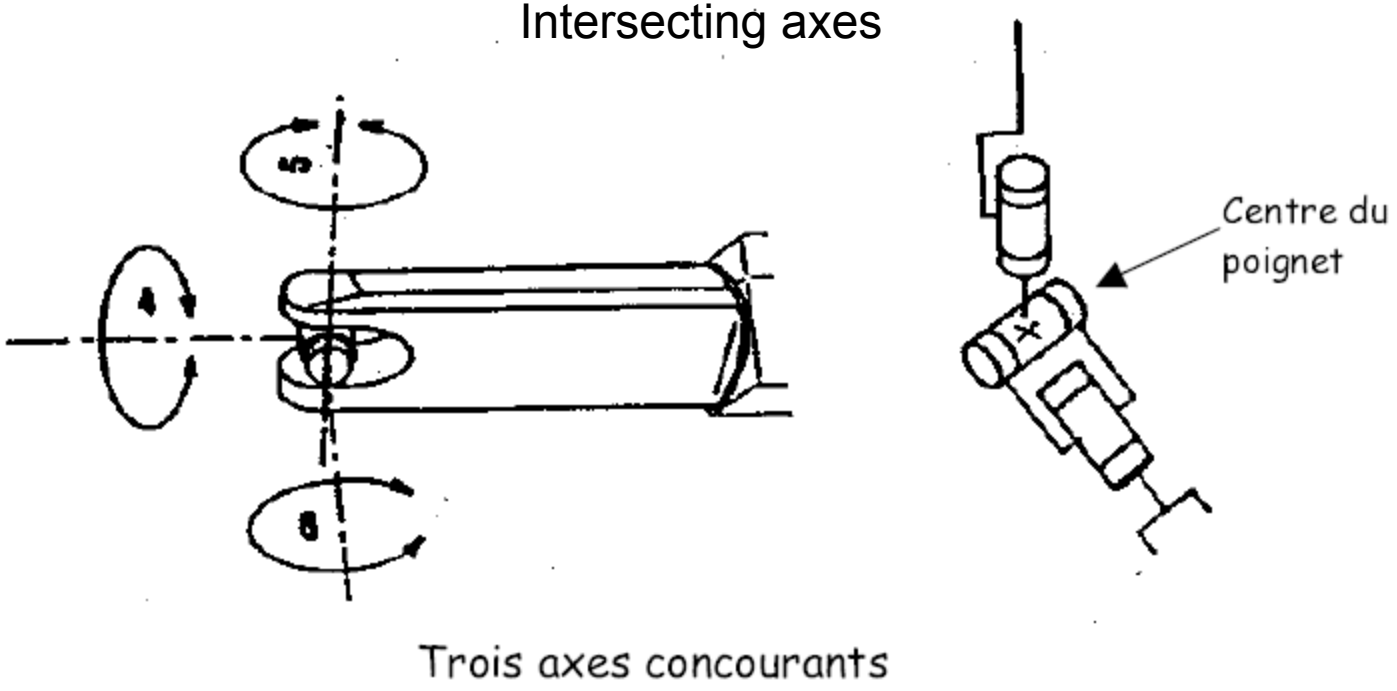
Holder with open kinematic chain

Robot	Axes		Examples
Principle	Kinematic Structure	Workspace	Photo
 Cartesian Robot			
 Cylindrical Robot			
 SCARA Robot			
 Articulated Robot			
 Parallel Robot			

Wrist configuration

Depending on the application, we can find a wrist with one, two or three joints.

Intersecting axes

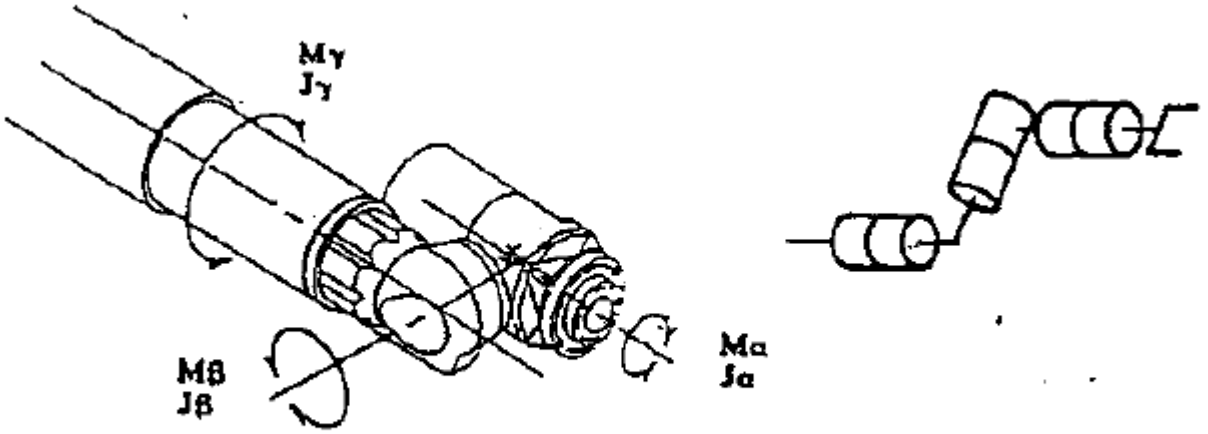


Trois axes concourants

This configuration is equivalent to a spherical joint. It allows a random orientation of the wrist. This may simplify the robot control since the center of the wrist is fix relative to the robot arm. Therefore, its position depends only on the robot arm position.

Wrist configuration

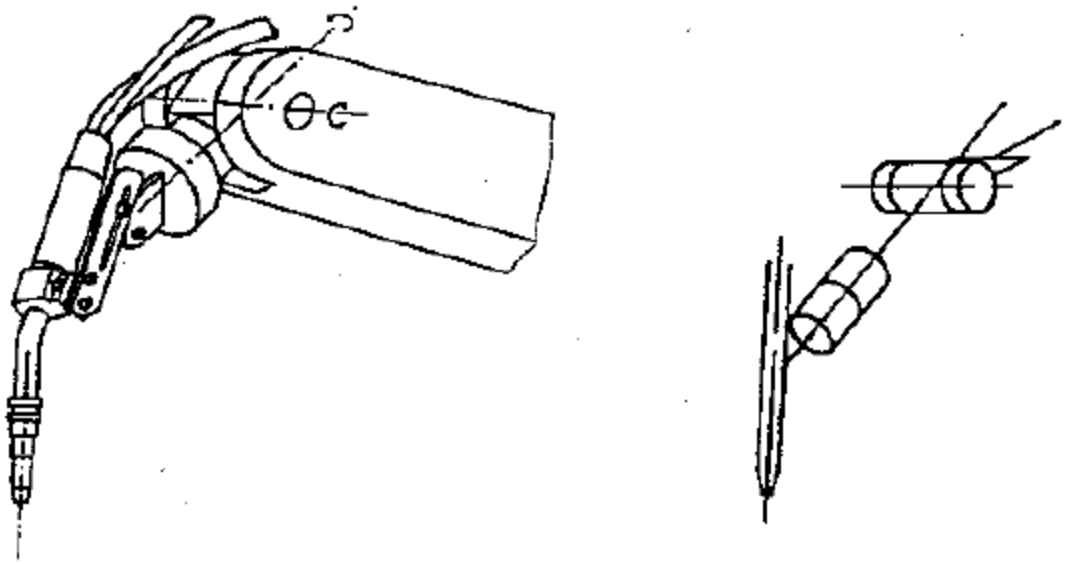
Non-intersecting axes



Trois axes non concourants

Wide angle joint but control is complex

Wrist configuration



Deux axes

Example of serial robots

ROBOT PORTIQUE COMAU

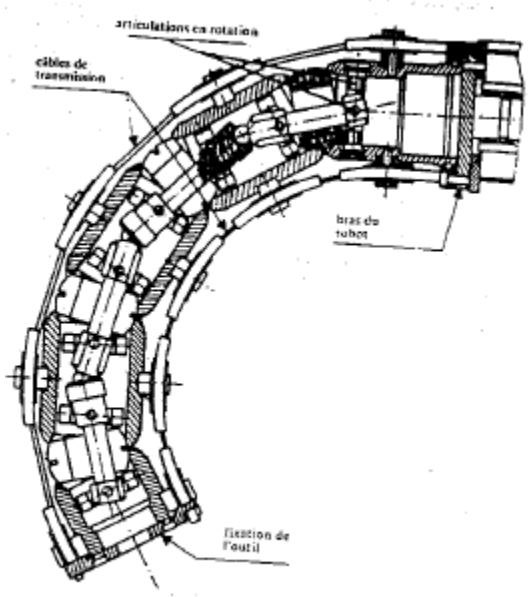
Example of serial robots

KUKA KR 5 sixx R650
(débrayable par mesure des efforts)

Example of serial robots

KUKA LWR (Light-Weight Robot),
5 kg, 7 axes

Redundant structures



Structure ouverte redondante

«Elephant trunk structure »

Example of serial robots

Motoman SIA20

Example of serial robots

Adept SCARA

Adept COBRA

Mitsubishi RP-1AH

Kuka LWR 1

Kuka LWR 2

Motoman SIA20

Stäubli 1

Stäubli 2

Stäubli 3

Adept

PHL

Parallel robots

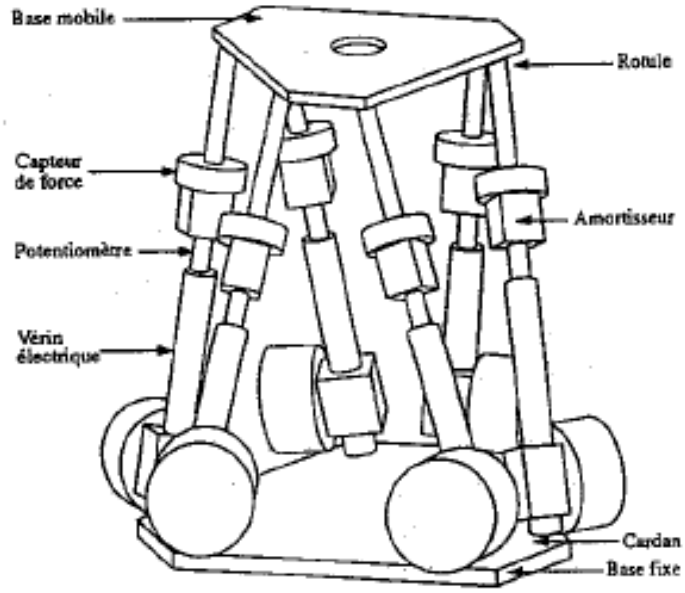
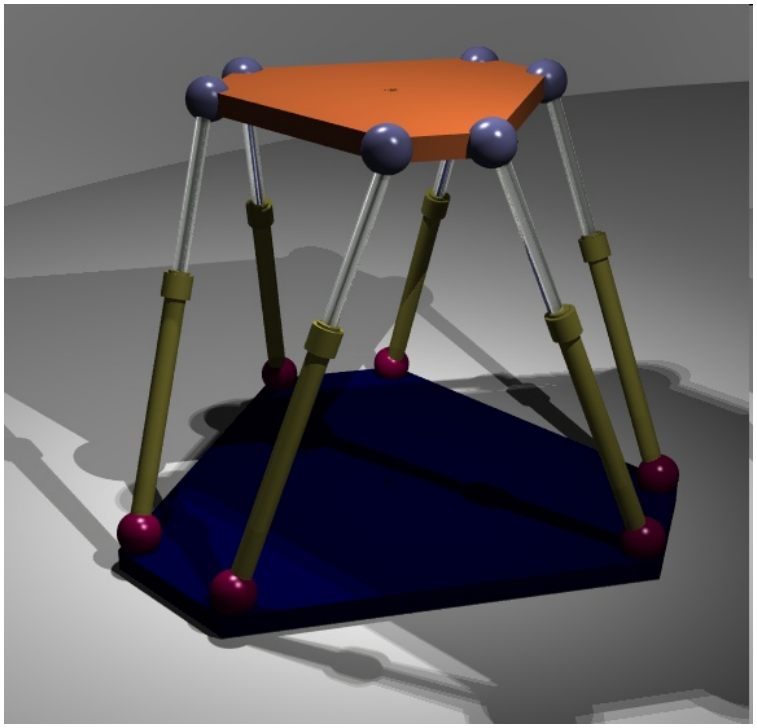
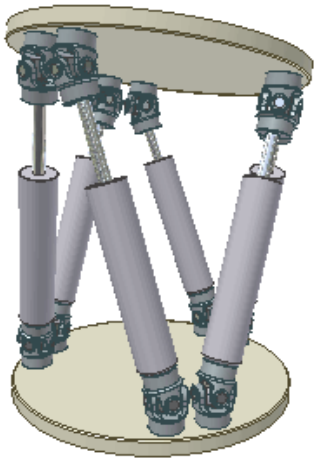


Plate-forme de Stewart

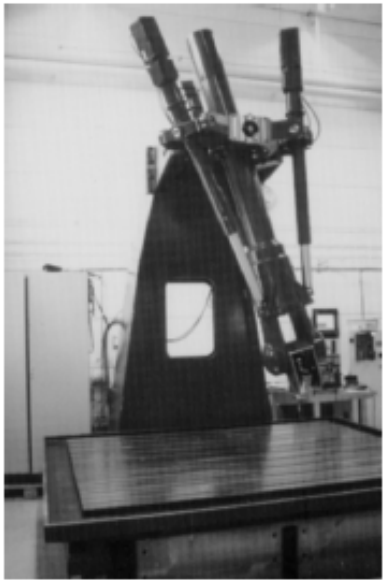




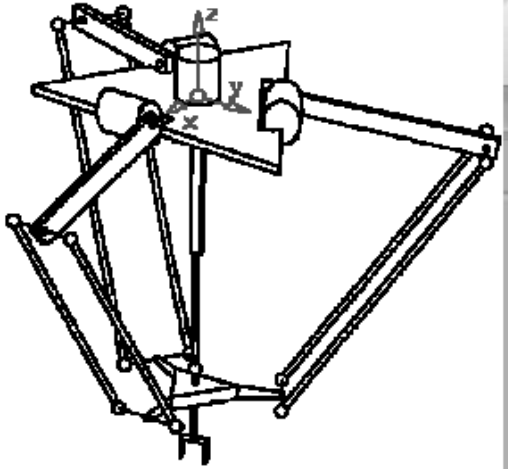
Parallel robots : Closed kinematic chain where the end effector is linked to the base through independent kinematic chains.

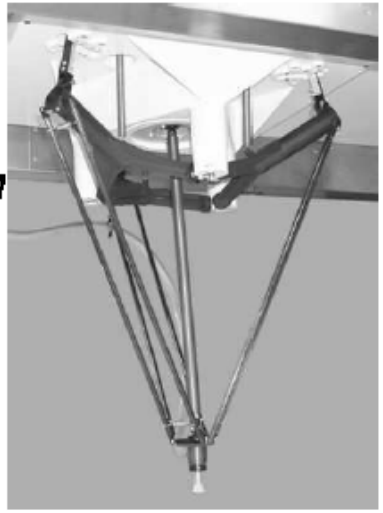
Parallel robots

IRB 360 ABB



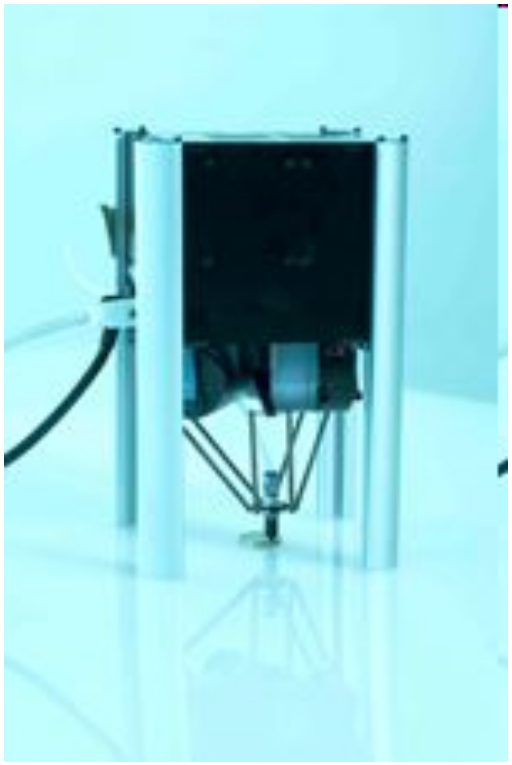
Robot Tricept (Comau)





Robot Delta (Demaurex)

Parallel robots



Pocket Delta (www.asyril.ch)

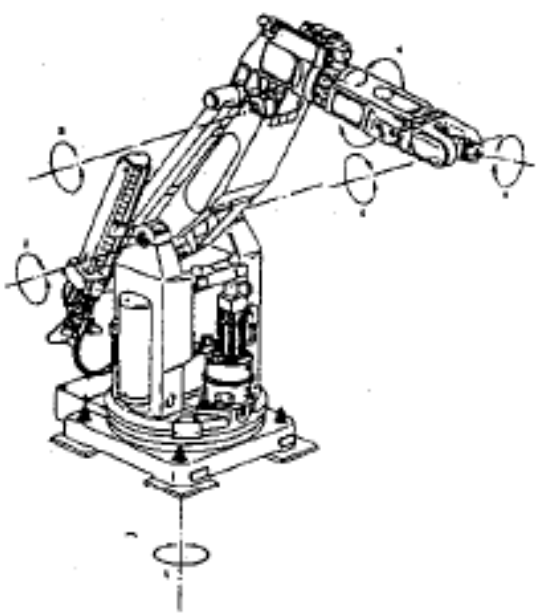
3 axes (x,y,z)
Repeatability : ± 0.0025 mm
Achievable domain (workspace): Ø 80 mm - z: 30 mm

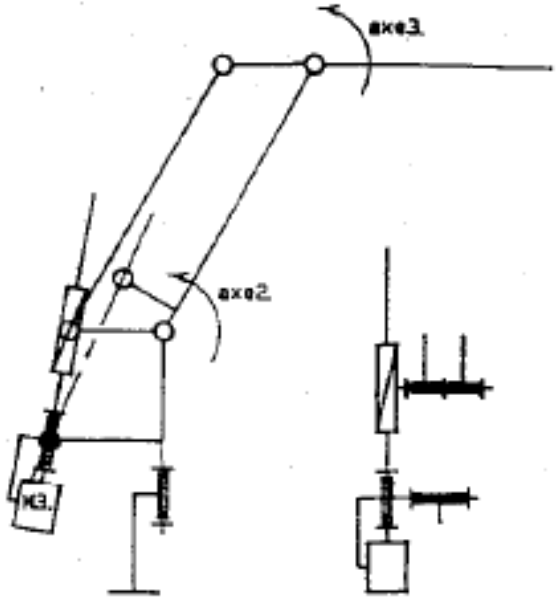
FANUC F-200iB

Parallel robots

ADEPT QUATTRO

Parallel robots





Robot à parallélogramme

Parallel robots

ABB IRB340 1

ABB IRB340 2

ABB IRB340 3

ABB IRB340 4

ADEPT QUATTRO

Example

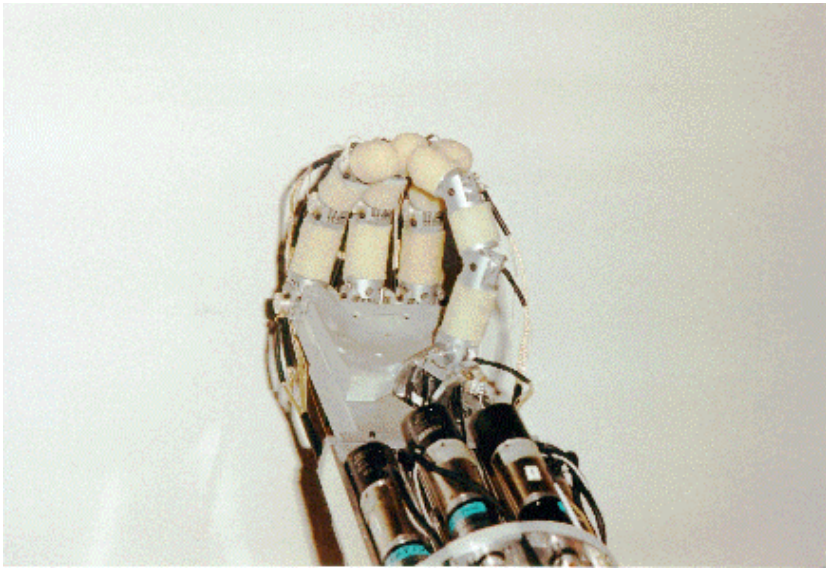
Prise et dépose à la volée par FlexPicker IRB 340 (préhenseurs développés sur-mesure), société Bifi (Groupe Unilever), permet datteindre des cadences de production élevées. Il s'agit de prendre jusqu'à 6 types différents de saucisses sur un convoyeur.

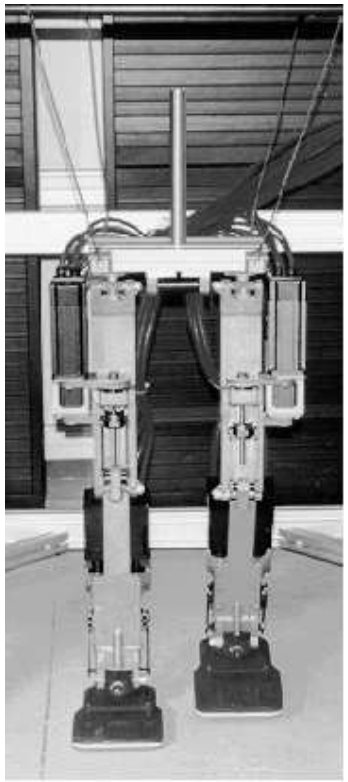
Example

Robot boucher, Alci SAS www.alci.fr

Manual cutting (5°C, 80% of humidity) : 100 kg/h, 10% of error
Robotic cutting: 250 kg/h, 5% of error

Robots with tree kinematics

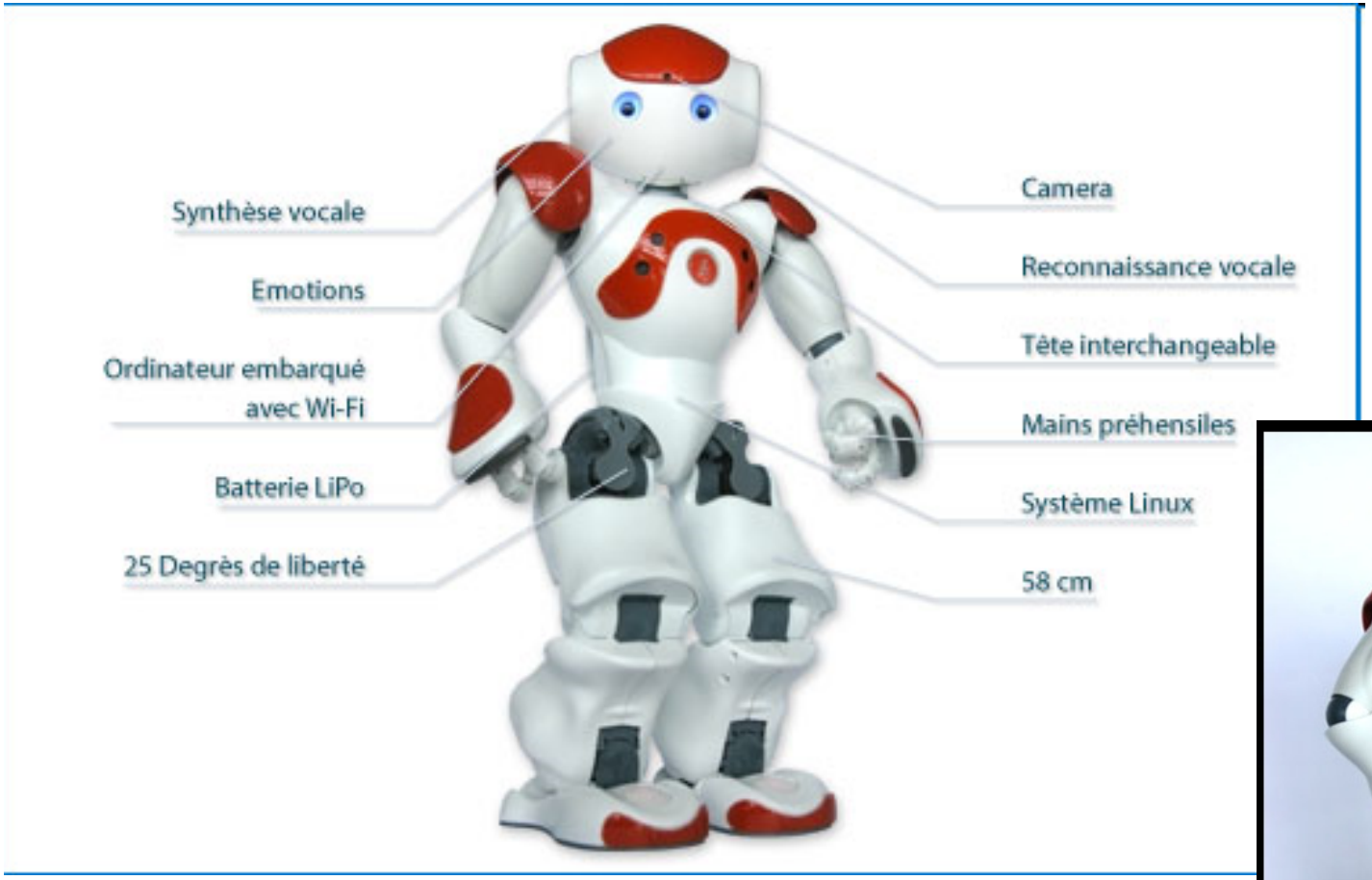




Main articulée et robot bipède, LMS Poitiers

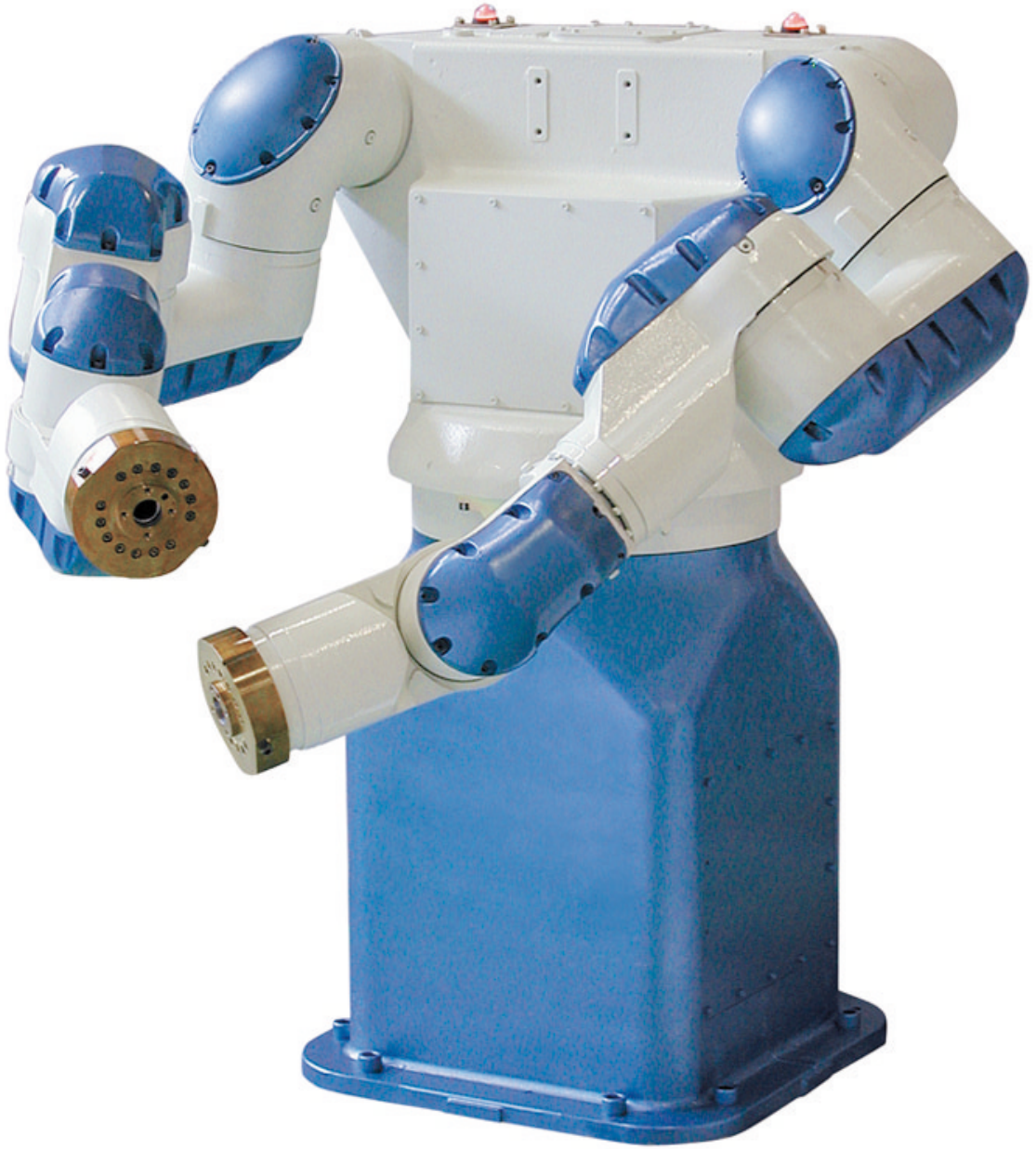
AIBO Sony

Robots with tree kinematics



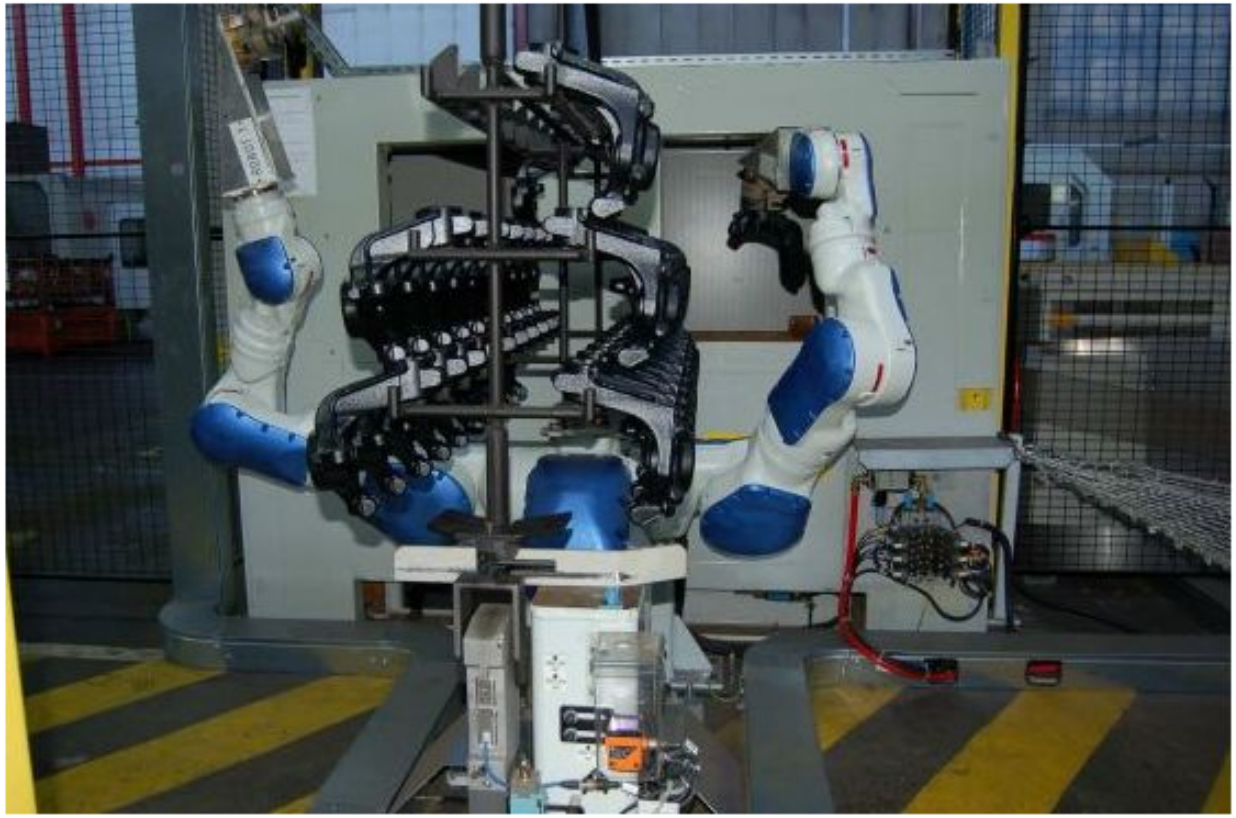
Nao Robot (Aldebaran Robotics)
www.aldebaran-robotics.com

Robots with tree kinematics



MOTOMAN – DA20
13 axes (=2x6 + 1)

Robots with tree kinematics



Robot programming

Off line programming

A bit of history

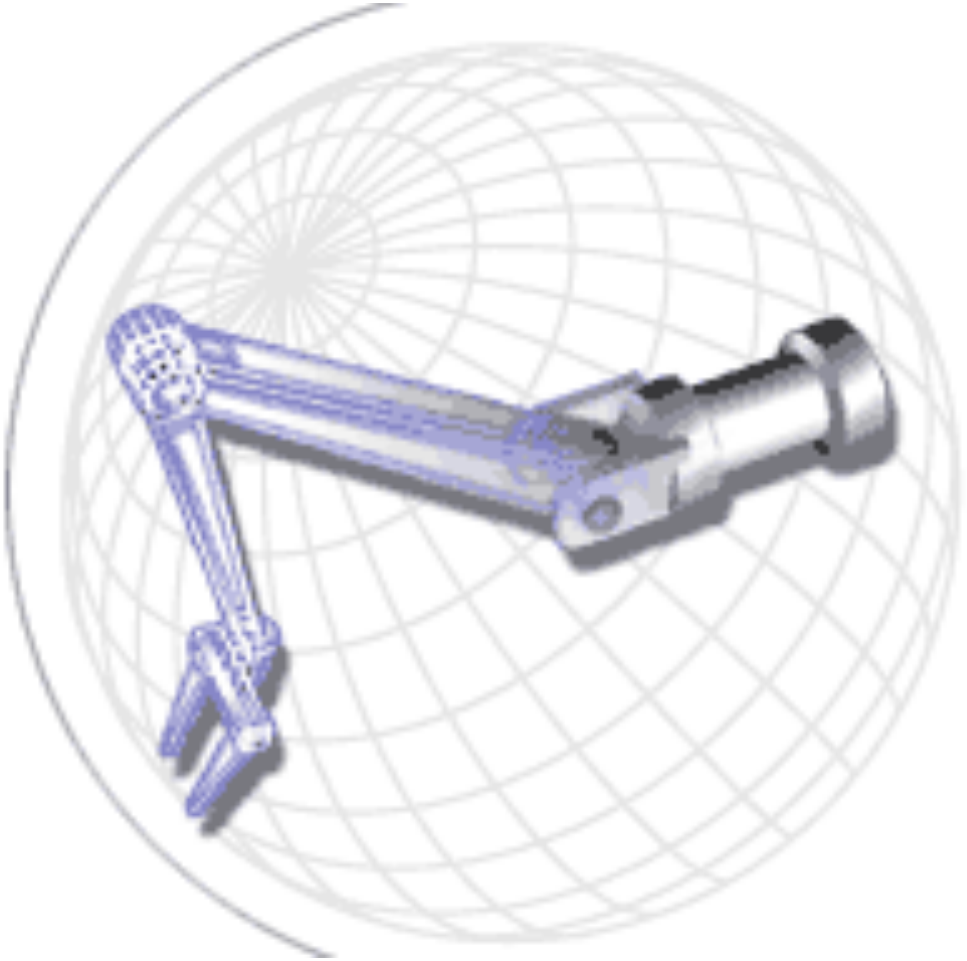
1947
First mechanical tele manipulatorde Goertz

1950
Isaac Asimov, "Les robots"

1954
First concept de industrial robot (Devol):
Manipulation arm control with electronics

1961
First patent and commercialization of Unimate robot n°001 (Unimation Inc.). (8500 unites !)

La robotique industrielle d'aujourd'hui



Chiffres 2007 et 2010, Sources : UN, UE, IFR, associations nationales de robotique
Stock opérationnel : robots en service depuis 12 ans ou moins

La robotique industrielle en chiffres

- Le nombre de robots industriels installés dans le monde représente en fin 2006 de l'ordre d'un million d'unités (3% d'augmentation depuis 2005), dont :
  - 352000 au Japon (37%)
  - 151000 en Amérique du Nord (Etats-Unis, Canada, Mexique) (16%)
  - 316000 en Europe (33%)
    - 133000 en Allemagne (42%)
    - 60000 en Italie (19%)
    - 32000 en France (6,2% d'augmentation par rapport à 2005) (10%)
    - 26000 en Espagne (8%)
    - 15000 au Royaume Uni (4,8%)

- 50% de ces robots en Asie, un tiers en Europe et 16 % en Amérique (0,1% en Afrique).

- En 2006, la vente de robots industriels en France est stable depuis 5 ans. Jusqu'en 2007, environ 3000 robots/an (stagnation dans l'automobile, montée significative de la métallurgie, montée remarquable de la chimie et de l'agroalimentaire).

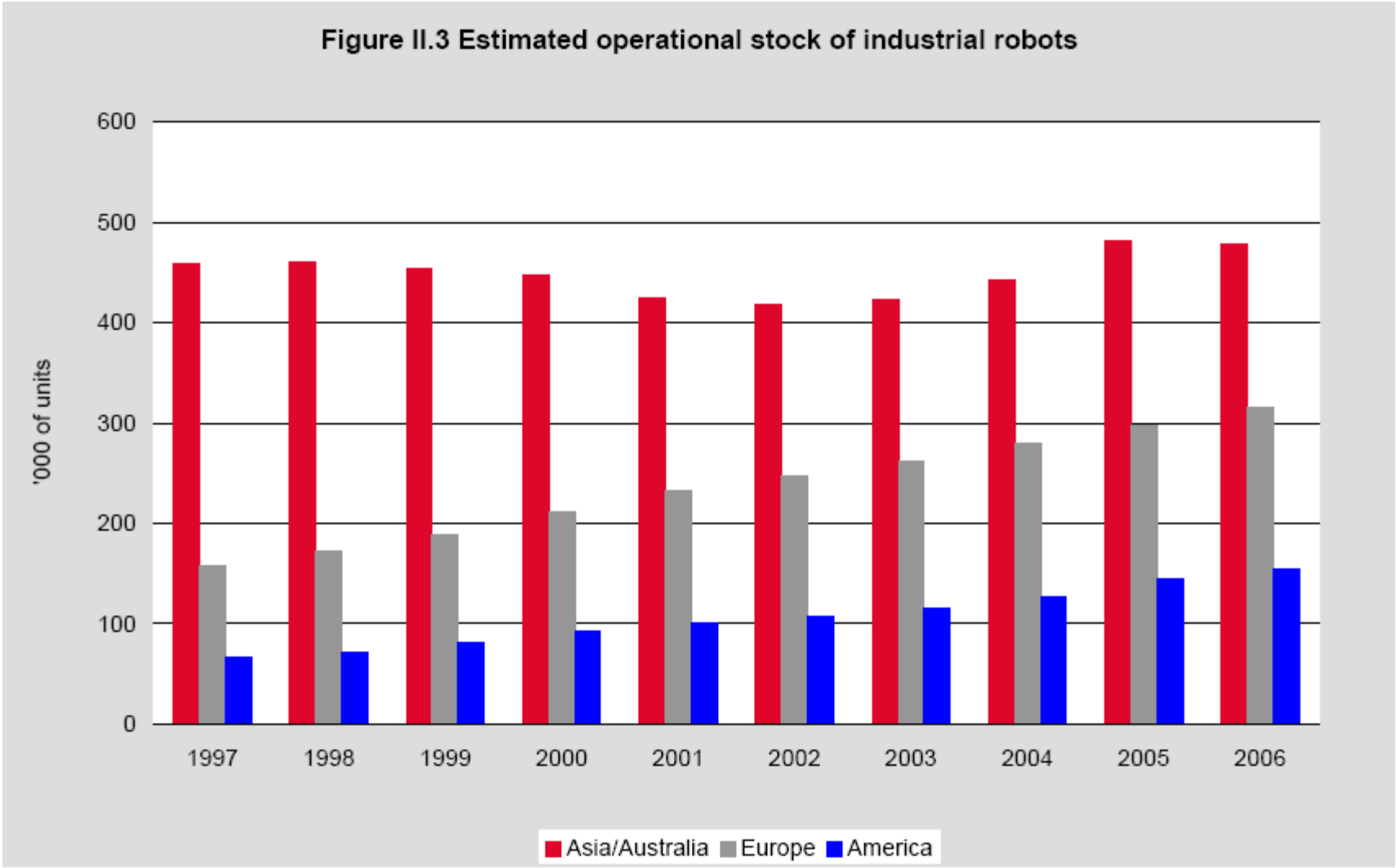
- En 2009, avec la chute mondiale des investissements, les commandes de robots ont diminué de 40 % à 70 %, selon les pays.

Stock opérationnel de robots industriels

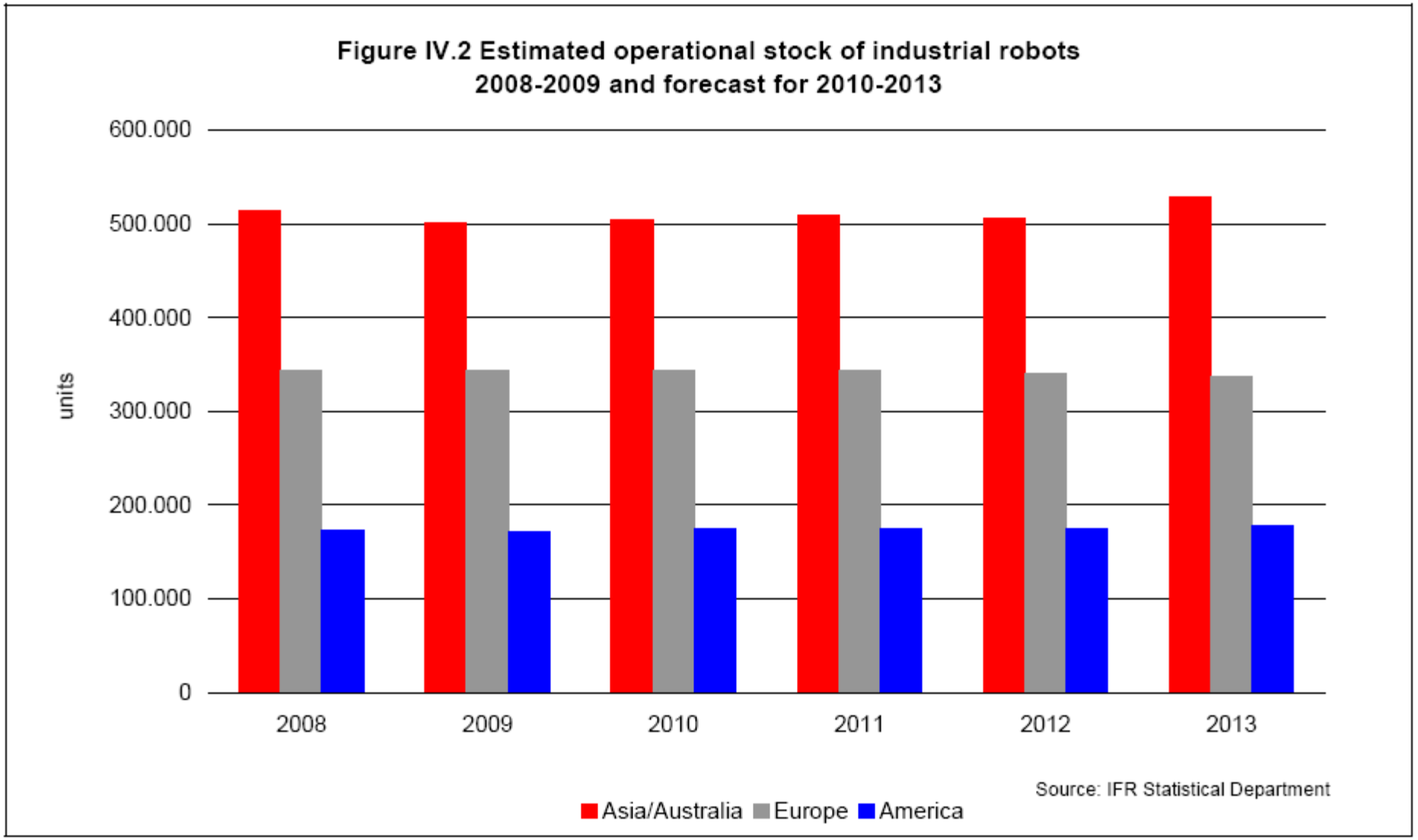
	Yearly installations			Operational stock at year-end		
Country	**2009**	**2010**	**2013**	**2009**	**2010**	**2013**
America	**8.992**	**11.900**	**15.300**	**172.141**	**174.600**	**178.700**
North America (Canada, Mexico, USA)	8.417	11.000	13.500	166.183	167.800	169.100
Central and South America	575	900	1.800	5.958	6.800	9.600
Asia/Australia	**30.117**	**40.500**	**57.100**	**501.422**	**504.600**	**528.500**
China	5.525	8.500	16.500	37.312	45.800	84.500
India	363	600	1.500	4.079	4.700	8.100
Japan	12.767	17.000	21.000	332.720	315.900	263.700
Republic of Korea	7.839	9.800	12.000	79.003	87.400	109.800
Taiwan	1.474	2.000	2.800	24.365	25.600	31.000
Thailand	774	1.000	1.400	7.185	8.200	11.900
Other Asia	866	1.600	1.900	10.061	17.000	19.500
Australia/New Zealand	509			6.697		
Europe	**20.483**	**23.000**	**29.100**	**343.661**	**344.400**	**337.200**
Benelux	1.286			11.678		
France	1.450	1.700	2.000	34.099	34.200	29.500
Germany	8.507	10.000	12.600	144.133	144.200	143.300
Italy	2.883	2.900	4.200	62.242	60.800	54.500
Spain	1.348	1.500	1.800	28.781	28.500	24.900
Sweden	587			9.396		
United Kingdom	635	650	900	13.923	13.300	10.800
Central/Eastern European countries	1.448			10.268		
other Europe	2.339	6.250	7.600	29.141	63.400	74.200
Africa	**196**	**300**	**500**	**1.973**	**2.300**	**3.300**
Total	**60.018**	**76.000**	**102.300**	**1.020.731**	**1.027.000**	**1.049.000**

Source: IFR, national robot associations

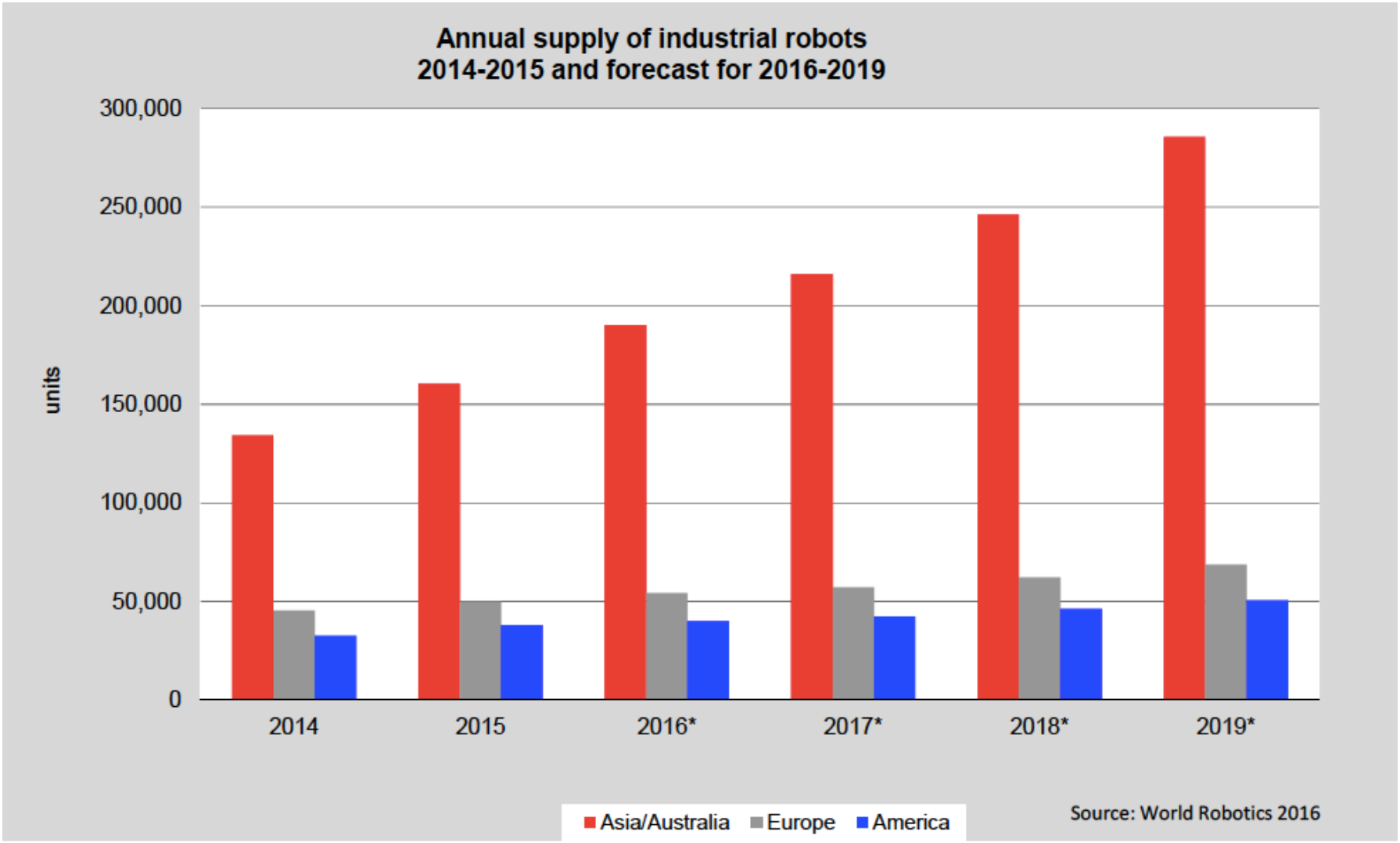
Stock opérationnel de robots industriels



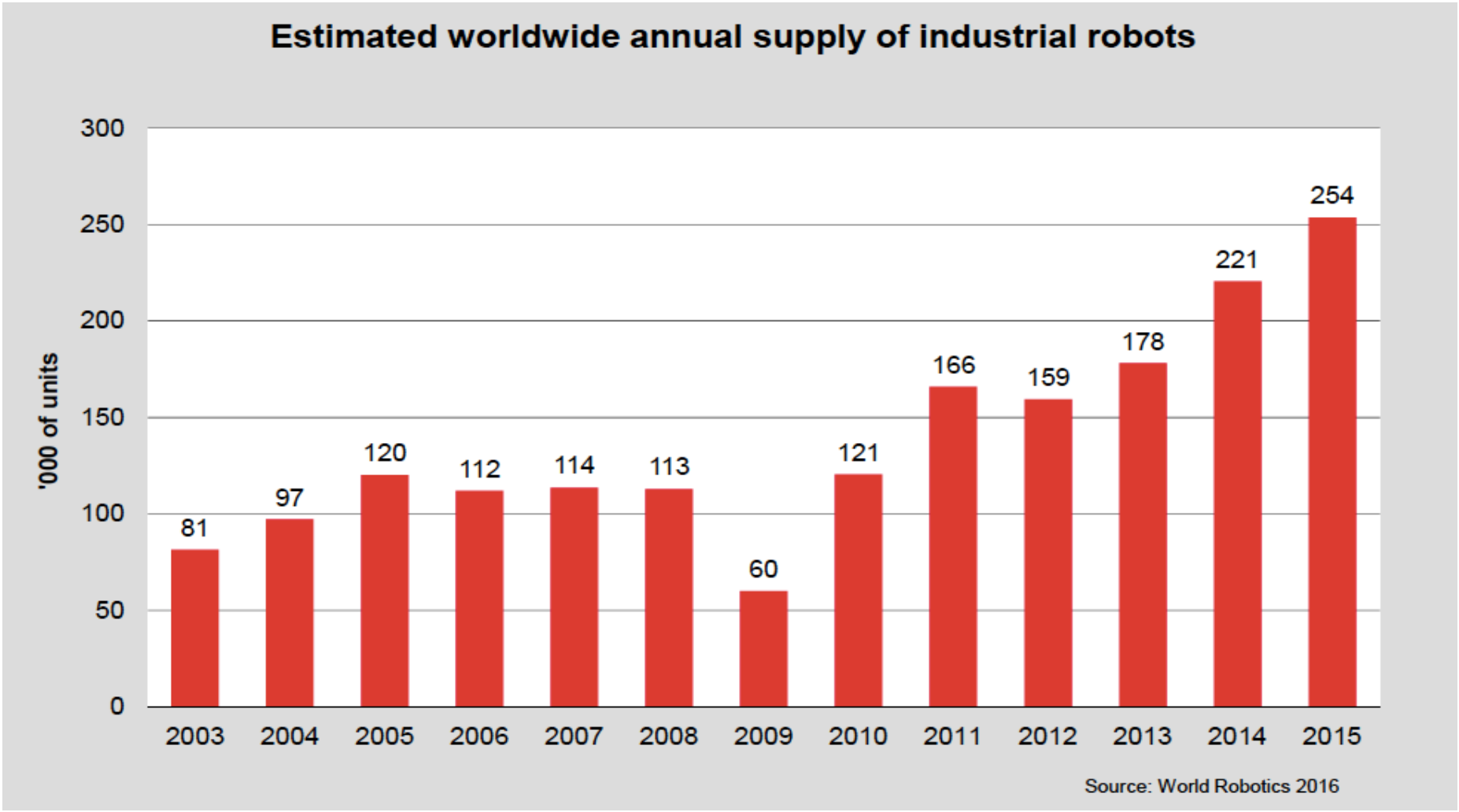
Stock opérationnel de robots industriels



Stock opérationnel de robots industriels



Stock opérationnel de robots industriels



Stock opérationnel de robots industriels

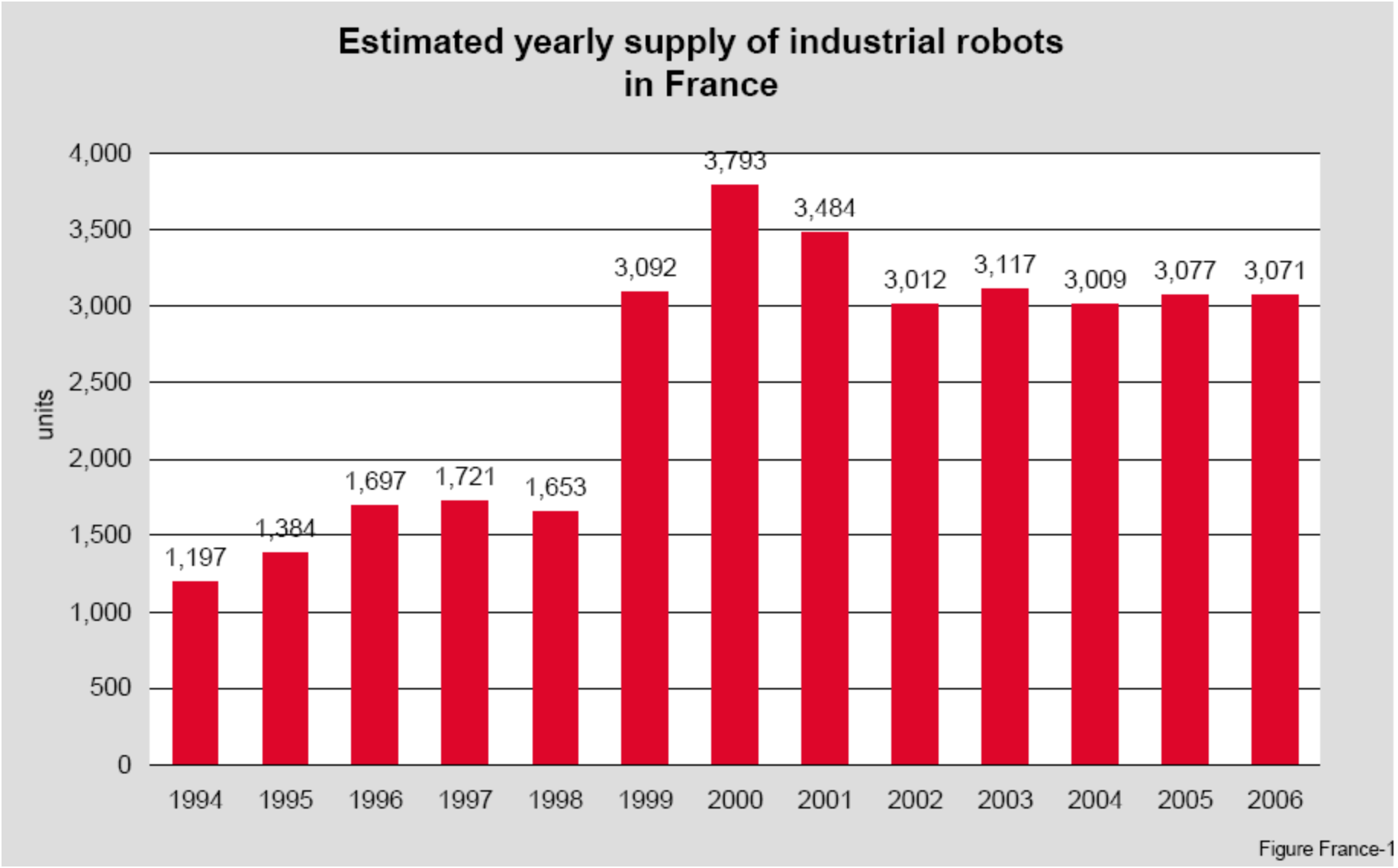


Figure France-1

Stock opérationnel de robots industriels

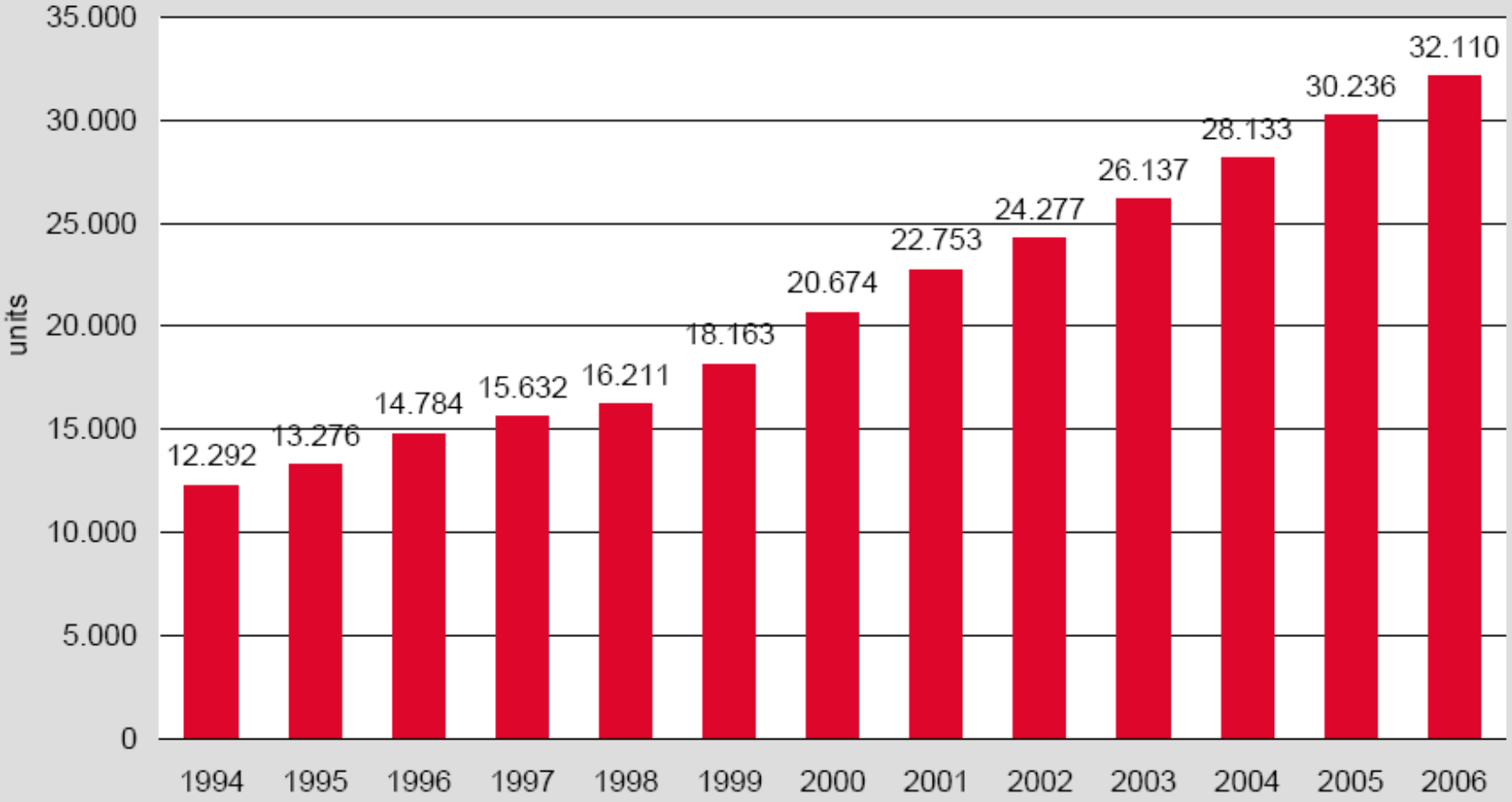


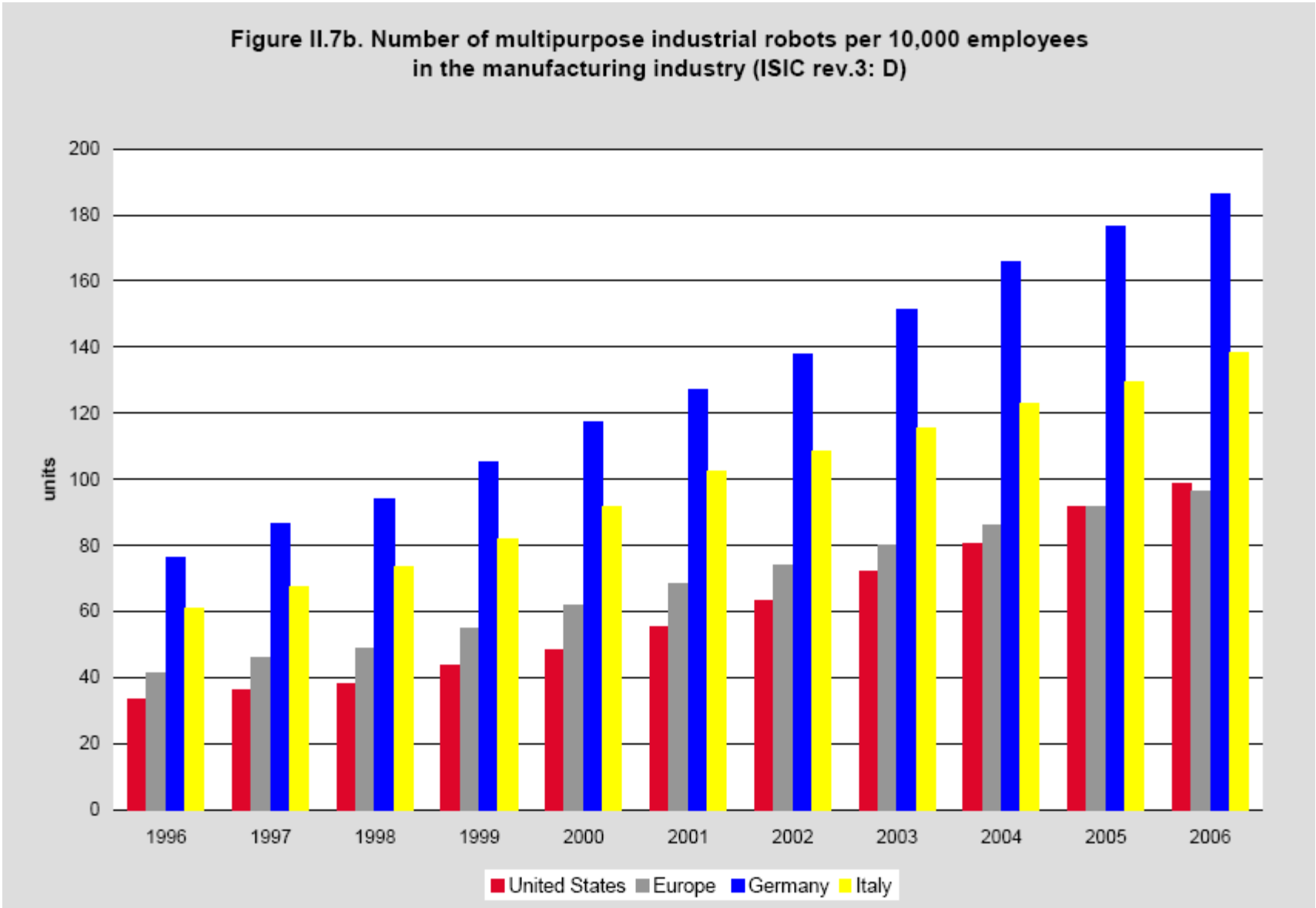
Figure France-3

La robotique industrielle en chiffres

Estimated number of multipurpose industrial robots per 10,000 persons employed in the manufacturing industry (ISIC rev.3: D).

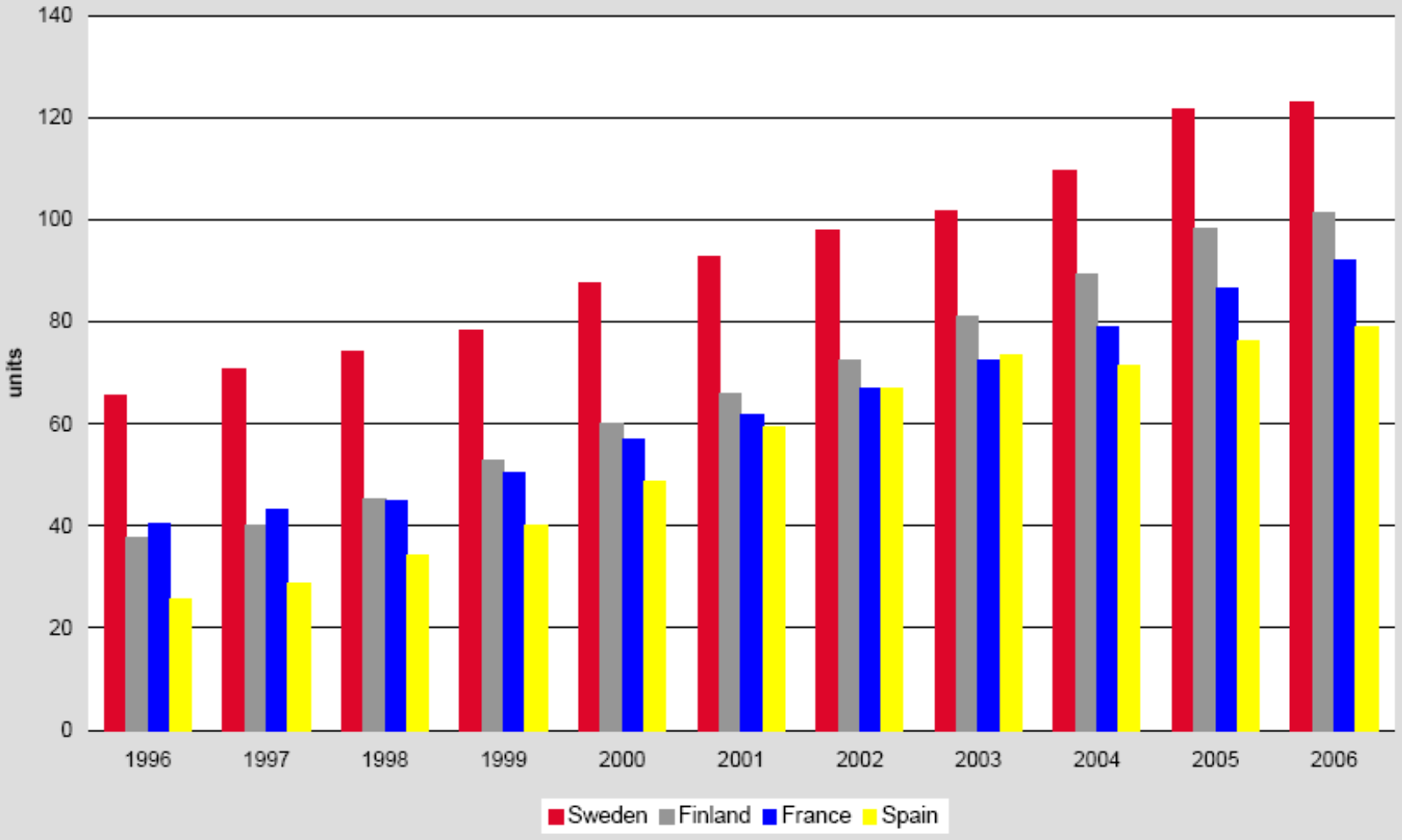
Country	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
United States	**31**	**34**	**36**	**38**	**44**	**48**	**55**	**63**	**72**	**81**	**91**	**99**
Asia/Australia												
Japan	**307**	**318**	**330**	**343**	**344**	**337**	**319**	**324**	**329**	**351**	**372**	**349**
Rep. of Korea	44	62	80	96	101	107	117	126	135	138	168	187
Australia	18	19	23	26	27	28	30	32	36	42	49	56
Europe	**36**	**41**	**46**	**49**	**55**	**62**	**68**	**74**	**80**	**86**	**92**	**97**
Austria	35	39	43	43	46	48	50	56	58	67	70	71
Benelux	30	35	38	42	47	48	51	53	57	54	58	62
Czech Rep.	3	4	4	5	7	8	8	8	12	13	17	21
Denmark	15	17	19	23	26	32	39	44	51	60	66	75
Finland	35	38	40	45	53	60	66	73	81	89	98	101
France	36	40	43	45	50	57	62	67	72	79	87	92
Germany	**63**	**76**	**86**	**94**	**105**	**117**	**127**	**138**	**151**	**166**	**176**	**186**
Hungary	3	3	3	3	3	3	2	2	2	3	5	7
Italy	54	61	68	73	82	92	102	108	115	123	130	138
Norway	16	16	15	15	16	18	22	24	24	26	28	33
Poland	2	1	1	1	2	2	2	3	3	3	4	5
Portugal	5	7	8	9	10	12	13	14	15	18	18	19
Spain	22	26	29	34	40	49	60	67	74	71	76	79
Sweden	62	66	71	74	78	88	93	98	102	110	122	123
Switzerland	0	0	0	53	57	56	56	53	53	57	60	61
United Kingdom	20	21	24	26	29	31	35	38	41	44	48	50

La robotique industrielle en chiffres



La robotique industrielle en chiffres

Figure II.7c. Number of multipurpose industrial robots per 10,000 employees in the manufacturing industry (ISIC rev.3: D)



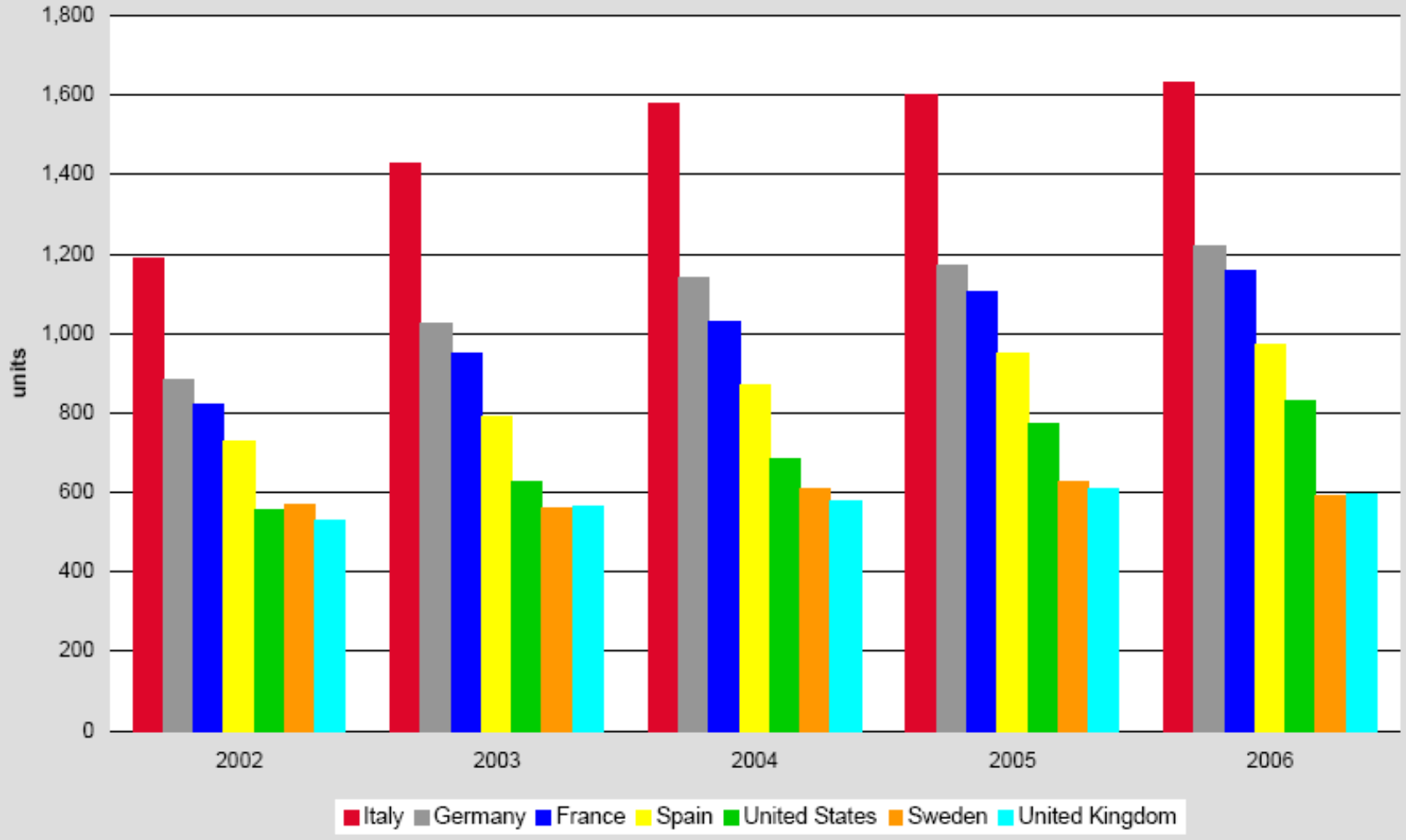
La robotique industrielle en chiffres

Estimated number of multipurpose industrial robots per 10,000 production workers in the manufacturing industry (ISIC rev.3: D) and in the motor vehicle industry (ISIC rev.3: 34)

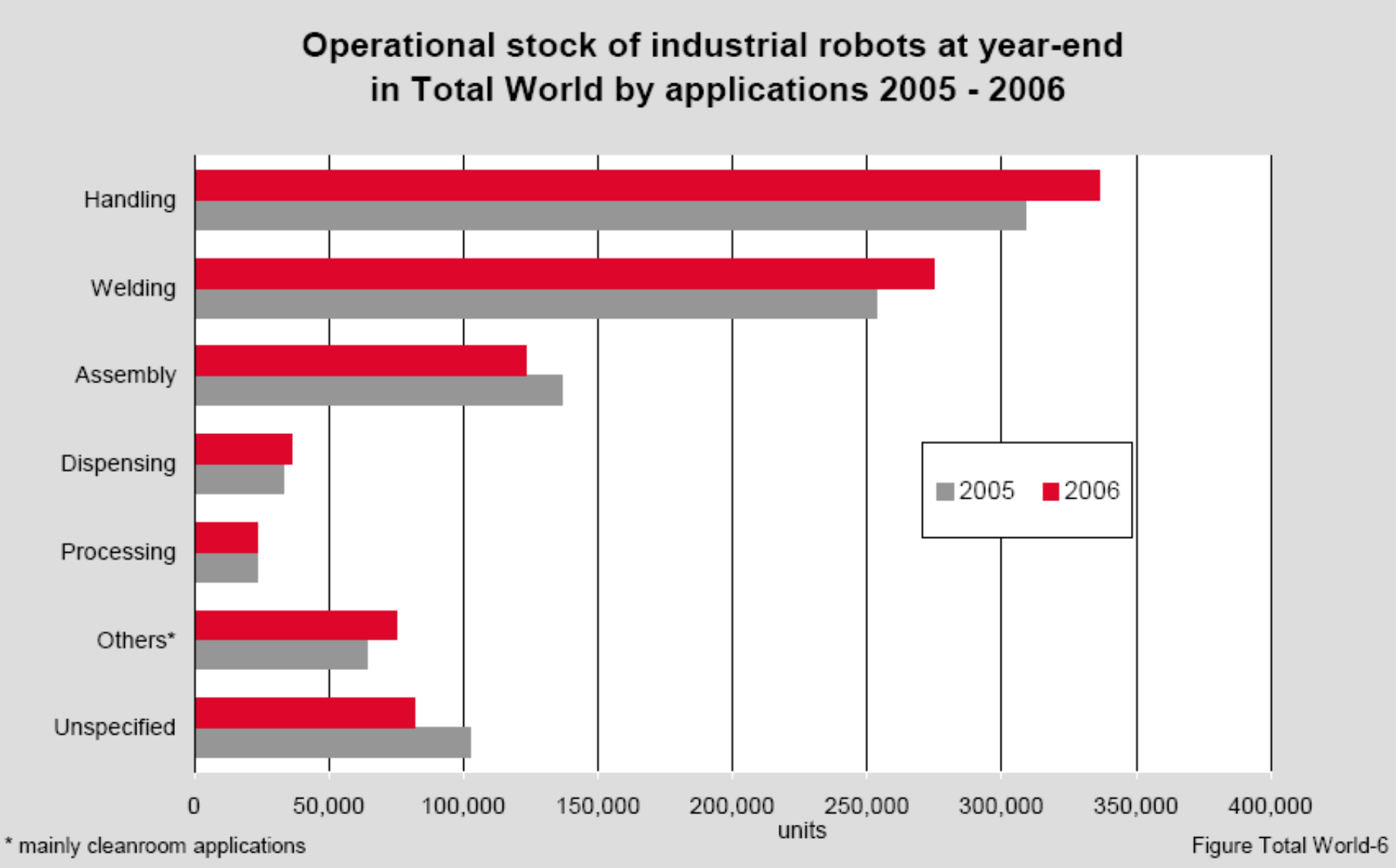
		2001	2002	2003	2004	2005	2006
France	**Motor vehicles**	**718**	**819**	**951**	**1,028**	**1,106**	**1,156**
	Manufacturing	94	105	117	128	138	146
Germany	**Motor vehicles**	**760**	**882**	**1,023**	**1,139**	**1,170**	**1,219**
	Manufacturing	202	222	245	264	273	288
Italy	**Motor vehicles**	**1,044**	**1,188**	**1,425**	**1,580**	**1,600**	**1,630**
	Manufacturing	168	179	189	201	212	227
Japan a/	**Motor vehicles**	**1,285**	**1,291**	**1,375**	**1,531**	**1,710**	**1,823**
	Manufacturing	476	484	491	502	526	495
Spain	**Motor vehicles**	**644**	**729**	**793**	**868**	**952**	**973**
	Manufacturing	122	137	151	166	183	197
Sweden	**Motor vehicles**	**564**	**571**	**561**	**607**	**626**	**588**
	Manufacturing	152	160	166	173	189	194
United Kingdom	**Motor vehicles**	**506**	**528**	**563**	**578**	**608**	**597**
	Manufacturing	53	57	61	62	65	66
United States b/	**Motor vehicles**	**494**	**555**	**626**	**684**	**771**	**829**
	Manufacturing	78	90	103	113	127	135

La robotique industrielle en chiffres

Figure II.8a. Number of multipurpose industrial robots per 10,000 production workers in the motor vehicle industry (ISIC rev.3: 34)



La robotique industrielle en chiffres



La robotique industrielle en chiffres

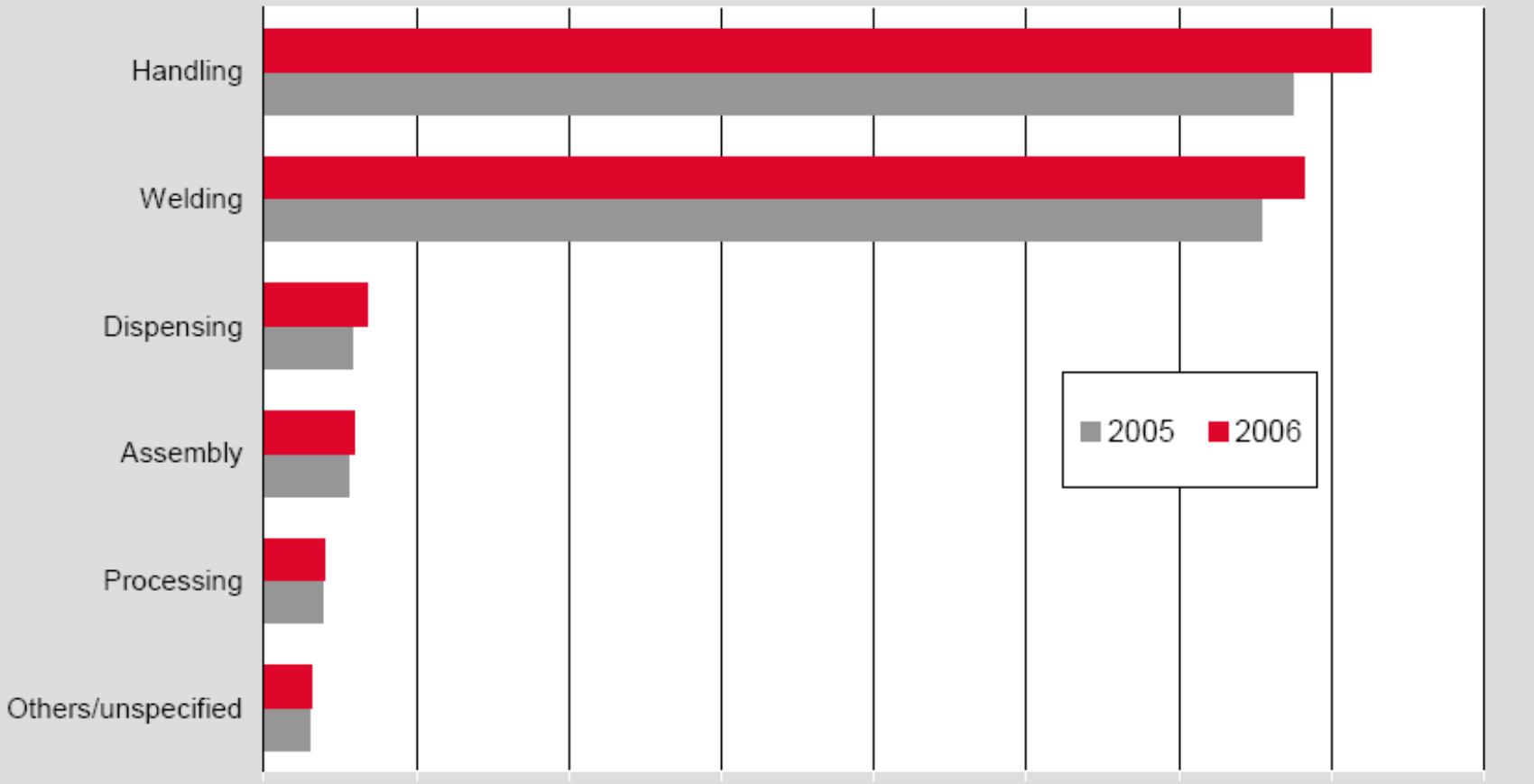


Figure France-6

La robotique industrielle en chiffres

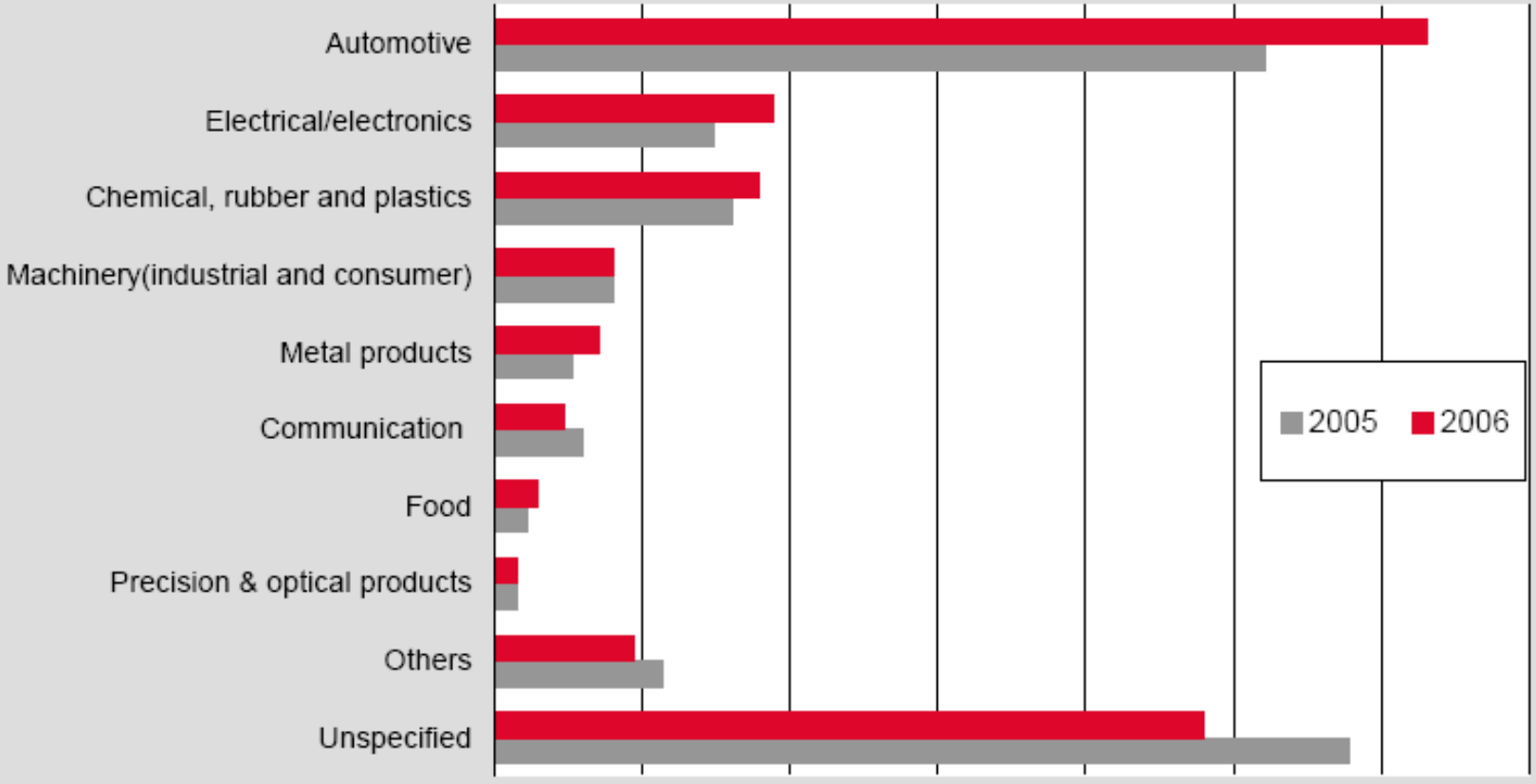


Figure Total World-8

La robotique industrielle en chiffres

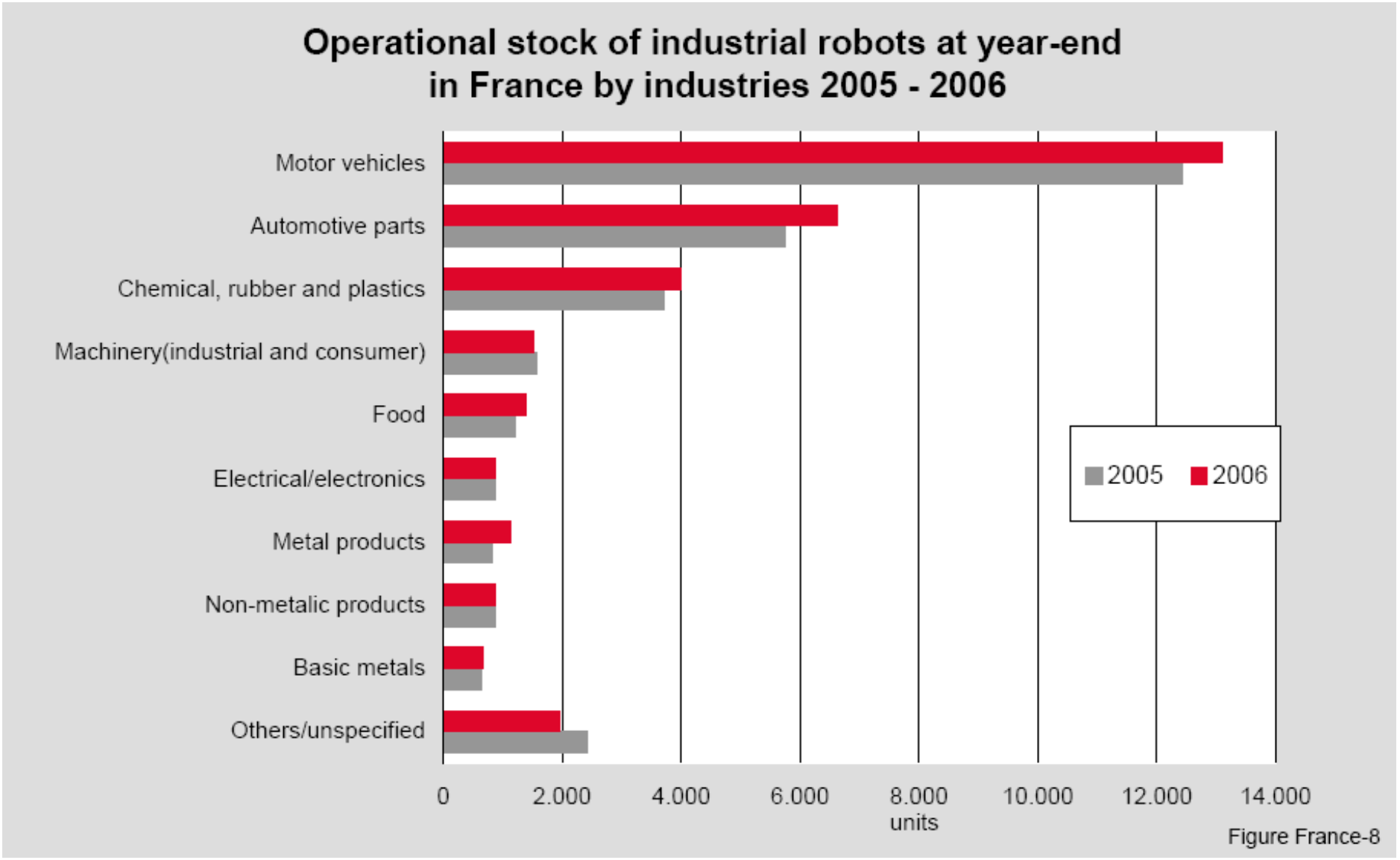
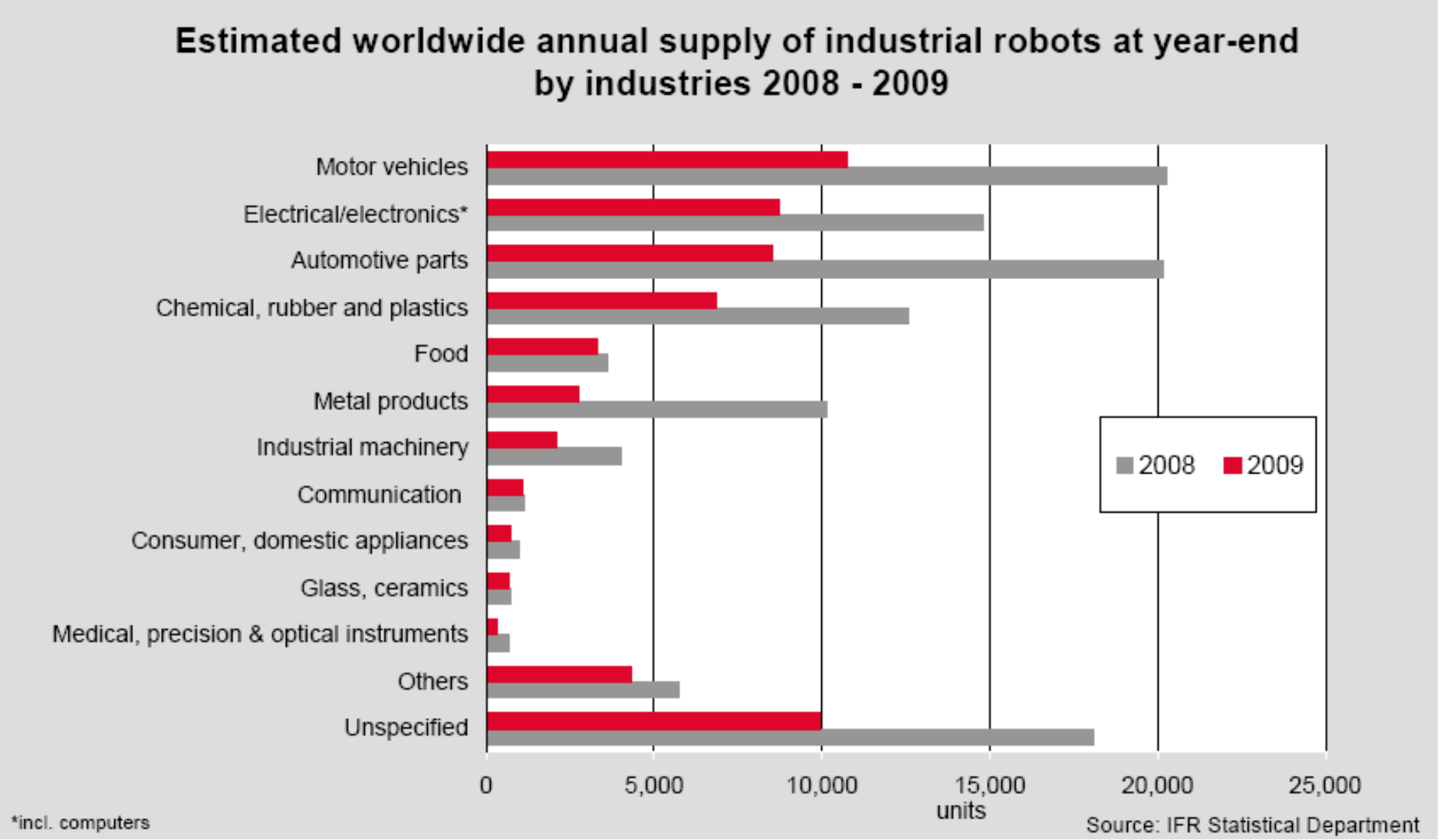
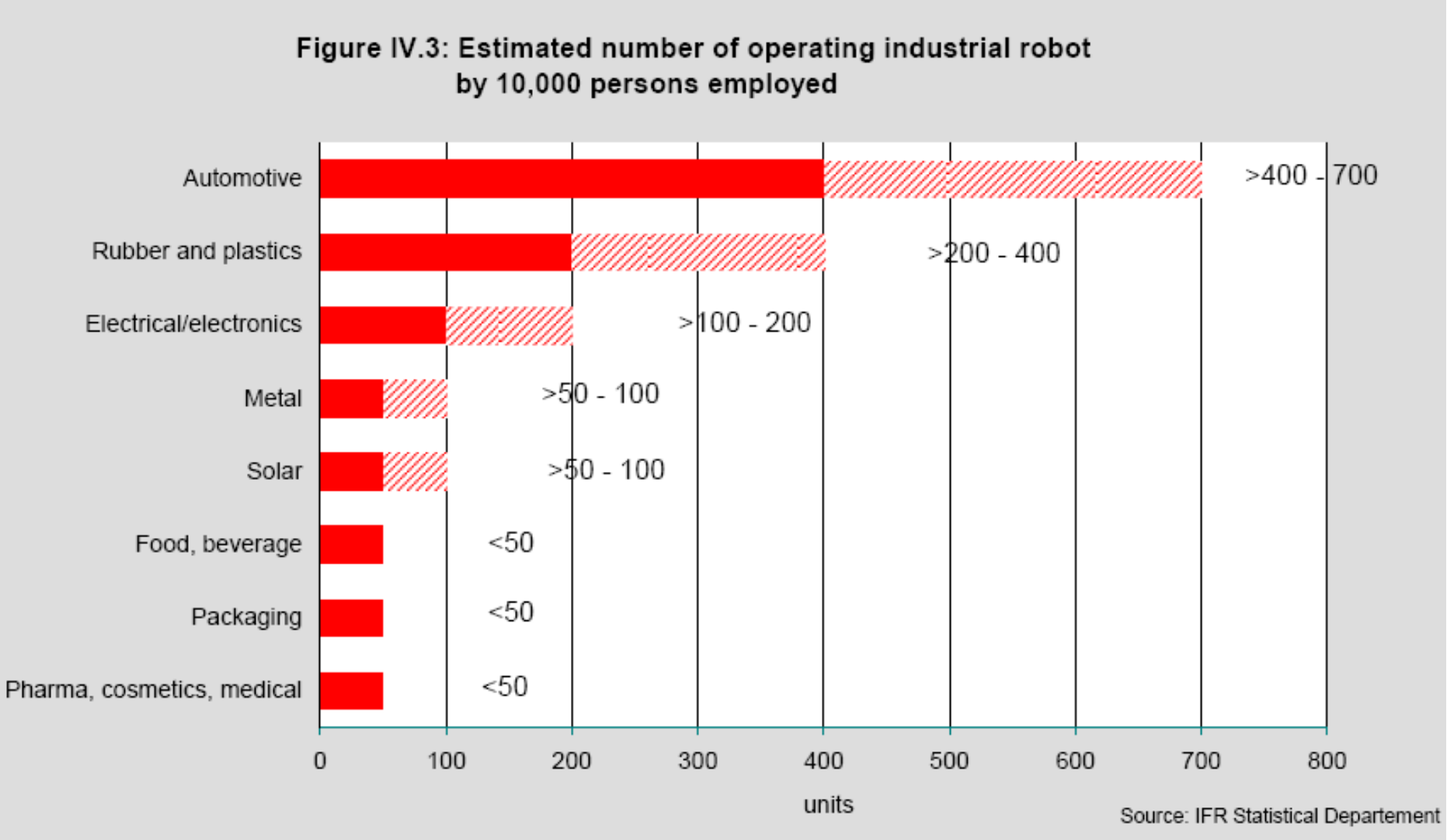


Figure France-8

Stock opérationnel de robots industriels



Stock opérationnel de robots industriels



La robotique industrielle en chiffres

Operational stock of industrial robots at year end in the automotive industry in selected countries and percentage share of the total operational stock in the particular country

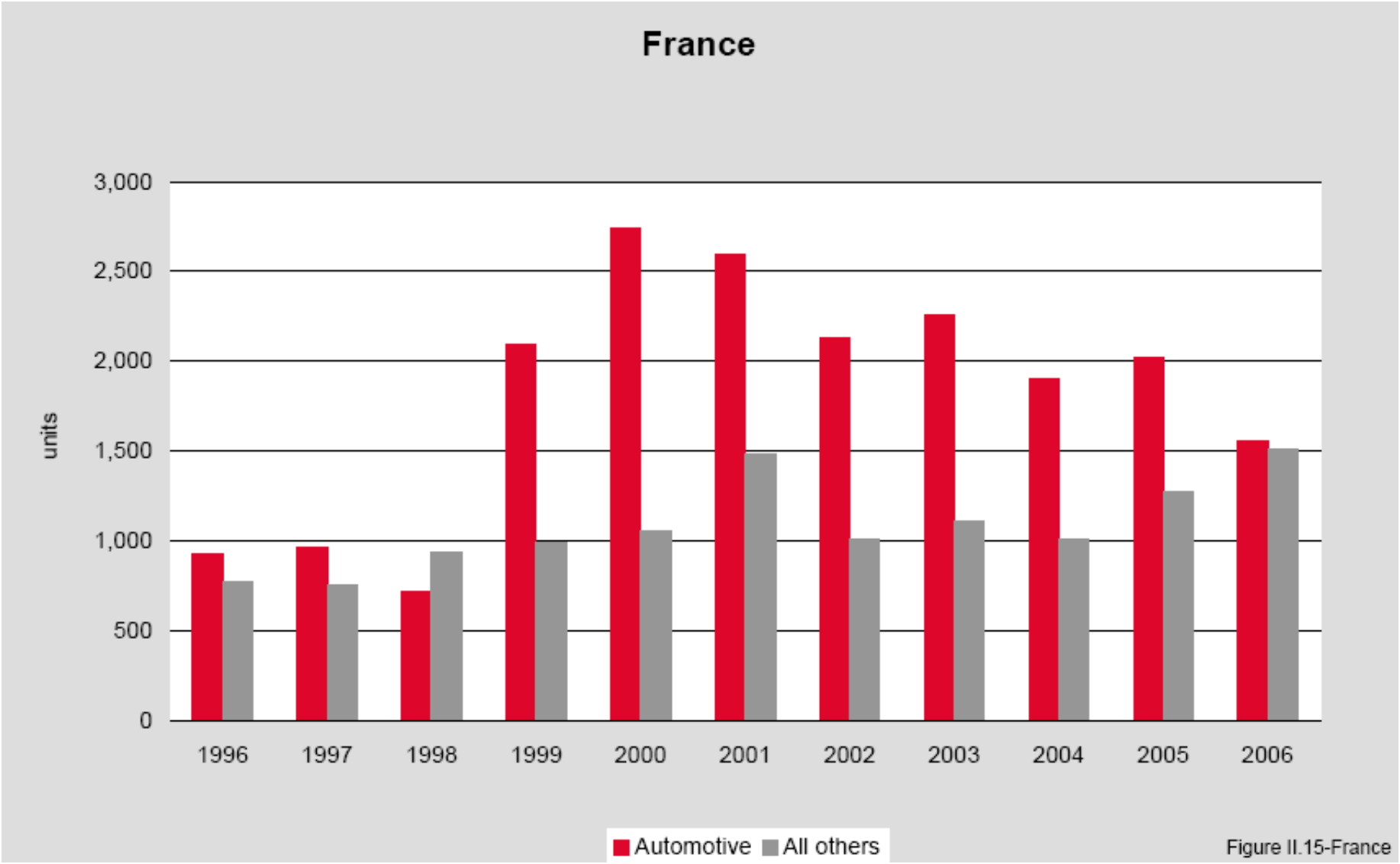
Number of units:

	2001	2002	2003	2004	2005	2006
Finland	91	78	117	141	185	195
France	13,919	15,240	16,726	18,076	19,450	20,341
Germany	51,251	56,260	63,097	69,664	73,111	75,845
Italy	13,655	15,162	17,770	19,696	19,946	20,317
Japan	89,385	91,411	95,844	106,728	119,208	127,035
Spain	11,157	12,629	13,725	15,027	16,477	16,851
Sweden	2,879	2,862	2,814	3,042	3,140	2,950
United Kingdom	7,988	8,215	8,585	8,805	9,267	9,094

Percentage of total operational stock:

	2001	2002	2003	2004	2005	2006
Finland	3.1%	2.5%	3.4%	3.8%	4.4%	4.5%
France	61.2%	62.8%	64.0%	64.3%	64.3%	63.3%
Germany	51.7%	53.5%	56.1%	57.8%	57.9%	57.2%
Italy	31.1%	32.3%	35.5%	37.0%	35.5%	33.8%
Japan	24.7%	26.1%	27.5%	29.9%	31.9%	36.1%
Spain	68.1%	68.8%	69.2%	68.6%	68.3%	64.8%
Sweden	42.9%	41.6%	40.4%	41.4%	39.1%	35.8%
United Kingdom	59.6%	60.2%	61.3%	62.1%	62.0%	60.3%

La robotique industrielle en chiffres



Achat annuel de robots

La robotique industrielle en chiffres

- En 2006, 60% des robots installés sont des robots 6 axes (59% en 2005), 22% des robots cartésiens/linéaires (20% en 2004), 13% des SCARA (8% en 2005), 4% des robots cylindriques (12% en 2005).

- Robots 6 axes : "tout", soudage, manipulation, assemblage, process.

- Robots SCARA : conditionnement, assemblage (pick-and-place), opérations en salle blanche. Très utilisé en Asie.

- Robots cylindriques : opérations en salle blanche, industrie des semi-conducteurs, industrie du plastique, automobile, électricité/électronique.

La robotique industrielle en chiffres

France

Apparent consumption (yearly supply) of industrial robots by types of robots. Number of units

Year	2001	2002	2003	2004	2005*	2006
Type of robot by mechanical structure:	**3,484**	**3,012**	**3,117**	**3,009**	**3,077**	**3,071**
of which:						
Cartesian/gantry	315	325	357	382	445	420
SCARA	154	131	111	143	103	138
Articulated	2,996	2,529	2,635	2,463	2,519	2,493
Cylindrical, spherical	19	27	14	21		7
Others (i.e. parallel)					10	13
Not classified						

La robotique industrielle en chiffres

1,000 of national currency, current prices

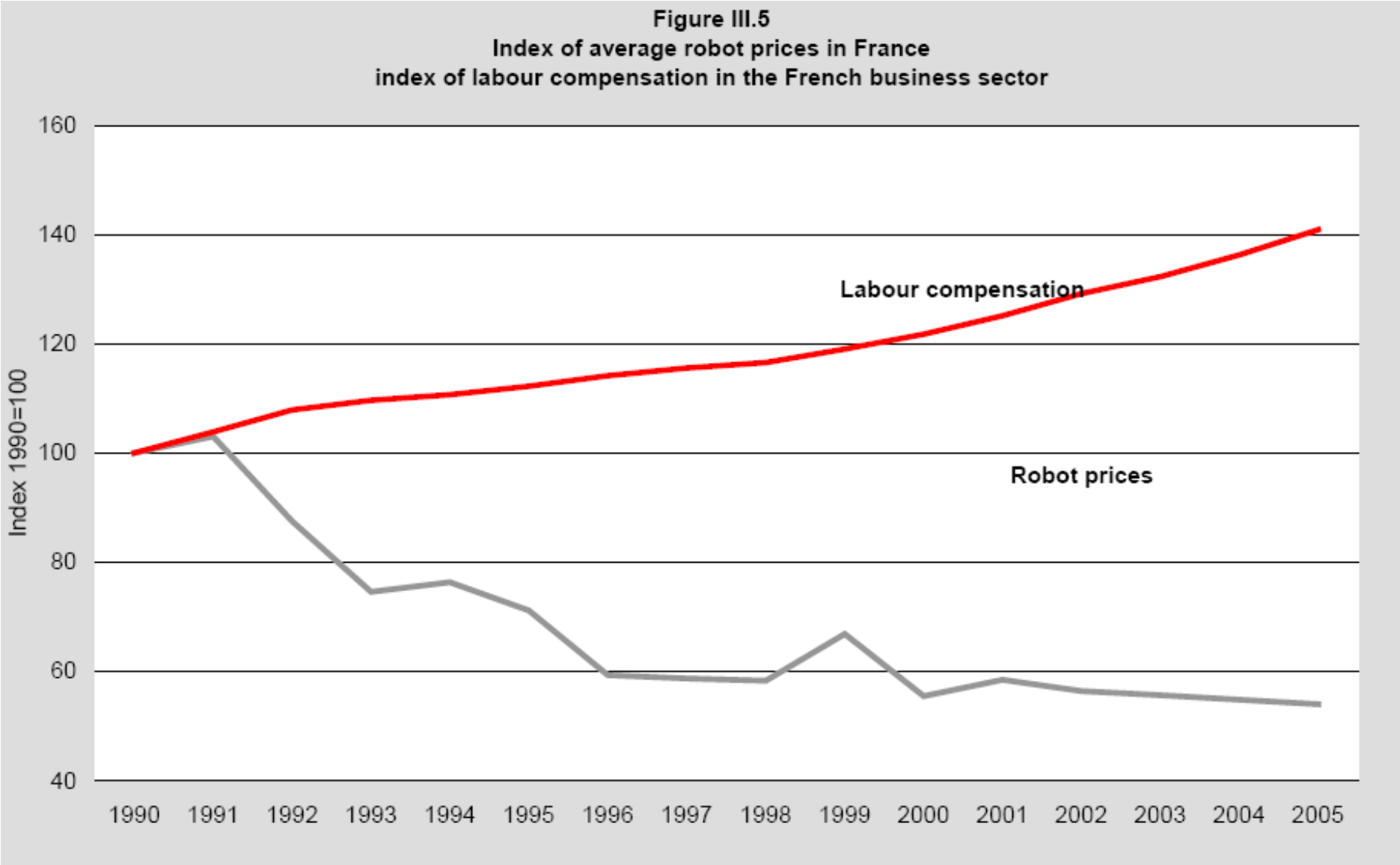
Country	2000	2001	2002	2003	2004	2005	2006	2006/ 2005, %
Japan	6,645.9	5,196.7	5,178.4	4,060.2	4,031.2	4,176.7	4,687.2	12.2
United States	78.5	81.6	74.8	70.1	68.0	58.8	67.0	13.9
Germany, €	51.1	51.2	52.1	49.0	49.0	50.0	50.0	0.0
Italy, €	65.6	72.2	73.7	74.3	72.4	72.4	80.0	10.5
Rep. of Korea	27.7	23.0	21.3	26.4	28.2	27.8	28.9	3.9
United Kingdom	34.8	32.6	30.4	33.8	27.8	25.3	25.5	0.8
France, €	49.0	51.6	49.8	49.1	48.4	48.4	48.5	0.2

Sources: UNECE, IFR and national robot associations.

Note: Millions of national currencies for Japan. The currency for the Rep. of Korea is in US dollars.

NB :
4687200 Yens = 30655 €
25500 Livres Sterling = 31755 €

La robotique industrielle en chiffres



La robotique industrielle en chiffres

Year	Index of robot prices, 1990=100	Labour compen-sation per employee 1990=100 a/	Index (1990=100) of hourly wages, including social costs. All wage earners		
			Manu-facturing industry ISIC rev 3: D	Food industry ISIC rev 3:15+16	Motor vehicle industry ISIC rev 3: 34
1990	**100.0**	100.0	100.0	100.0	100.0
1991	**103.0**	103.8	105.1	103.6	105.0
1992	**87.5**	107.9	109.1	109.4	110.6
1993	**74.6**	109.6	113.0	112.5	115.9
1994	**76.4**	110.7	117.4	114.3	124.1
1995	**71.2**	112.2	119.9	116.6	125.7
1996	**59.3**	114.1	122.9	118.9	130.3
1997	**58.7**	115.6	127.7	119.5	133.7
1998	**58.3**	116.6	128.6	120.0	132.8
1999	**66.9**	119.0	133.2	123.0	138.5
2000	**55.5**	121.7	139.5	125.6	147.1
2001	**58.5**	125.1	143.2	128.9	150.4
2002	**56.4**	129.2	150.4	134.5	160.1
2003	**55.7**	132.3	156.4	139.6	164.7
2004	**54.8**	136.3	162.4	143.8	171.8
2005	**54.0**	140.9	169.1	149.1	179.3
2006	**54.0**	146.8			

Technical performances

- Repeatability: few millimeters
- Repeatability and accuracy

Better repeatability and accuracy when the robot is small

- Speed : several m/s

- MTBF (mean time between failures) : 50000 hours

Most efficient production equipment

- *Robot with 6 axes is a little bit precise than CNC machine but it is 3 times less expensive with working are 10 times bigger than CNC*

- Return on investment: 12 to 18 months

Industrial robotics

Main motivations of industrial robotics (no preferential order)

1. Improve the quality and the uniformity of the product
2. Improve the work conditions (avoid over charges, repetitive cycles, hard environment conditions, etc)
3. Reduce the costs
4. Improve the productivity
5. Improve the flexibility of the product
6. Reduce the material failure
7. Better respect of security rules
8. Reduce turnover (stuff rotation) and the difficulty related to recruitment

Ideas about industrial robotics

False ideas…… and reality

- La robotique ne concerne que les grandes séries (donc l'automobile)
- Temps de changement de série diminuent
  Applications métiers, périrobotique, dialogue avec les automates
- Il faut des ingénieurs pour faire fonctionner les robots
- Programmeur : bac pro, BTS
  Utilisateur : pas de diplôme

Le robot est un équipement « banal » de l'automatisation !

Ideas about industrial robotics

Mais ….

Il est nécessaire de réaliser le continuum entre l'utilisateur et le robot !

Surtout pour :

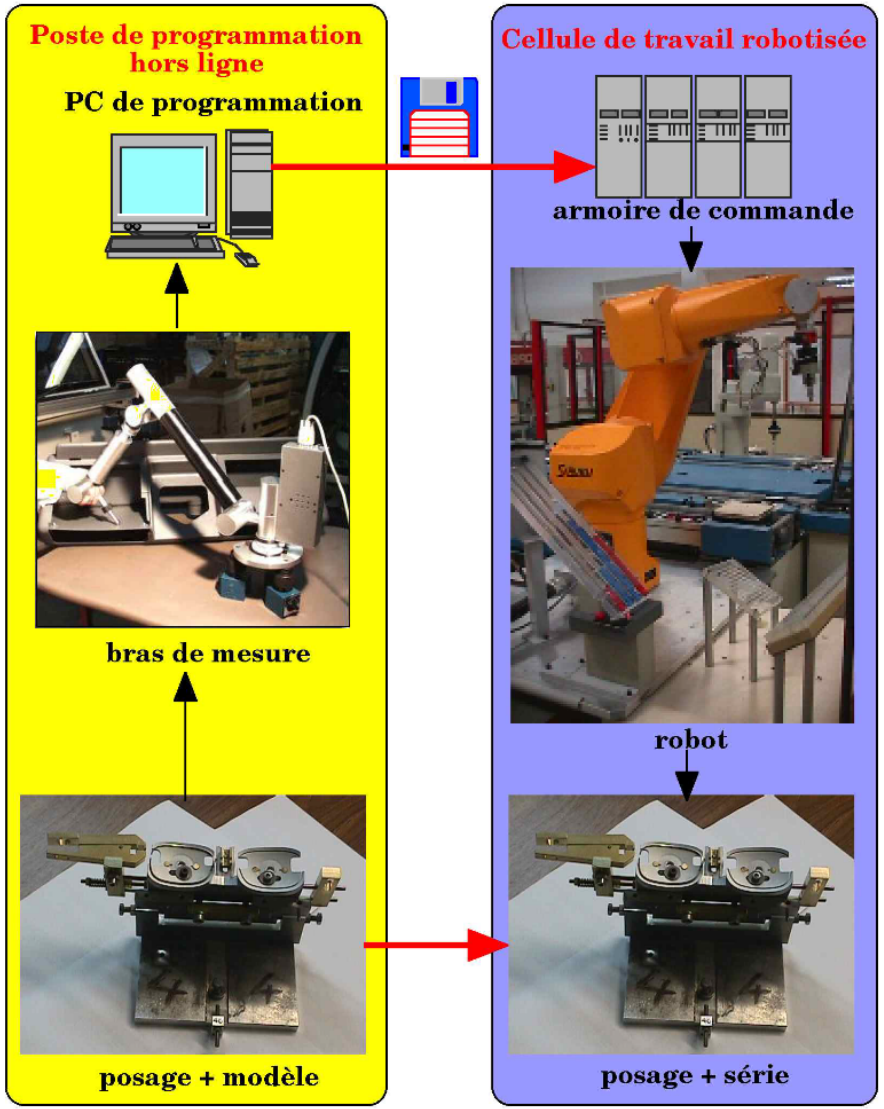
- petites séries
- géométrie des pièces non connue a priori
- nécessité d'un savoir-faire (trajectoires complexes)

La robotique industrielle en exemples

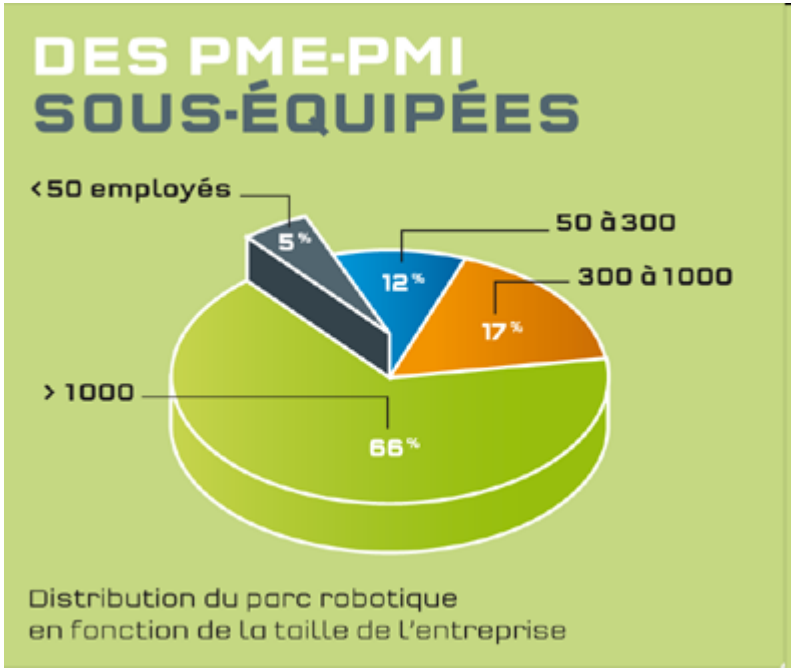
Exemple A.LU.TEC

Programmation par bras de mesure

film



La robotique industrielle en exemples



http://www.robotcaliser.com

Vers une robotique de moins en moins industrielle

Robot de service – robot domestique – robot de divertissement
Service robots – entertainment robots – domestic robots

Robot mi ou totalement autonome accomplissant des services utiles au bien-être de l'homme et également utilisé sur du matériel, à l'exception des tâches industrielles.

Vers une robotique de moins en moins industrielle

Robots de service

Vers une robotique de moins en moins industrielle

Robots domestiques et de divertissement (sociaux ?)

Vers une robotique de moins en moins industrielle

- Fin 2006, 2,4 millions de robots de service professionnels et domestiques (aspirateurs, tondeuses à gazon, robots médicaux, sous-marins, de surveillance, ...) et 1 million de robots de divertissement étaient en fonction dans le monde.

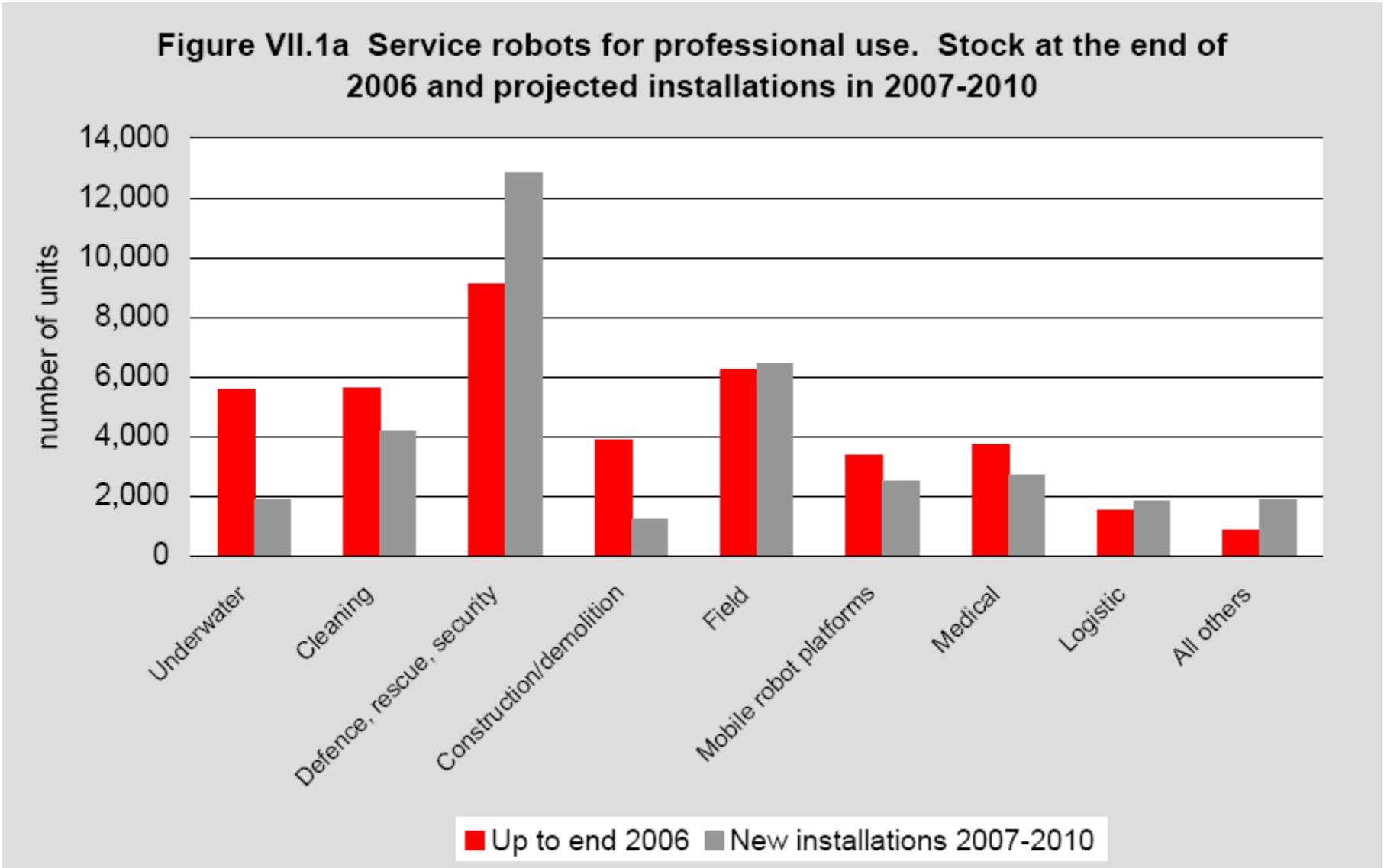
- Il était prévu en 2006 que ce chiffre s'accroisse de 3,5 millions d'ici 2010 (1,3 million robots domestiques et 2,2 millions robots de divertissement).

Vers une robotique de moins en moins industrielle

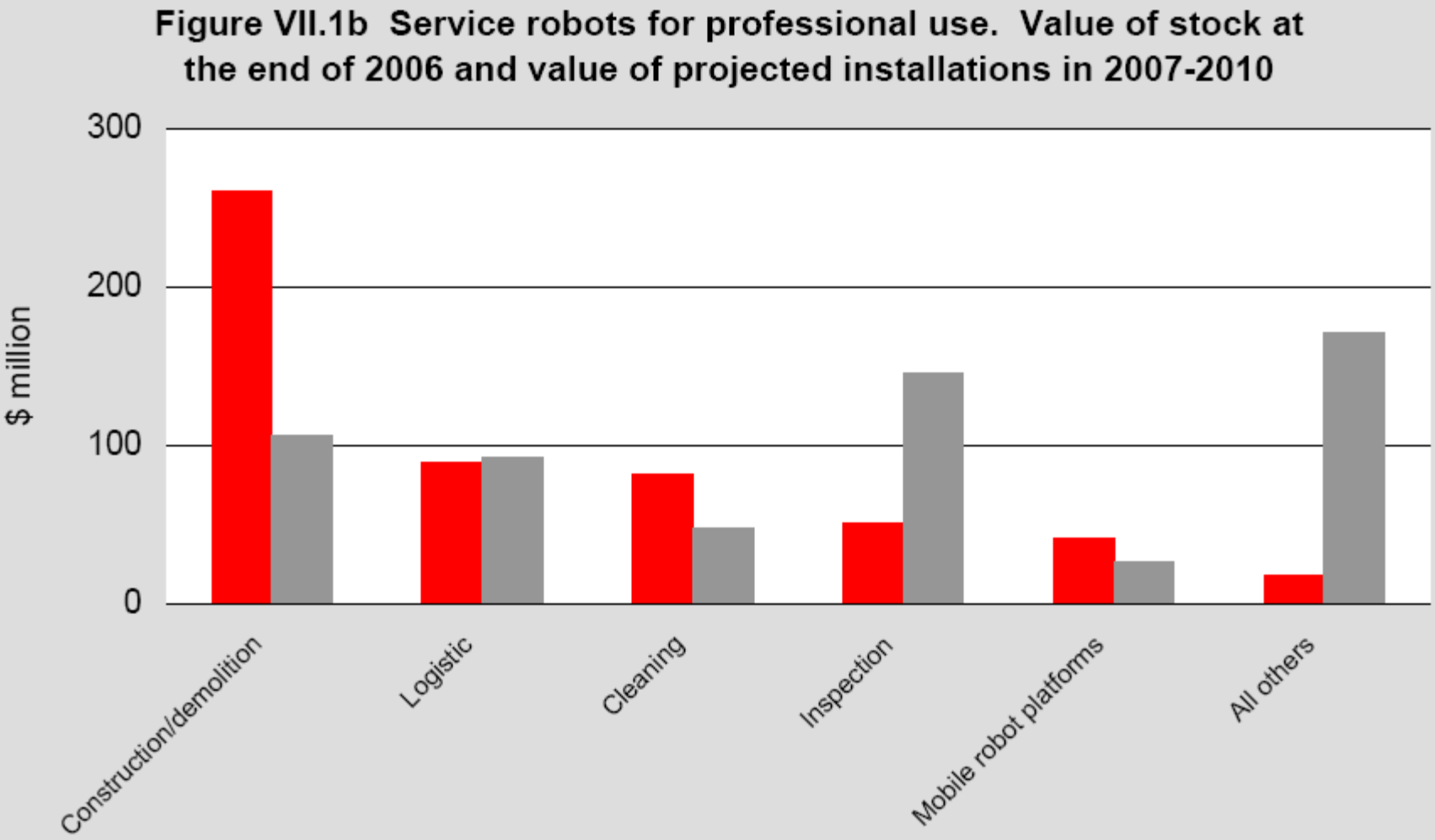
Estimated number and value of service robots installed up to the end of 2006, by application areas, and forecasts for the period 2007-2010

Types of robots	Stock at end 2006	Installations 2007-2010	Sales in 2006	Stock at end 2006	Installations 2007-2010
	No. of units	No. of units	No. of units	$ million	$ million
Professional service robots					
Field robotics	**6,240**	**6,450**	**1,539**	**1,251**	**1,278**
- Agriculture					
- Milking robots	6,180	6,350	1,538	1,243	1,276
- Forestry					
- Mining systems					
- Space robots					
- Others	60	100	1	8	2
Professional cleaning	**5,620**	**4,175**	**266**	**82**	**47**
- Floor cleaning	335	2,650	8	31	17
- - Window and wall cleaning (including wall climbing robots)	10	500	2	3	14
- Tank, tube and pipe cleaning					
- Pool cleaning	5,250	1,000	250	45	14
- Other cleaning tasks	25	25	6	2	3
Inspection and maintenance systems	**595**	**1,380**	**312**	**50**	**145**
- Sewer robots	410	1,200	292	26	86
- Tank, tubes and pipes*					
- Other inspection and maintenance systems	185	180	20	24	59
Construction and demolition	**3,875**	**1,190**	**291**	**260**	**106**
- Nuclear demolition & dismantling	100	50	9	27	38
- Other demolition systems	3,680	1,060	265	229	64
- Construction support and maintenance	85	70	16	3	3
- Construction	10	10	1	1	1
- Other types of construction					
Logistic systems	**1,550**	**1,800**	**417**	**89**	**92**
- Courier/Mail systems	360	210	53	30	23
- Factory logistics (Incl. Automated Guided Vehicles for factories)	1,190	1,590	364	59	68
Cargo handling, outdoor logistics					
- Other logistics					
Medical robotics	**3,725**	**2,700**	**537**	**892**	**1,318**
- Diagnostic systems	100	300	66	68	221
- Robot assisted surgery or therapy	3,600	2,400	470	824	1,097
- Rehabilitation systems					
- Other medical robots	25		1	1	
Defense, rescue & security applications	**9,095**	**12,855**	**4,119**	**1,198**	**1,380**
- Demining robots	305	250	17	300	336
- Fire and bomb fighting robots	650	440	558	152	128
- Surveillance/security robots	1,340	3,100	731	72	175
- Unmanned aerial vehicles	5,100	5,100	2,001	480	446
- Unmanned ground based vehicles	1,500	3,900	801	119	288
- others	200	65	11	76	5
Underwater systems	**5,570**	**1,900**	**484**	**1,904**	**835**
Mobile Platforms in general use	**3,350**	**2,500**	**797**	**41**	**26**
Robot arms in general use**					
Public relation robots	**110**	**300**	**16**	**1**	**122**

Vers une robotique de moins en moins industrielle

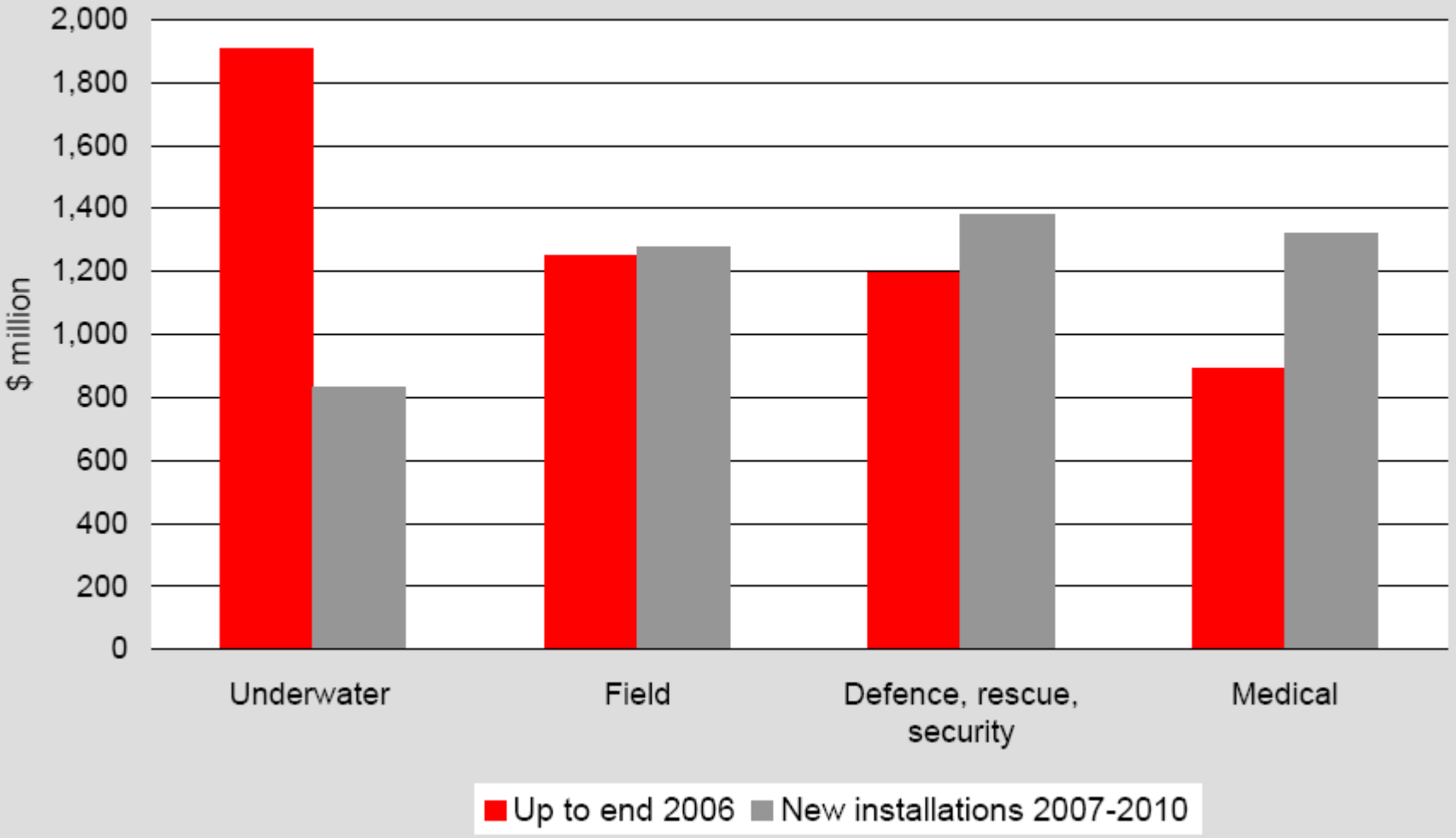


Vers une robotique de moins en moins industrielle

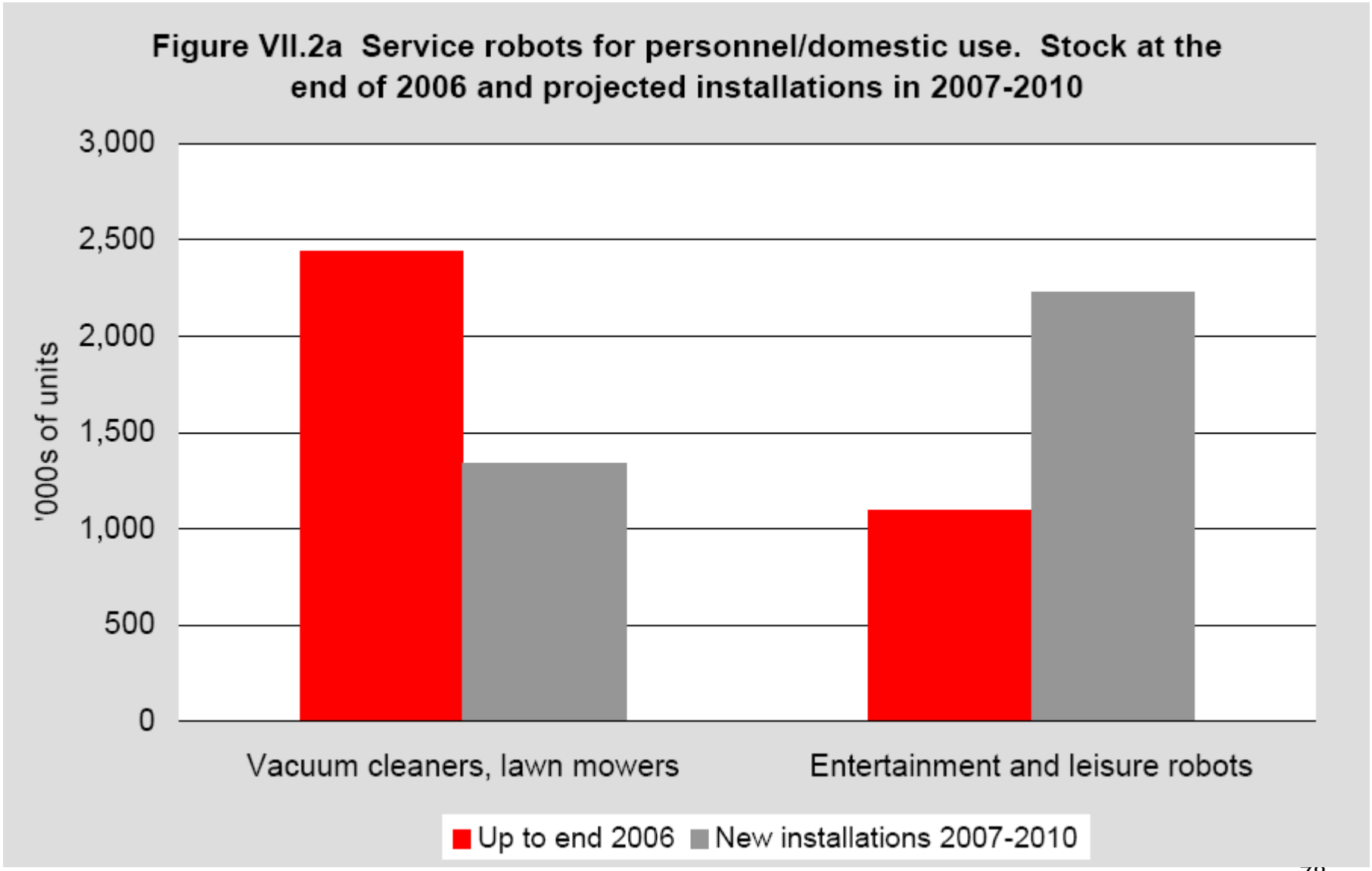


Vers une robotique de moins en moins industrielle

Figure VII.1c Service robots for professional use. Value of stock at the end of 2006 and value of projected installations in 2007-2010

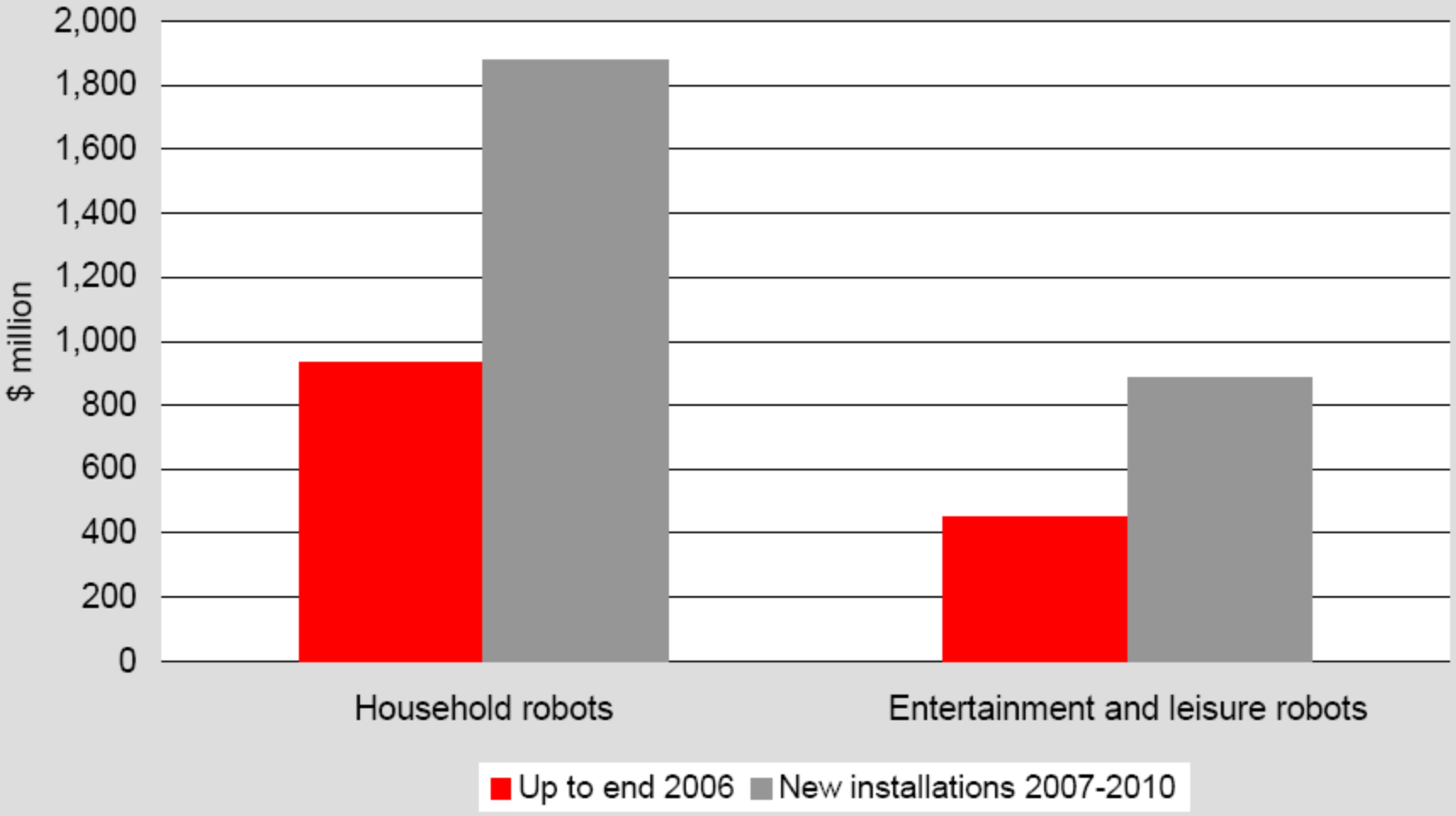


Vers une robotique de moins en moins industrielle



Vers une robotique de moins en moins industrielle

Figure VII.2b Service robots for personal/domestic use. Value of the stock at the end of 2006 and of the projected installations in 2007-2010



Robot « de compagnie »

Paro, le robot bébé phoque

Film

Robots de type SCARA : Robodoc

INTEGRATED SURGICAL SYSTEMS

Redefining Surgery ... ... around the World!

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ROBODOC

THA Pinless

Revision Arthroplaty

Total Knee Arthroplasty

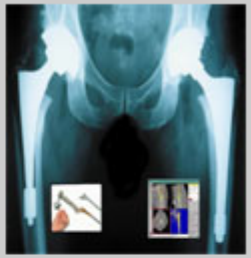
Supported Implants

ROBODOC® is a surgical robot that performs the following procedures:

Primary total hip replacement:
The robot mills a cavity in the femur for the placement of a prosthetic implant. The system is designed to accurately shape the cavity for a precise fit and precise positioning of the implants in the cavity for optimum biomechanics.

Revision hip replacement:
The robot automatically removes bone cement and creates a new, accurately shaped cavity for a revision prosthesis.

Total knee replacement:
The robot planes knee surfaces on the femur and tibia to achieve a precise fit of the implant.



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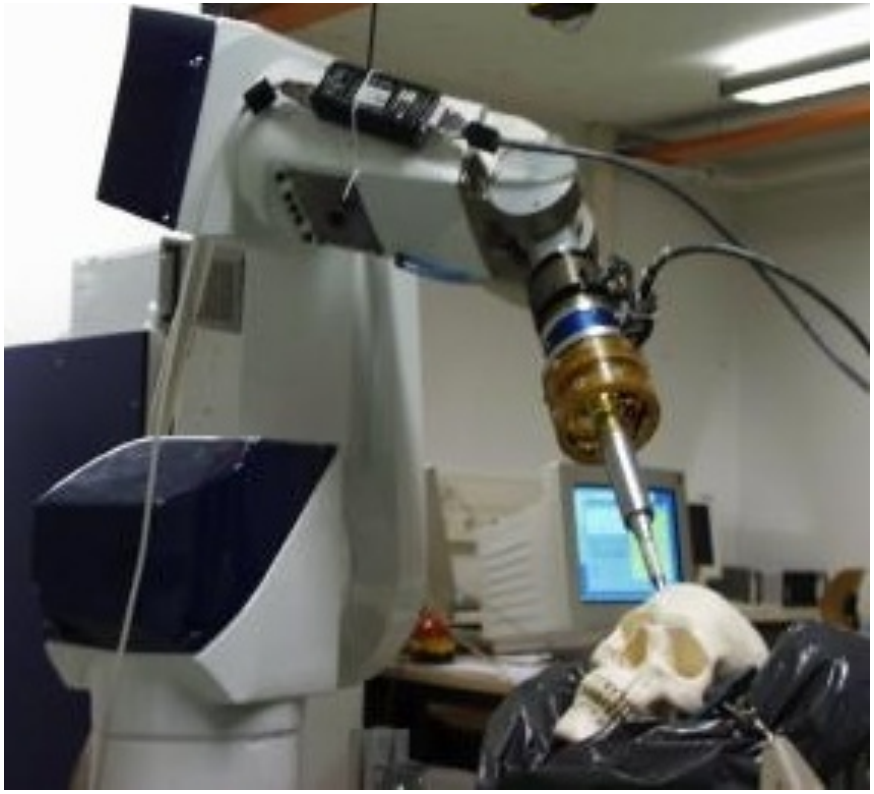
Robots de type SCARA : Robodoc

Robot de type SCARA : Dermarob

Film

Robot de type Anthropomorphe : CASPAR



CASPAR : Computer Assisted Surgical Planning and Robotics

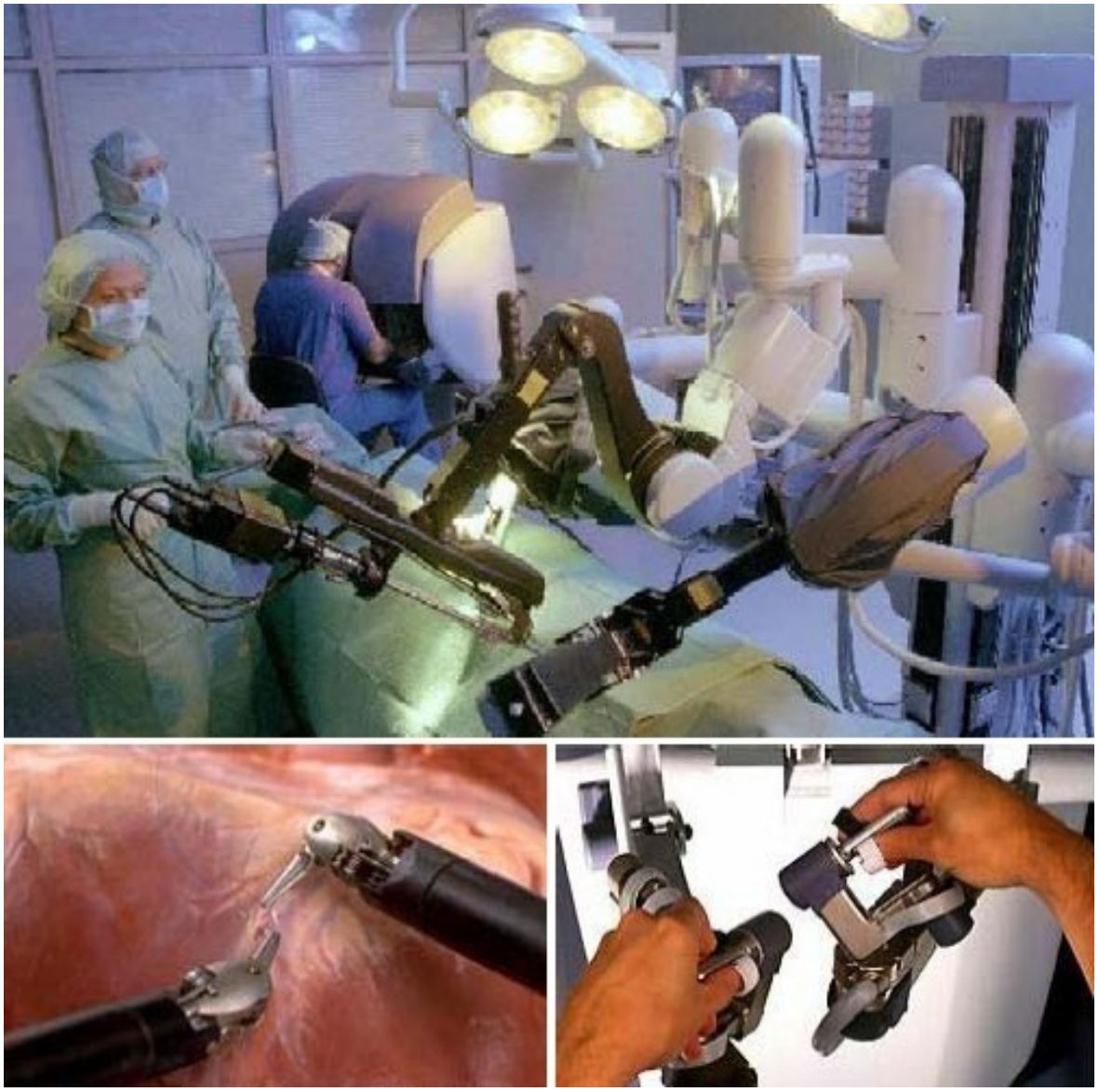
(chirurgie orthopédique)

Robot parallèle

Robots de type SCARA : AESOP

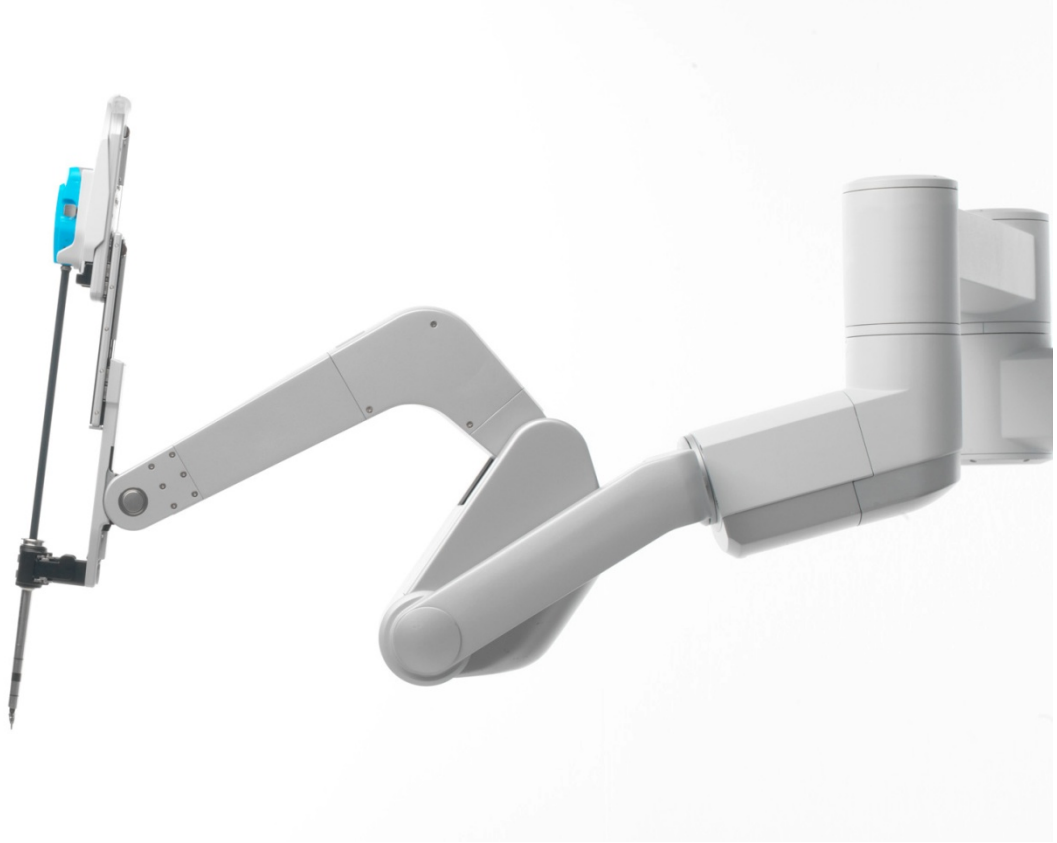
AESOP : Automatic Endoscopic System for Optimal Positioning

Téléopération : robot Da Vinci



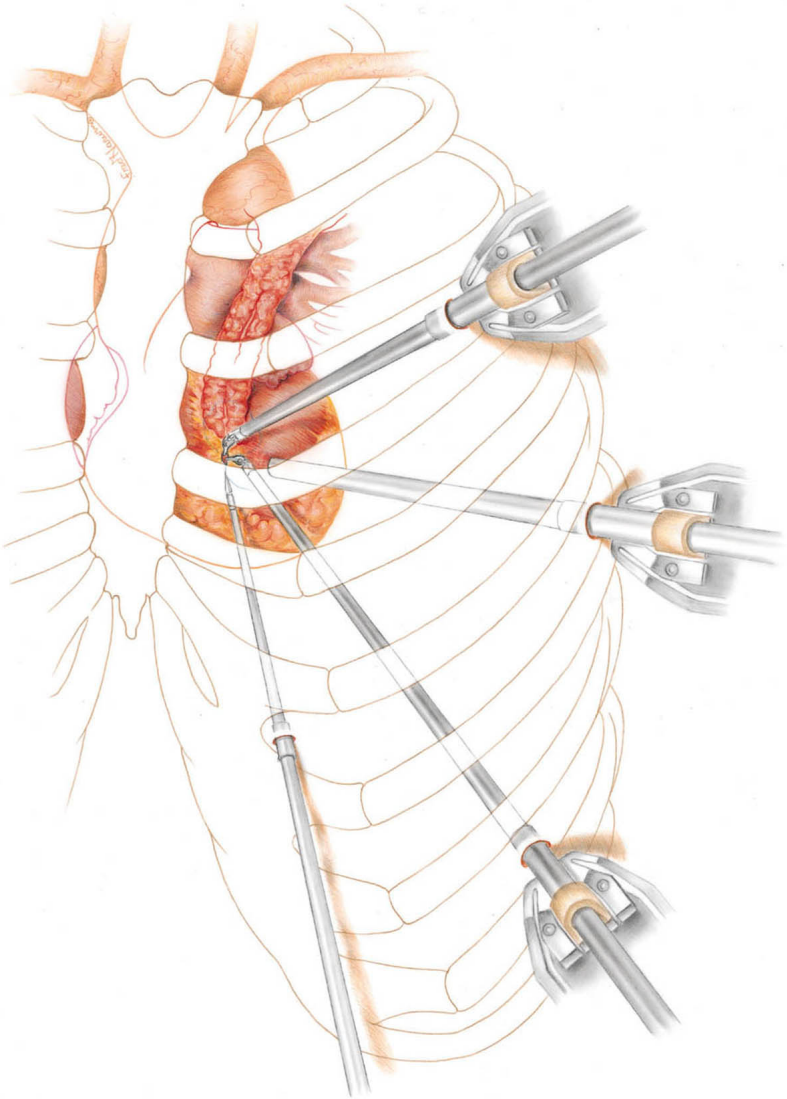
Téléopération : robot Da Vinci

Téléopération : robot Da Vinci



Film

Téléopération : robot Da Vinci



Téléopération : robot Zeus

Téléopération : système haptique Phantom

Exemples

Microrobotique 1

Microrobotique 2

Pick & place micro

Assemblage

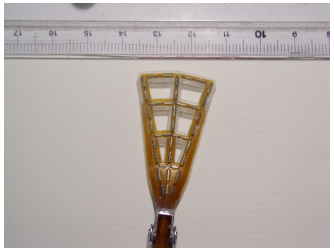
Chirurgie

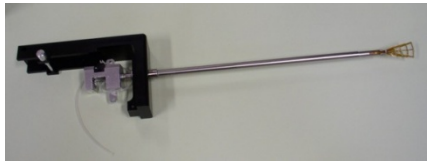
Chirurgie à cœur battant

L'objectif : traiter la fibrillation cardiaque *(1 personne sur 20 > 60 ans)*

Le principe

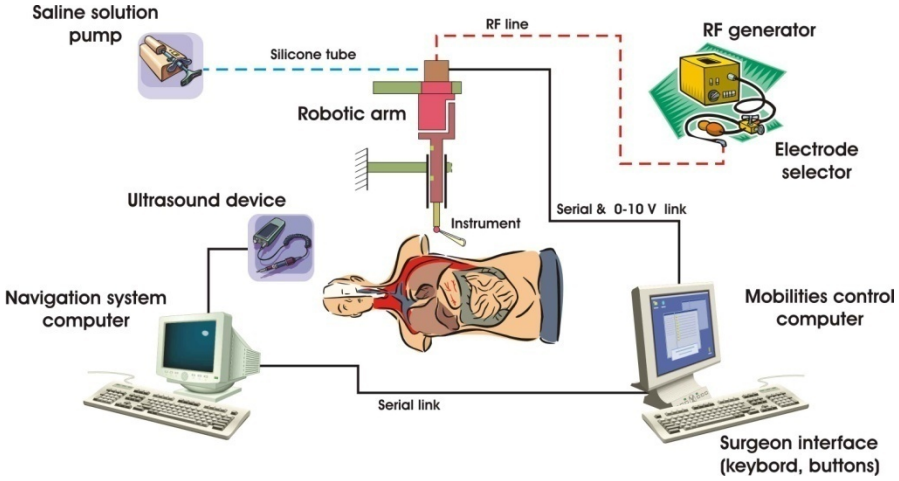
- **utiliser la radio-fréquence pour léser certaines parties internes du cœur,**
- **déployer et piloter une maille de 22 électrodes RF pour réaliser des lignes d'ablation.**





Le système

- **un robot à 5 ddl,**
- **une tête à 2 ddl,**
- **un instrument déployable jetable,**
- **un système de commande.**

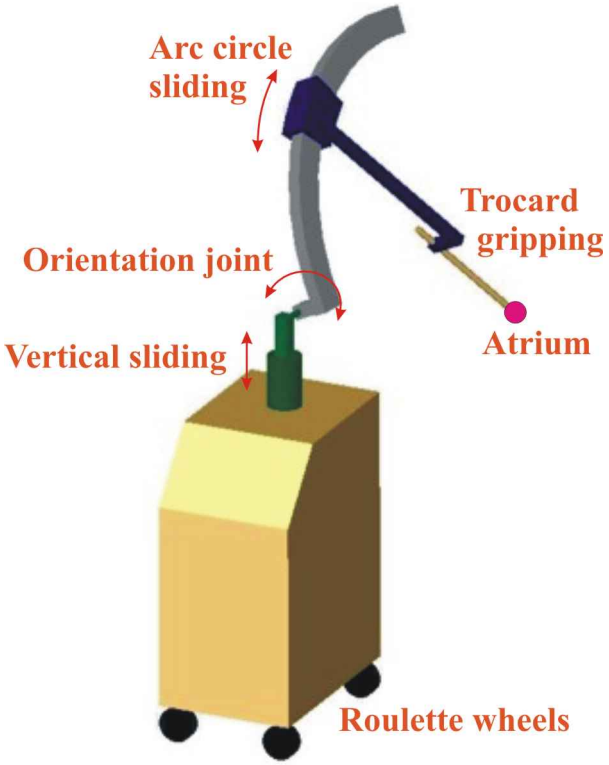


Les résultats

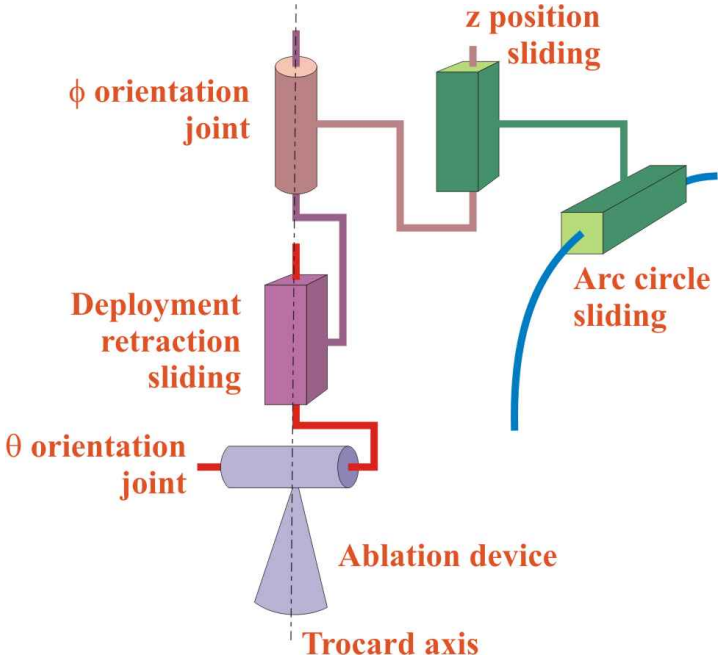
Exemples

L'objectif : traiter la fibrillation cardiaque *(1 personne sur 20 > 60 ans)*

Le robot (Amstrong Healthcare)



L'organe terminal

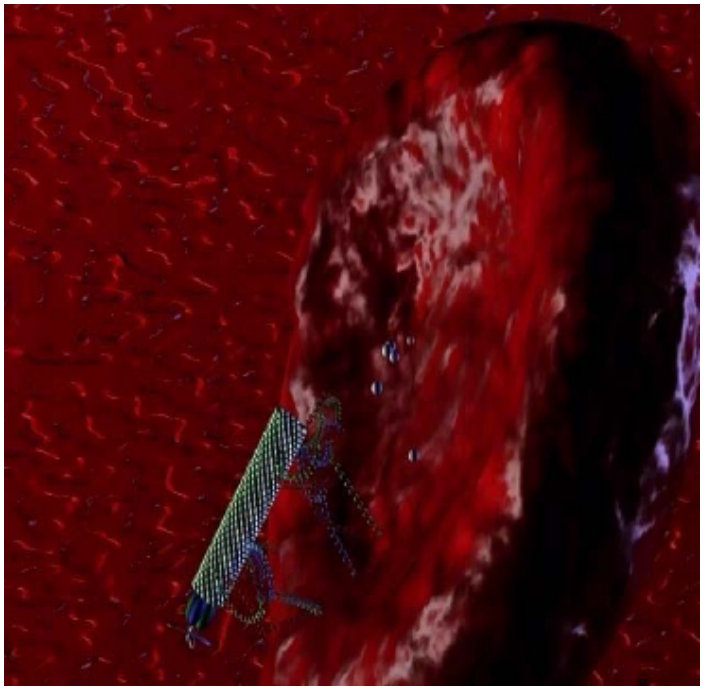


Chirurgie à cœur battant

Les nanorobots

→ De futurs robots moléculaires

Nanorobot dans une veine, cherchant une cellule infectée



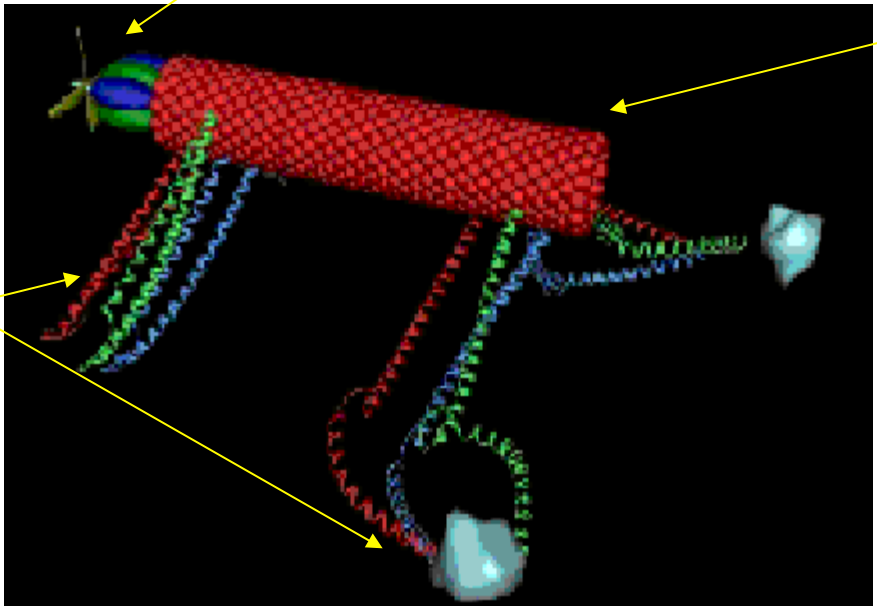
Le même nanorobot, accroché à la cellule infectée, lui injectant un produit

Les nanorobots

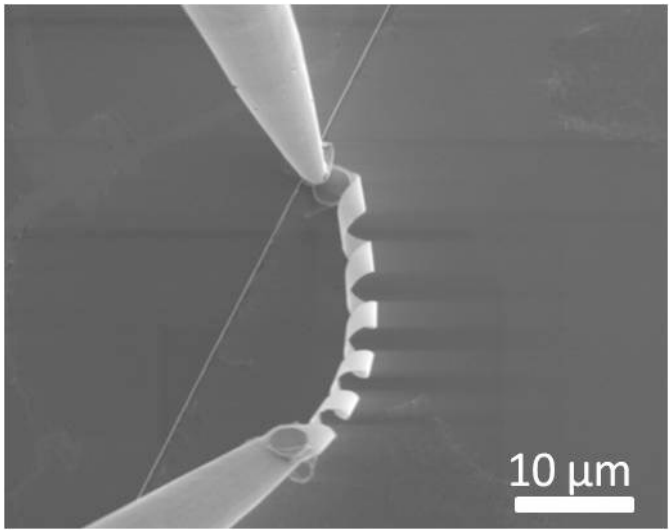
moteur biomoléculaire
de propulsion

corps : nanotube
de carbone

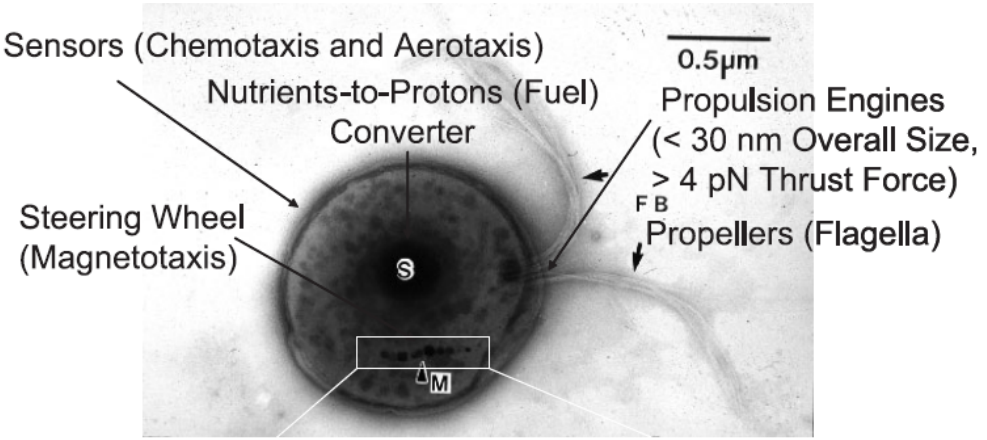
membres : peptide
(locomotion,
manipulation)

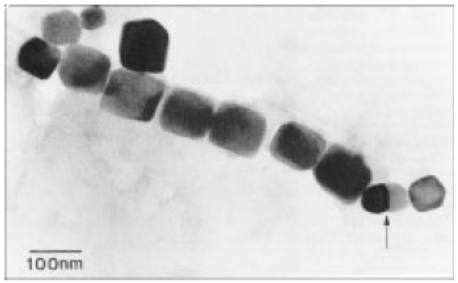


Les nanorobots

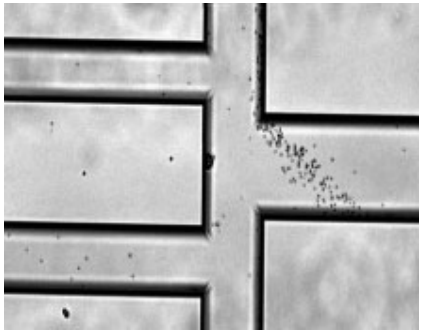


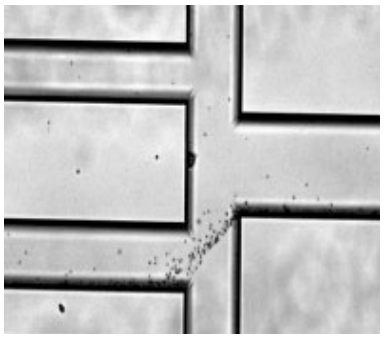
Hélices HNB

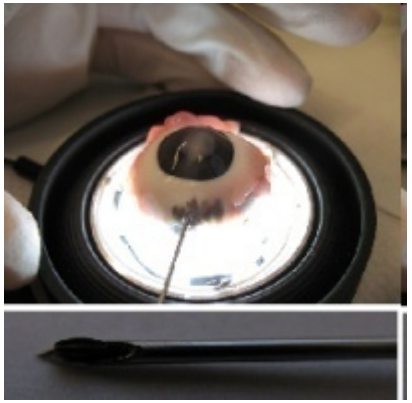




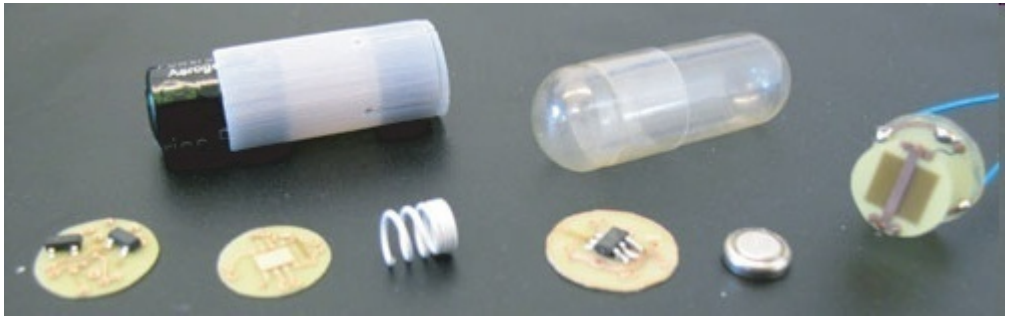
Bactéries magnétotactiques (BMT)

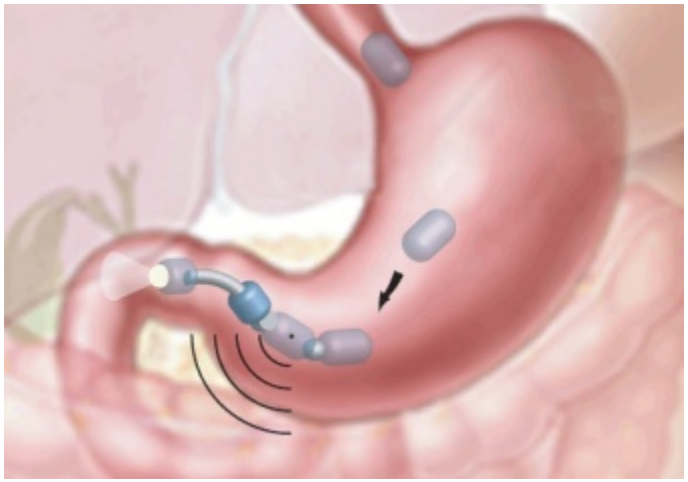






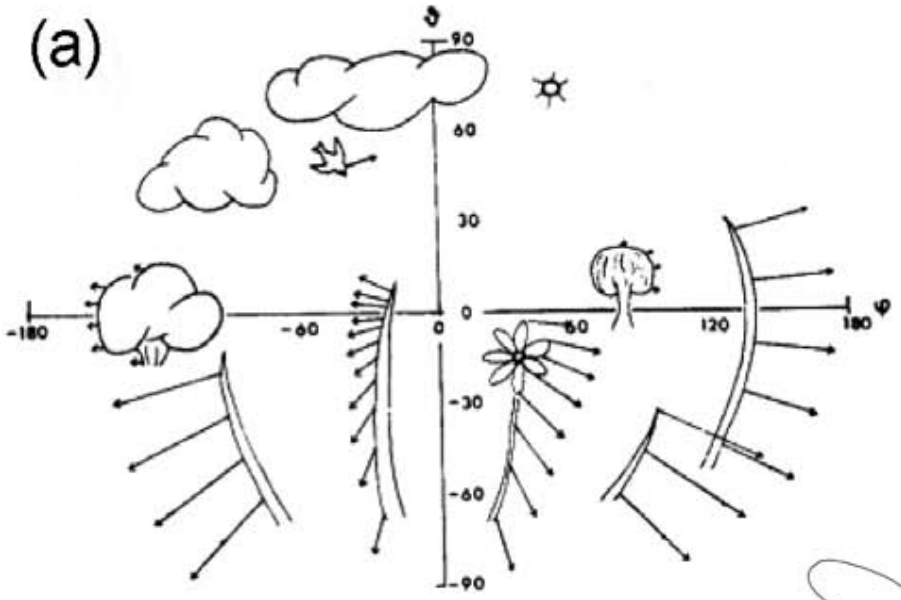

Frame 44/250
20.7 fps
3 mm
IRIS

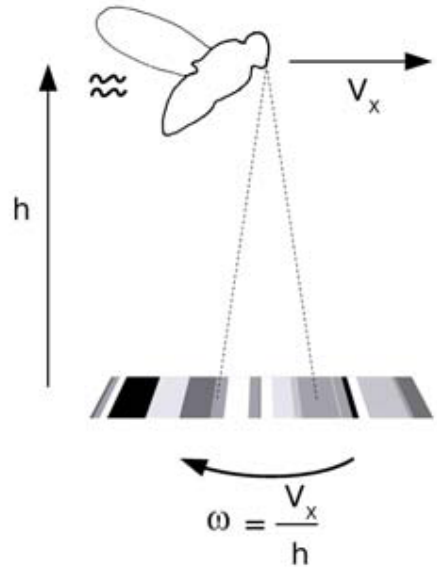




Exemples

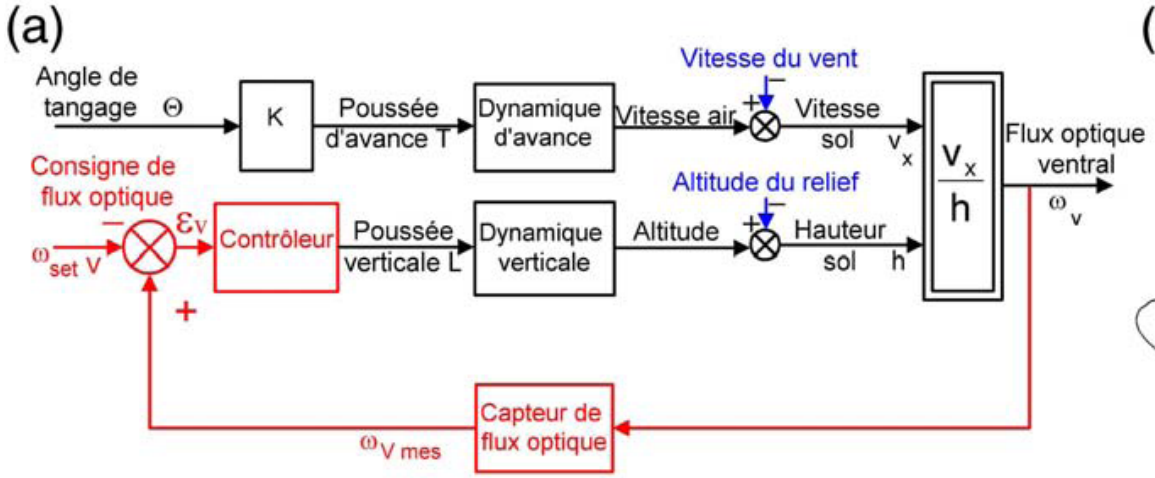
Biorobotique

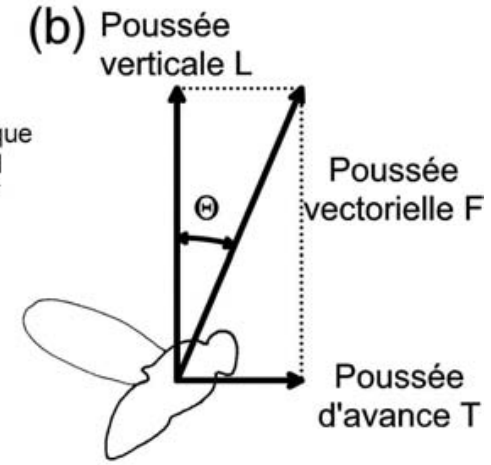


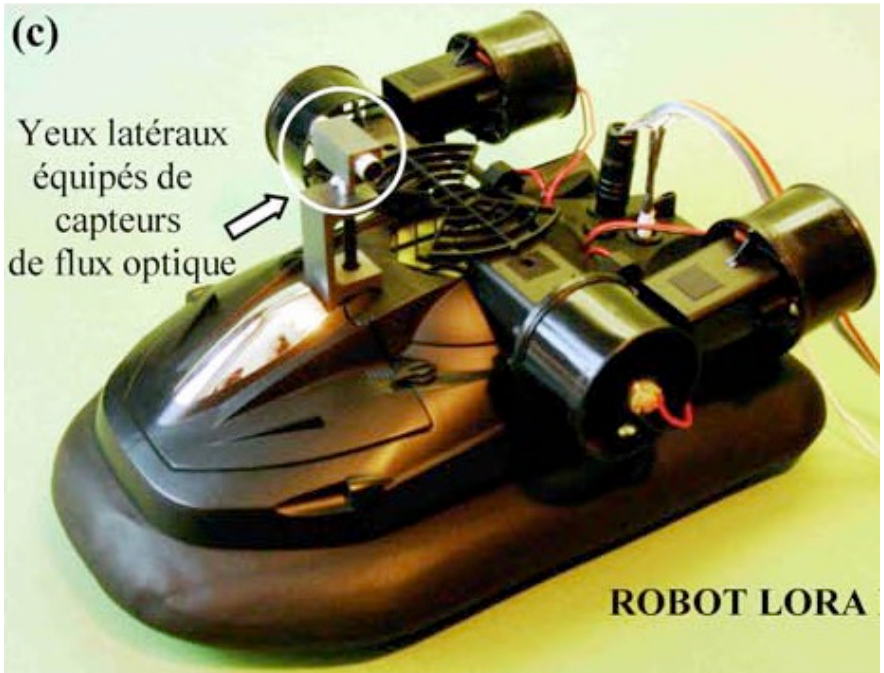


Exemples

Biorobotique







Exemples

Collaborative robotics
Soft robots
Cobots