INTERNATIONAL ADDENDUM

ABOUT INPUT

INPUT provides planning information, analysis, and recommendations to managers and executives in the information processing industries. Through market research, technology forecasting, and competitive analysis, INPUT supports client management in making informed decisions. Continuing services are provided to users and vendors of computers, communications, and office products and services.

The company carries out continuous and in-depth research. Working closely with clients on important issues, INPUT's staff members analyze and interpret the research data, then develop recommendations and innovative ideas to meet clients' needs. Clients receive reports, presentations, access to data on which analyses are based, and continuous consulting.

Many of INPUT's professional staff members have nearly 20 years' experience in their areas of specialization. Most have held senior management positions in operations, marketing, or planning. This expertise enables INPUT to supply practical solutions to complex business problems.

Formed in 1974, INPUT has become a leading international consulting firm. Clients include over 100 of the world's largest and most technically advanced companies.

X

CAD1

Improving the Productivity of Engineering and Manufacturing

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INPUT Planning Services for Management

IMPROVING THE PRODUCTIVITY OF ENGINEERING AND MANUFACTURING USING CAD/CAM
INTERNATIONAL ADDENDUM

A MULTICLIENT STUDY

DECEMBER 1981

IMPROVING THE PRODUCTIVITY OF ENGINEERING AND MANUFACTURING USING CAD/CAM INTERNATIONAL ADDENDUM

CONTENTS

IMPROVING THE PRODUCTIVITY OF ENGINEERING AND MANUFACTURING USING CAD/CAM
INTERNATIONAL ADDENDUM

EXHIBITS

1 INTRODUCTION

I INTRODUCTION

A. PURPOSE AND SCOPE

- Research for the INPUT five-volume CAD/CAM (Computer-Aided Design/ Computer Aided Manufacturing) multiclient study was conducted in the U.S., Europe (United Kingdom, France, West Germany, Holland), and Japan.

- Some foreign interview programs were completed too late to be included in the major volumes, so the decision was made to publish these results as an addendum to the study.

- Approximately 80% of the interviews for the INPUT CAD/CAM study were conducted in the U.S.

  - The U.S. was the focus of the study because of its greater concentration of systems, users, and vendors.

  - CAD/CAM systems developed by U.S. vendors are currently the most prevalent, worldwide.

- The demographic profile of user respondents is shown in Exhibit I-1.

- The size profile of user respondent companies is shown in Exhibit I-2. The Japanese company profile very closely parallels that of the U.S. Extensive

EXHIBIT I-1

DEMOGRAPHIC PROFILE OF USER RESPONDENTS

LOCATION / TYPE	UNITED STATES	JAPAN	EUROPE	TOTAL
Mechanical	61	6	19	86
Electronics	59	6	6	71
Architectural	39	3	2	44
Total	159	15	27	201

EXHIBIT I-2

SIZE PROFILE OF USER RESPONDENTS
(PERCENT OF TOTAL RESPONDENTS IN GIVEN AREA)

COMPANY SIZE / AREA	SMALL	MEDIUM	LARGE
United States	17%	18%	65%
Europe	25	36	39
Japan	14	22	64

DEFINITIONS:

Mechanical and Electronics Companies
- Small - Under $100 million (total company annual sales)
- Medium - $100 million to $1 billion
- Large - Over $1 billion

Architectural Firms
- Small - Under $2 million (total annual billings)
- Medium - $2 million to $10 million
- Large - Over $10 million

user lists were not available for Europe, so the size profile varies from the other two geographic areas.

- The purpose of this volume is to provide clients with a basis for comparisons of general issues at a summary level (two or three applications combined) and some selected issues at a more detailed level.

- Data are provided for comparative purposes only and should be used with the limited sample sizes in mind for European and Japanese data.

B. QUALIFICATION OF RESULTS

- European and Japanese sample sizes are too small to be considered statistically significant, so conclusions should be drawn with caution. The data in this volume are not represented to be a precise basis for extrapolating the research results to the entire geographic areas of Europe and Japan.

- However, when used at a summary level where all three applications are combined, the data generally are valid in a broader context. The reader is cautioned not to attempt to make extremely fine distinctions in the results.

- Even broader considerations are called for in the use of data for more detailed levels (two applications combined or a single application). These data should be considered to be indicative of trends rather than an exact representation of the entire area-wide population.

C. ORGANIZATION

- This volume relies more heavily on exhibits than the other volumes in order to better illustrate the comparisons.

- The general issues are presented in the same sequence as the questionnaires used in the research. Copies of the questionnaires have been included in each of the major applications volumes.

- Following the general issues, some selected application-specific issue comparisons are presented. It was not possible to present all issues due to sample size limitations.

II INTERNATIONAL OVERVIEWS

II INTERNATIONAL OVERVIEWS

A. INTRODUCTION

- Background reports were prepared for INPUT by research correspondents in the United Kingdom, West Germany, France, and Japan.

- Extracts are presented here to provide a background to INPUT clients and give them some flavor of the CAD/CAM activities in the respective countries.

- Researchers were asked to provide write-ups on CAD/CAM activities in their geographic area with no conditions set, to allow them freedom to select topics they considered to be of importance. This technique yielded an interesting cross-section of observations.

B. UNITED KINGDOM

- The U.K. background report focuses on government, university, and research institute efforts.

- Government funding for research in the U.K. is allotted and monitored by the Department of Industry. The DOI also administers government research establishments such as the National Engineering Laboratory, the Production,

Engineering, Research Association, and the CAD Center. The current trend is to encourage these organizations to become self-supporting by getting them to perform contract work at commercial rates for industry. Other government ministries such as the Department of the Environment also have research establishments where some CAD research work is undertaken.

- Other government funding for CAD/CAM is directed at equipment seeding and retraining projects. The Department of Industry has contributed from 25% to 100% of the cost of turnkey systems for use and evaluation by industry. The first beneficiary in the U.K. of the seeding scheme was the Ford Motor Company.

- If it had not been for these government grants and the exposure to others of their use (which was one of the conditions imposed) the use of CAD systems, particularly turnkey systems, would not be as widespread as it is now.

- At the present time, the government is initiating a program of education and training. Particular emphasis is being placed on retraining redundant drawing office staff in the use of CAD techniques.

- There is no central government plan for coordinating CAD/CAM research and development, either across the various ministries or the academic institutions and research associations. It is believed that many worthy requests for funding get rejected because of the nature of the selection panels, the time involved, and the amount of paperwork.

- One government program is aimed at helping smaller industries evaluate CAD/CAM. The Manufacturing Advisory Service allows for 15 days of free consultancy to firms of 2,000 or less employees.

- An extensive list of the universities and activities was provided for this report. Interested readers may request the full list from INPUT. Some examples are:

- Cambridge University - The CAD Center was once the hub of academic work on CAD in the U.K. The role of the center has changed radically over the last three years when the Department of Industry attempted to close it down but bowed to intense pressure from industry. It originally was an organization that undertook research and development, provided a CAD service bureau through a national network of computers and produced specific turnkey systems. The computer network was disbanded and many key staff moved away and formed their own enterprises. The center is now reduced to a software house undertaking contract work for industry. Attempts are now underway to reestablish Cambridge as a CAD Center with a new team being assembled by the Department of Control Engineering.

- Bath - CAD training needs in mechanical engineering.

- Brunel - Extensive research in integrated circuit (IC) design and circuit simulation with funding by the European Economic Community. They are also performing work on finite element methods and drafting systems research.

- Cranfield Institute of Technology - Curve and surface development with numerical control (NC) machine tool interfaces for aerospace.

- Edinburgh - Architectural design, artificial intelligence techniques for CAD and manufacturing problems, and development of standards.

- Imperial College - Heavily involved in CAD in circuit synthesis, drafting, interactive graphics, geometric modeling, nuclear prototype and design, engine design, and finite element systems.

- Leeds - Joint effort with the University of Rochester (U.S.) on the development of PADL System (geometric modeler).

- Nottingham - Development of special purpose packages including the PAFEC Finite Element System.

- University of Aston - Production of a low-cost, desk-top drafting system and research into CAM.

- University of Wales - The main U.K. center for finite element research. Also worked on the automatic scanning of drawings for input into drafting systems (particularly electric schematics).

C. WEST GERMANY

- A CAD/CAM study conducted in Western Europe has shown that West Germany is not very well advanced in the use of CAD/CAM compared to other countries.

- The German electronics and software industry related to the production of CAD systems consists of subsidiaries of foreign companies, particularly U.S. organizations. There seems to be a reluctance on the part of smaller organizations to use this imported technology.

- Another reason seems to be the concentration of the reserach institutes on the production of total systems. There is no provision for the gradual transfer of technology to industry at key points within these projects. There has been much duplication of effort and competition between the various projects.

- These problems have been addressed by the appointment of a national CAD/CAM manager. The manager's role is to remove the rivalry, select the best systems to concentrate upon, and proceed on a step-by-step basis. He realizes that the original plans of the researchers for total systems to present to industry will not be realized.

- From 1972 to 1979, the West German government spent approximately $50 million on support of CAD research. This program was replaced in 1980 by a manufacturing support program in which approximately $125 million was budgeted to be spent over a three-year period. Thus, since 1980, the support in West Germany has been on industrial applications of CAD systems with research projects obtaining less support.

- Some university research activities supported by the German government are:

  - Two-D drawings (Aachen, Bochum, and Berlin).

  - Three-D models (Berlin and Bochum).

  - Two- and three-D geometry processing (Stuttgart).

  - Process plan generation (Aachen and Berlin).

- The large multinational organizations are the dominant CAD users in Germany. The majority of CAD/CAM work is performed on mainframe computers. Computervision is estimated to be the dominant turnkey system supplier with approximately 30 installations in Germany.

- Prior to 1980, a great deal of dependence was placed on using systems at research institutes rather than implementing in-house systems. There is, however, much talk of impending in-house implementation of software packages, particularly MCS AD2000.

- At the present time, Germany lacks an adequate commercially based software industry for technical products. Reliance is placed on products from other European countries.

- There is a great deal of use of numerically controlled machine tools in Germany and the concentration has been on NC applications.

D. FRANCE

- CAD was first used in France about 10 years ago by large firms in aerospace, automotive, and electronics. Each of these large companies developed its own system.

- At the present time, approximately 150 companies are equipped with CAD systems. Most of them are very large companies. Most small and medium-size companies are not using CAD systems due to their cost.

- It has been estimated that 80% of the potential market for CAD systems in France in 1985 will be concentrated in firms of more than 200 employees, with 60% in firms of more than 500 employees. The distribution of the market among the different sectors of French industry is shown in Exhibit II-1.

- A number of CAD systems are now available in France. While some of them are French products, an important number of them are coming from foreign countries (especially the U.S.).

- Some of the general software packages developed in France are:

  - EUCLID - a volumetric modeler.

  - FORTRAN 3D - an extension of FORTRAN for describing three-dimensional objects.

  - GRI 2D - two-dimensional drafting software.

  - SYSTRID - general software for the design of complex surfaces.

  - RA 3D - description and manipulation of three-dimensional objects.

EXHIBIT II-1

ESTIMATED MARKET DISTRIBUTION
FRANCE - 1985

INDUSTRY	SYSTEMS	WORKSTATIONS
Mechanical and Electronics	50%	50%
Aeronautics and Shipbuilding	6	11
Transportation	7	10
Civil Engineering	11	10
Others	26	19

- CASSANDRE - a language for the description and simulation of logical systems.

- CACT - a library of programs for architecture and civil engineering.

- SIFRA - a library of programs for civil engineering.

- STRESS - programs for structural analysis.

- Turnkey systems developed by French companies include:

  - SECROL and CIRRUS - printed circuit routing and schematics.

  - IPA and IPB - architectural applications.

  - ADEL - electrical engineering applications.

  - LGP - architectural applications.

- A variety of hardware components are also manufactured by French companies including computers, printers, CRTs, graphics displays, and plotters.

- A number of French governmental agencies are engaged in efforts to popularize and promote the use of CAD. Their efforts are in the form of education, financial aids, and guidance and consulting.

E. JAPAN

- The sale of turnkey systems was begun around 1974 and has increased rapidly since about 1978. Computervision, Applicon, and Calma have been the predominant suppliers.

- Domestic suppliers such as Hitachi, Sharp, and Daini Seikosha have recently entered the market. Fujitsu has recently acquired rights to sell the Lockheed CADAM package and is expected to actively compete with IBM.

- It is estimated that 60% of all turnkey systems are used in the design of printed circuit boards and large-scale integrated circuits.

- Custom built systems are used by large companies in the automotive, ship building, architectural, electronics, and construction industries. The introduction of graphic displays approximately 10 years ago allowed these companies to convert their systems from batch to interactive.

- The total number of turnkey and custom built CAD/CAM systems in Japan at the end of 1980 was estimated to be approximatley 600. Sixty percent of these systems were turnkey and 40% were custom-built.

- Some of the larger firms have developed distributed systems with multiple turnkey systems connected to a large host computer. One company has 10 turnkey systems connected to its host computer.

- Few companies in Japan use only remote computing services (RCS). In many cases, RCS are used with turnkey or custom-built systems for processing of analyses or simulations.

- Most of the companies using only RCS are small companies involved in printed circuit board and architectural design.

- Companies supplying RCS in Japan include the Nippon Telegraph and Telephone Public Corporation, Japan Information Processing Service, Fujitsu, and IBM Japan.

- It is estimated that there are approximately 50 to 100 users relying solely on RCS CAD/CAM systems.

- There are legal restrictions in Japan on the usage of public communication lines. It is possible that these restrictions may be relieved in the near future which would result in an increase in the level of RCS activities. If this occurs, the number of RCS users is estimated to increase at a rate of 20% per year.

- The number of turnkey systems in the mechanical area is not as high as in electronics, but the market growth for mechanical systems is expected to be very high as the turnkey vendors begin emphasizing this market segment.

- At the present time, software vendors do not play an important role in the CAD/CAM market. It is expected that they will play some important roles in developing software for the mechanical area. Some software packages for finite element modeling and circuit and logic simulation are on the market, but the market is not widely developed at the present time.

- Storage tubes are the most widely used displays in Japan at the present time; however, stroke refresh and raster scan displays are becoming more widely used.

- Color displays are important in the electrical and electronics areas for distinguishing multiple layers. Color is not considered to be important in the mechanical and civil engineering areas at the present time, but it is estimated that it will be widely used in five years.

- The keyboard and data tablet are the most widely used input devices and will continue to be so for some time. It is estimated that digitizers are now used on 50% of all systems. Voice recognition techniques are being developed and are seen as being important for wider utilization of CAD/CAM systems due to more simplified operations.

- Software development and integration is an area of major concern in Japan. Research is being conducted on data structures, data bases, and data management systems.

- There is a growing need for 3-D modeling systems in the mechanical and architectural areas. Tokyo University, Hokkaido University, and Kobe University have all been active in the solids modeling area as well as in other CAD/CAM applications such as process planning, NC machining, robotics, unmanned manufacturing, etc.

- CAD and CAM integration has made some progress in the electronics and mechanical areas but has not progressed in architectural applications because of the organizational separation of the design and construction functions. Good progress in integration is expected to take place over the next five years in all but the architectural applications. Computer-aided testing is seen as a very important area for integration in Japan.

- While universities and major corporations are developing software for CAD/CAM systems, there are no studies which are financially supported by the government or other public organizations.

III COMPARISON OF RESEARCH RESULTS

III COMPARISON OF RESEARCH RESULTS

A. GENERAL ISSUES

1. SYSTEM AND PRODUCT USAGE

- The types of systems installed at respondent sites are shown in Exhibit III-1.

- European respondents reported a significantly higher percentage of multiple system type installations (a mix of turnkey, custom, software, or hardware vendor supplied). The U.S. and Japan reported approximately the same percentage of multiple system types, but showed significant differences in the mix of systems installed.

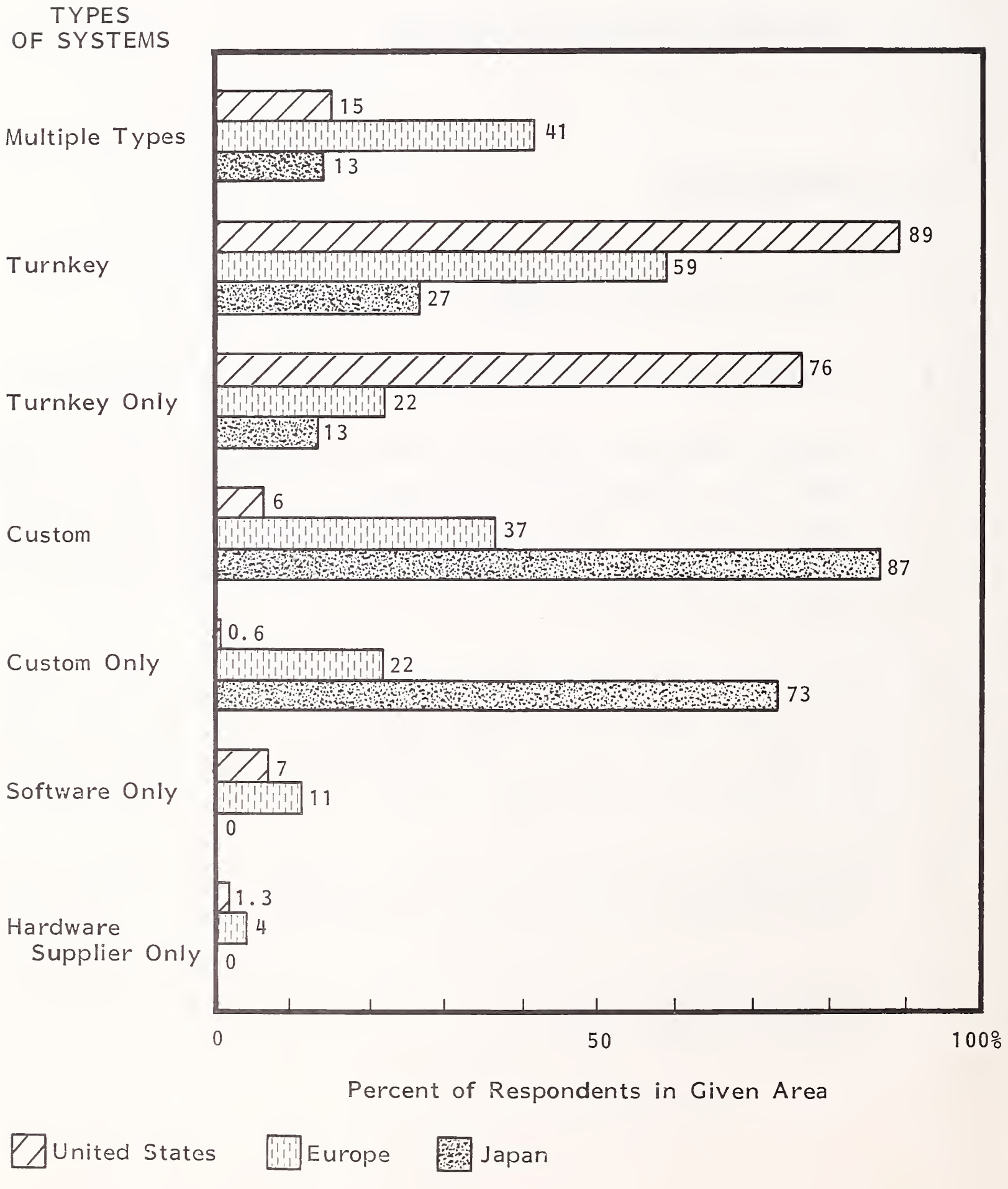
- Eighty-nine percent of the U.S. respondents reported the use of turnkey systems while Japanese respondents reported approximately the same percent of custom systems. Turnkey-only installations are predominant in the U.S. while custom-only is predominant in Japan.

- No geographic area reported a significant installed base of systems from software suppliers, hardware suppliers, or RCS vendors only.

- Remote computing services were reported by nine respondents in Europe and only one respondent in Japan.

EXHIBIT III-1

TYPES OF SYSTEMS INSTALLED AT RESPONDENT SITES



- As in the U.S., the number of workstations per site varied widely from one to 107. The average number of workstations per turnkey system was approximately four in both geographic areas. The highest number of workstations reported per site in Europe was 107 (connected to a variety of turnkey, in-house, and RCS systems for an automobile manufacturer) and 60 in Japan (connected to two in-house host computers at an electronics firm).

- Analysis and processor-intensive functions were reported being performed via workstations linked with multiple systems (in-house mainframes, turnkey systems, or RCS processors) by 17 European respondents and five Japanese respondents. In-house mainframes were more widely used in both areas than any other system type for analysis.

- Exhibit III-2 lists the turnkey vendors mentioned by respondents in Europe and Japan. This exhibit is not meant to indicate the number or proportion of vendor systems installed, but rather their presence among the study respondents. A number in parentheses after the vendor name indicates mentions by multiple respondents.

- The software systems and application packages mentioned by respondents are shown in Exhibit III-3. European respondents are using a wide variety of software packages from numerous domestic and foreign vendors. A limited number of commercially available software packages were reported by Japanese respondents.

2. SYSTEM SELECTION FACTORS

- All geographic areas considered software to be one of the most important system selection factors and gave it approximately equal weight, as shown in Exhibit III-4.

- European respondents gave higher weights to system flexibility, future enhancements, and access to data bases than U.S. respondents which could be interpreted as a greater concern for integration-related issues.

EXHIBIT III-2

TURNKEY VENDOR MENTIONS

GEOGRAPHICAL AREA / APPLICATION	EUROPE	JAPAN
Mechanical	Applicon Computervision (9) Evans and Sutherland Ferranti-Cetec Lucas Logic Unigraphics	Tektronix FEM 181
Electronics	Applicon (2) Calma Computervision (2) Danish Systems	Applicon Calma (2) Daini Seikosha
Architectural	Computervision (2)	

NOTE: Number in parentheses after vendor name indicates number of mentions

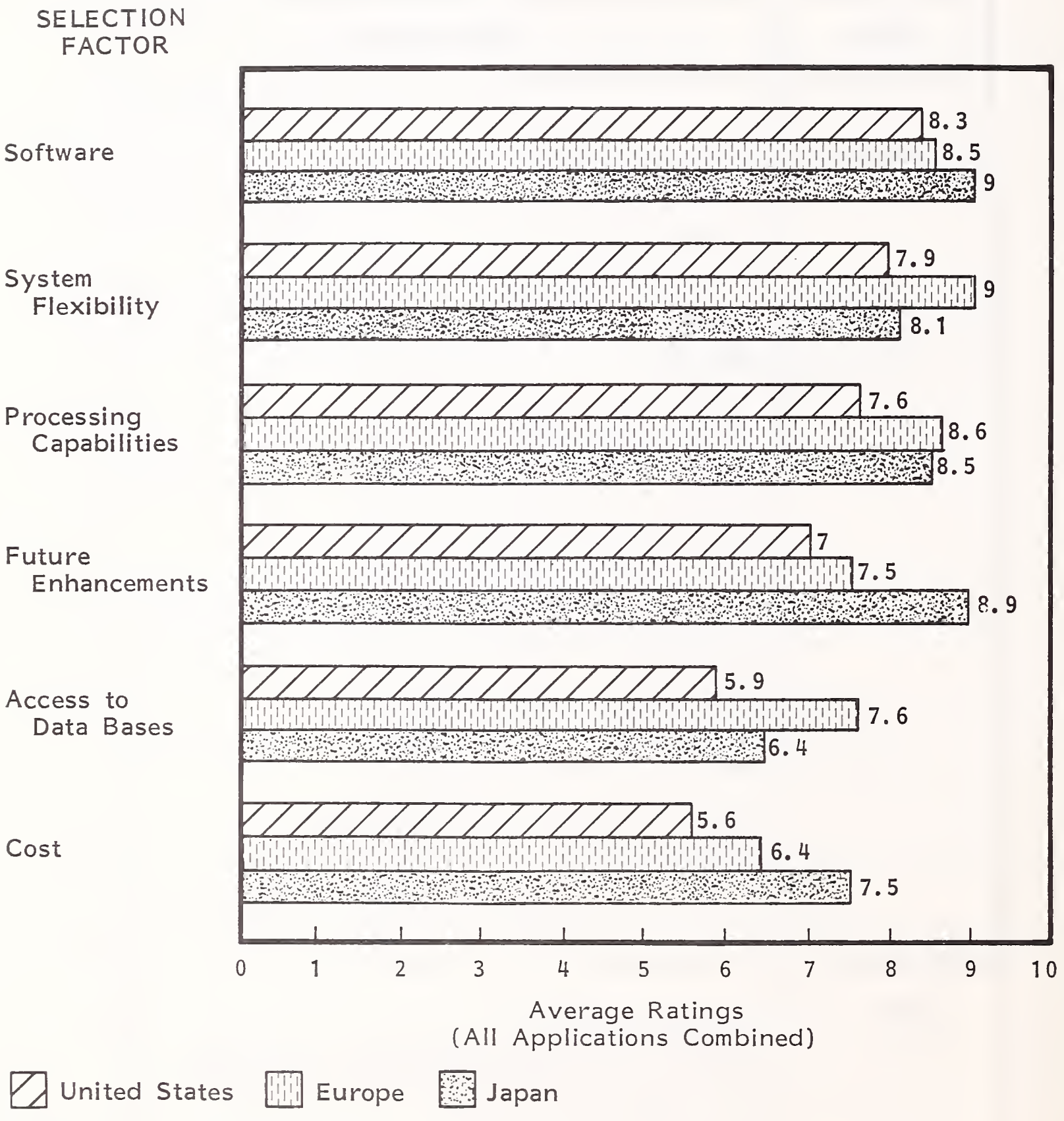
EXHIBIT III-3

SOFTWARE SYSTEMS AND PACKAGES MENTIONED

AREA	SOFTWARE
Europe	Battelle SYSTRID Bosch GRAPHICS 1000 II CGIS TEGAS COMPEDA DRAGON ETPS FEMGON GENSYS Lockheed CADAM MARC Matra EUCLID MCS AD2000 Micado CASSANDRA NASTRAN NCA (Design Rules Checking) Pafec FE SAP IV Scientific Calculations SCI-CARDS SDRC SUPERTAB, SUPERB SIFRA
Japan	Lockheed CADAM Niigata CAD/PIPLAN, CAD EFD, ISAS, AGP Toyo Information Systems FEMIS, FEMOS Univac Japan CIRCUIT

EXHIBIT III-4

RESPONDENT RATINGS
SYSTEM SELECTION FACTORS



SCALE: 1 = No Impact, 10 = Major Impact

- Both European and Japanese respondents gave higher weights to processing capabilities than U.S. respondents which indicates a more intensive utilization of systems than in the average U.S. respondent site.

- The Japanese respondents were considerably more cost-sensitive in system selection than either the Americans or Europeans. In any case, cost is one of the least important system selection factors in all geographic areas, as shown in Exhibit III-4.

- Respondent satisfaction levels are shown in Exhibit III-5. Japanese respondents showed the lowest level of satisfaction with their systems. Some of their comments indicate that this dissatisfaction may be conditioned by the fact that a high percentage of respondent systems were developed in-house some time ago and are presently performing at less than satisfactory levels.

- The low number of Japanese respondents who said they would buy again from the same vendor is due to a large extent to maintenance problems. Their comments indicated that poor maintenance of both turnkey and in-house systems was a significant problem.

3. SYSTEM JUSTIFICATION FACTORS

- Ratings of system justification factors are shown in Exhibit III-6.

- Cost savings received the highest overall rating in all geographic areas.

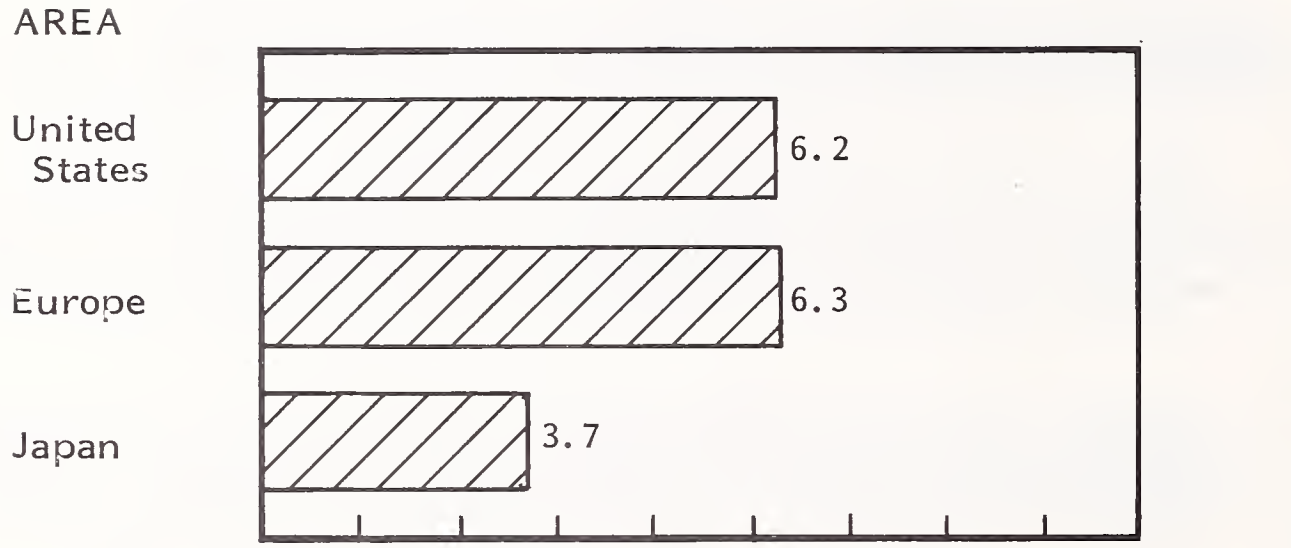
- The U.S. respondents rated design and drafting quality significantly lower than respondents in the other areas.

- The importance of CAD/CAM to designs and projects, operations and manufacturing efficiency, and plant or manpower loading is given considerably more weight by non-U.S. respondents. This response could be related to more pressing needs to improve productivity in all phases of company operations.

EXHIBIT III-5

RESPONDENT SATISFACTION LEVELS

"Rate Your Total CAD/CAM Installation in Terms of it Meeting Your Expectations at the Time of Purchase."



"If You Were to Start Over Again Today, Would You Buy From the Same Vendor(s)?"

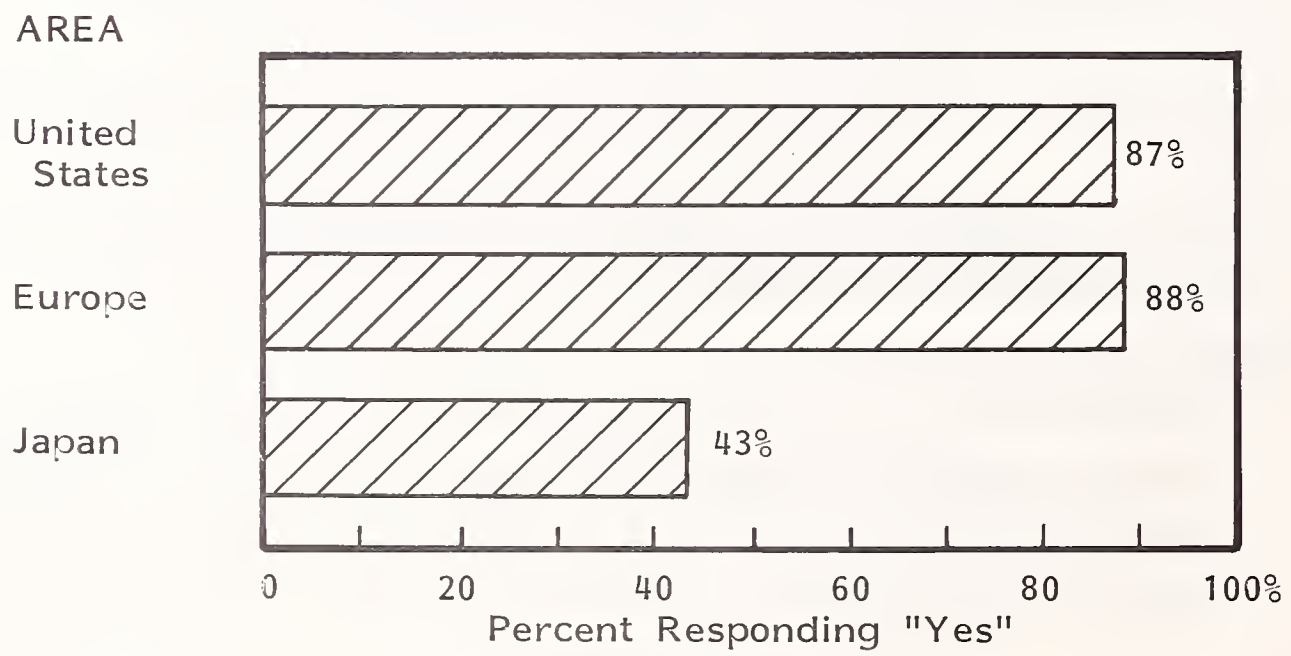
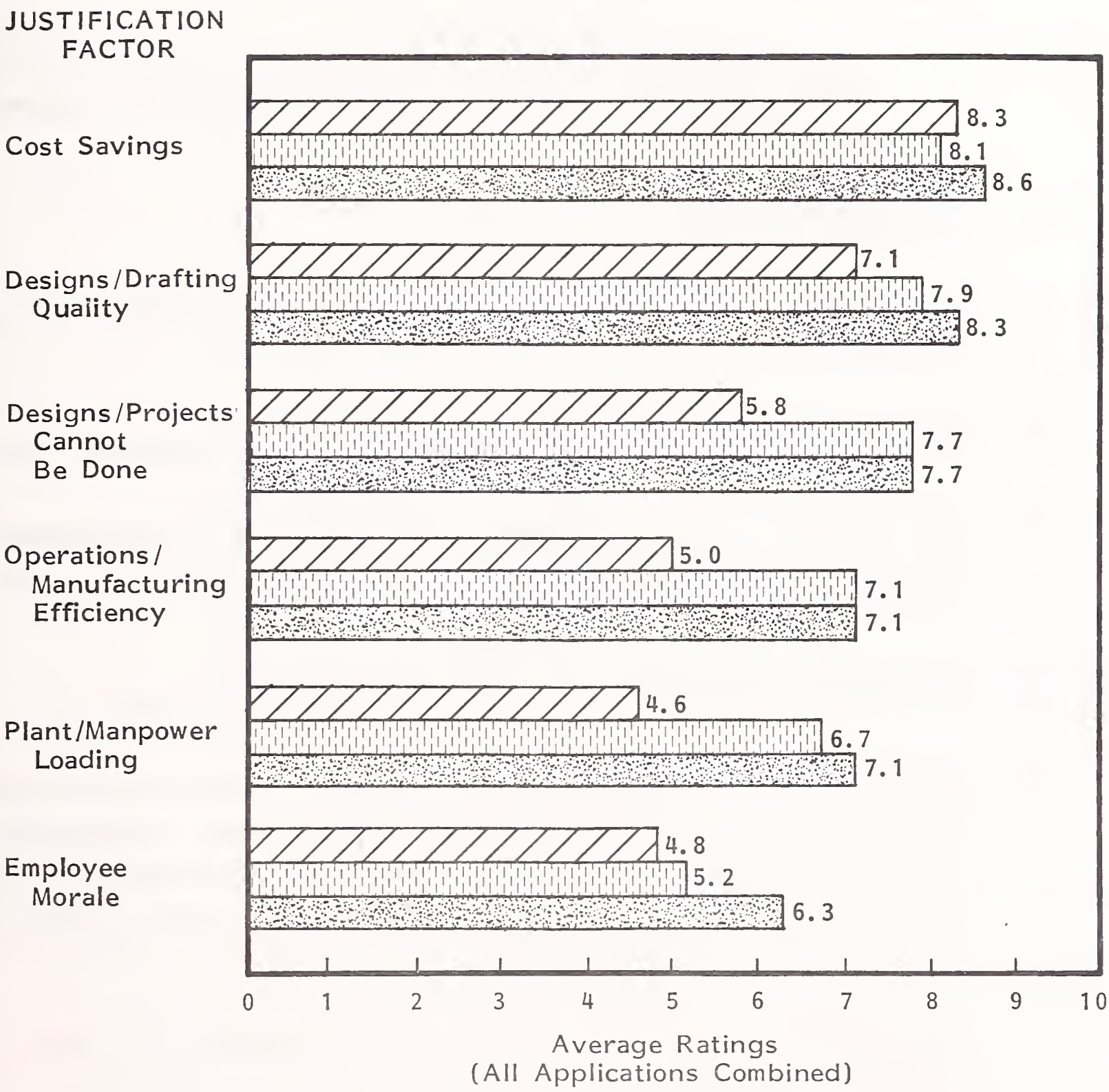


EXHIBIT III-6

RESPONDENT RATINGS
SYSTEM JUSTIFICATION FACTORS



SCALE: 1 = Not Important, 10 = Vital

- Another explanation of this rating discrepancy may be the high level of emphasis in the U.S. which is placed strictly on cost savings. European and Japanese corporations are also sensitive to cost savings, but apparently place a significant value on non-cost aspects as well. They appear to take a more global view of the importance and benefits of a CAD/CAM system.

- Given the management philosophies and attitudes in Japan, it is not surprising that Japanese respondents rated employee morale more highly than the other two geographic areas.

4. TECHNOLOGY ISSUES

- Ratings of the adequacy of display technologies are shown in Exhibits III-7, III-8, and III-9.

- Ratings of display technologies were very uniform across all geographic areas.

- All respondents agreed that storage tube technology was the least adequate, with stroke refresh and raster scan being considered better and approximately equal at the present time.

- Raster scan displays are the clear choice of all respondents in 1986.

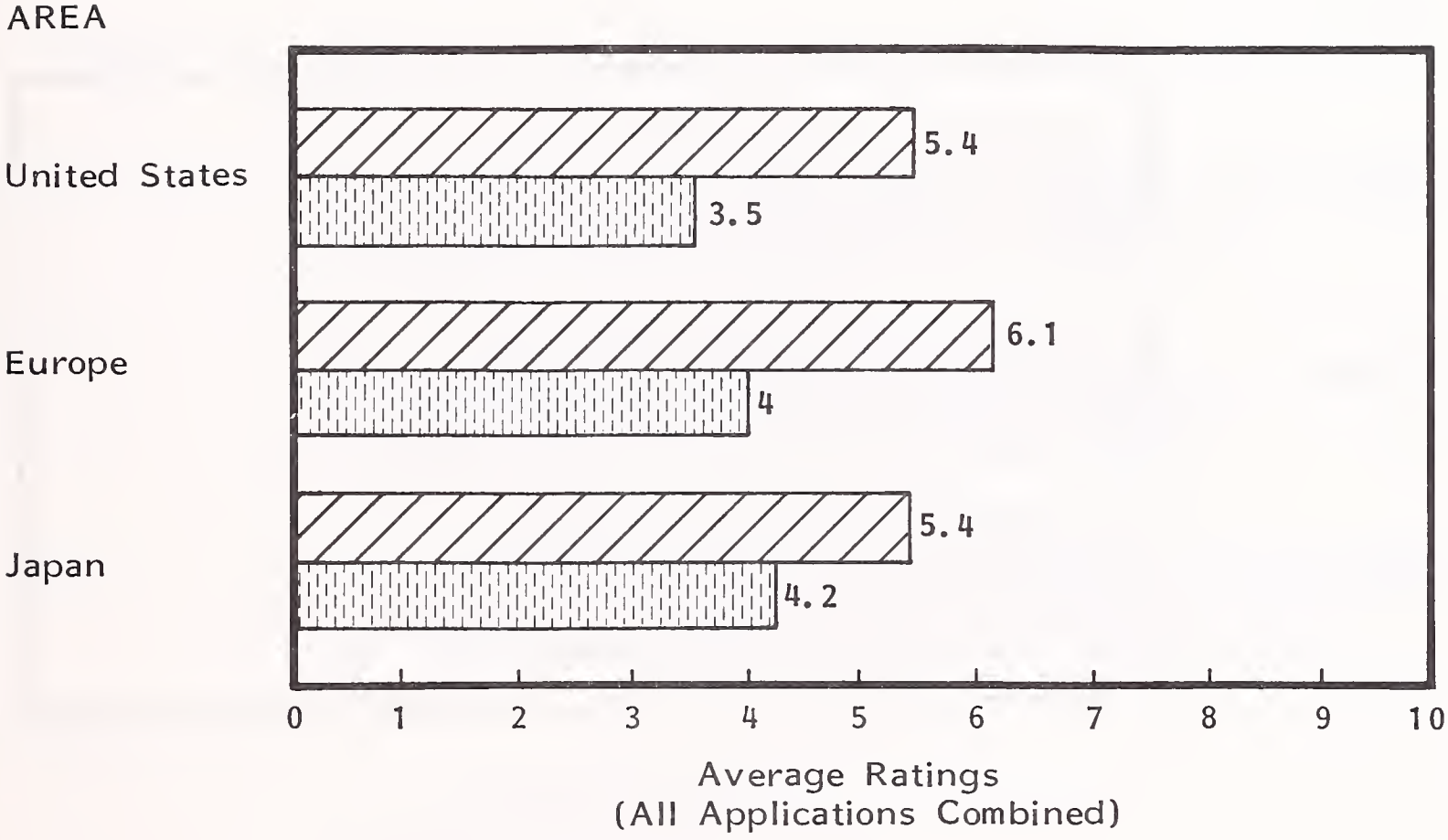
- Ratings of display technology by application area for Europe and Japan showed the same patterns as were seen in the U.S. Electronics users feel that raster scan displays are adequate for their present needs while mechanical and architectural users gave raster scans somewhat lower ratings in 1981 but agreed that they would be very adequate by 1986.

- The same patterns were seen in the ratings of the importance of color displays as shown in Exhibit III-10.

- Responses to questions concerning system response times showed a high degree of variance, as they did in the U.S. surveys. As in the U.S., this was due to

EXHIBIT III-7

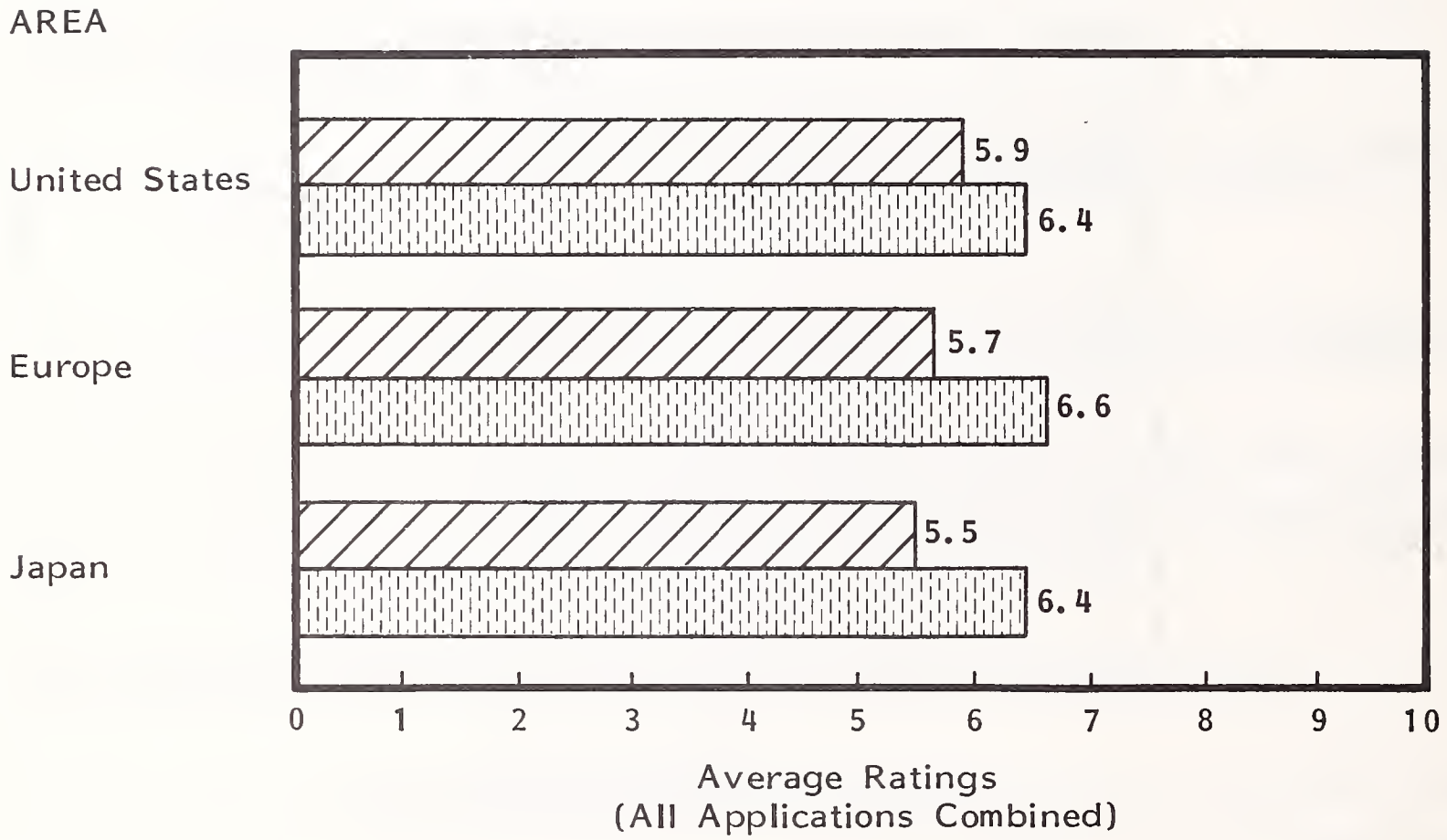
RESPONDENT RATINGS
ADEQUACY OF STORAGE TUBE DISPLAYS



SCALE: 1 = Inadequate, 10 = Exceeds Needs

EXHIBIT III-8

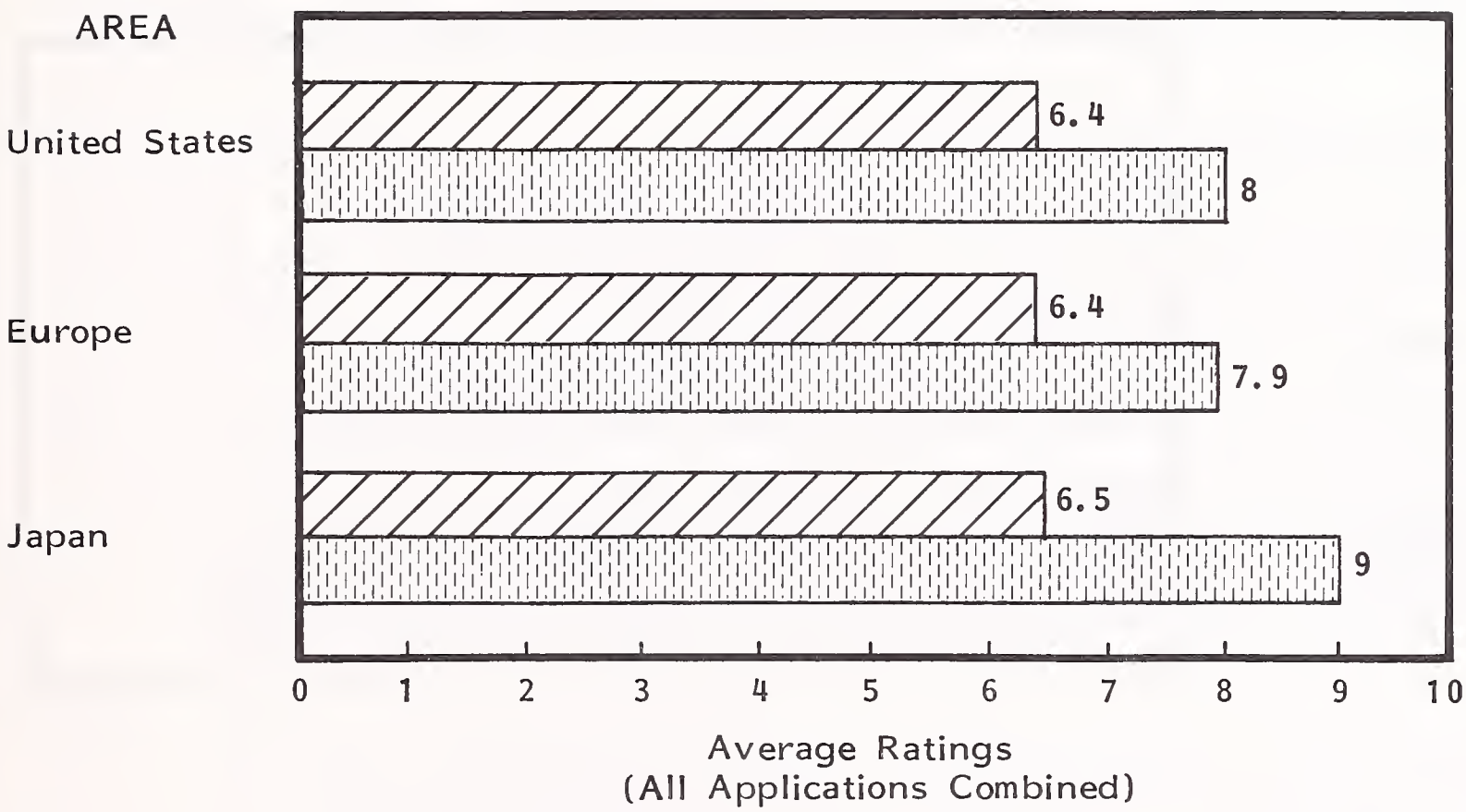
RESPONDENT RATINGS
ADEQUACY OF STROKE REFRESH DISPLAYS



SCALE: 1 = Inadequate, 10 = Exceeds Needs

EXHIBIT III-9

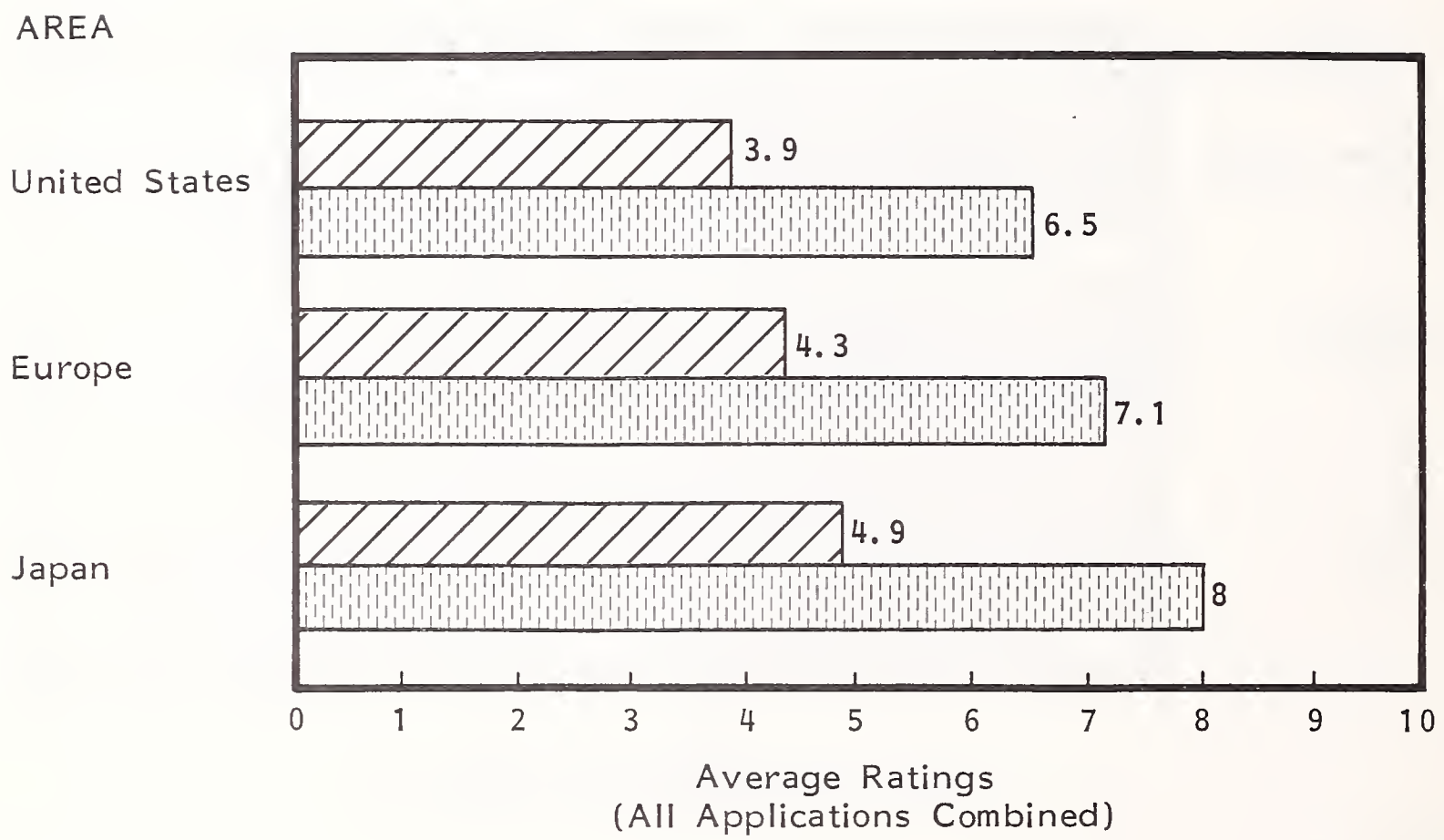
RESPONDENT RATINGS
ADEQUACY OF RASTER SCAN DISPLAYS



SCALE: 1 = Inadequate, 10 = Exceeds Needs

EXHIBIT III-10

RESPONDENT RATINGS
IMPORTANCE OF COLOR DISPLAYS



SCALE: 1 = No Requirement, 10 = Essential

definitional problems, difficulty in accurately measuring response times, and the lack of hard data.

- Eighty-eight percent of the European respondents rated the response time of their systems as adequate compared to 54% in the U.S. Japan showed the lowest level of satisfaction with response times, with only 7%, or one respondent, reporting that his response times were adequate.

- From the comments on the Japanese questionnaires, it appears that a large part of the dissatisfaction results from older in-house developed systems, many of which were converted from batch to interactive operations.

5. USE FACTORS

- The time to train new users is a significant issue in all applications and geographic areas. The average training time is shown in Exhibit III-11.

- All geographic areas reported approximately the same time to train new users for initial use of their system. However, a significant difference can be seen in the time for Japanese respondents to train a new user to full proficiency compared to the other geographic areas. This four- to eight-week difference would represent a significant cost savings in a large installation.

- Government and university efforts in CAD/CAM training were reported underway in the U.K. and France. U.S. efforts in this field need to be increased.

- Exhibit III-12 shows the ratings of the location and operators of workstations.

- Japanese respondents are clearly ahead of the other geographic areas in distributing their workstations to the design group locations as opposed to concentrating them in a central design facility. Part of this flexibility may

EXHIBIT III-11

RESPONDENT RATINGS

TIME REQUIRED TO TRAIN NEW USERS

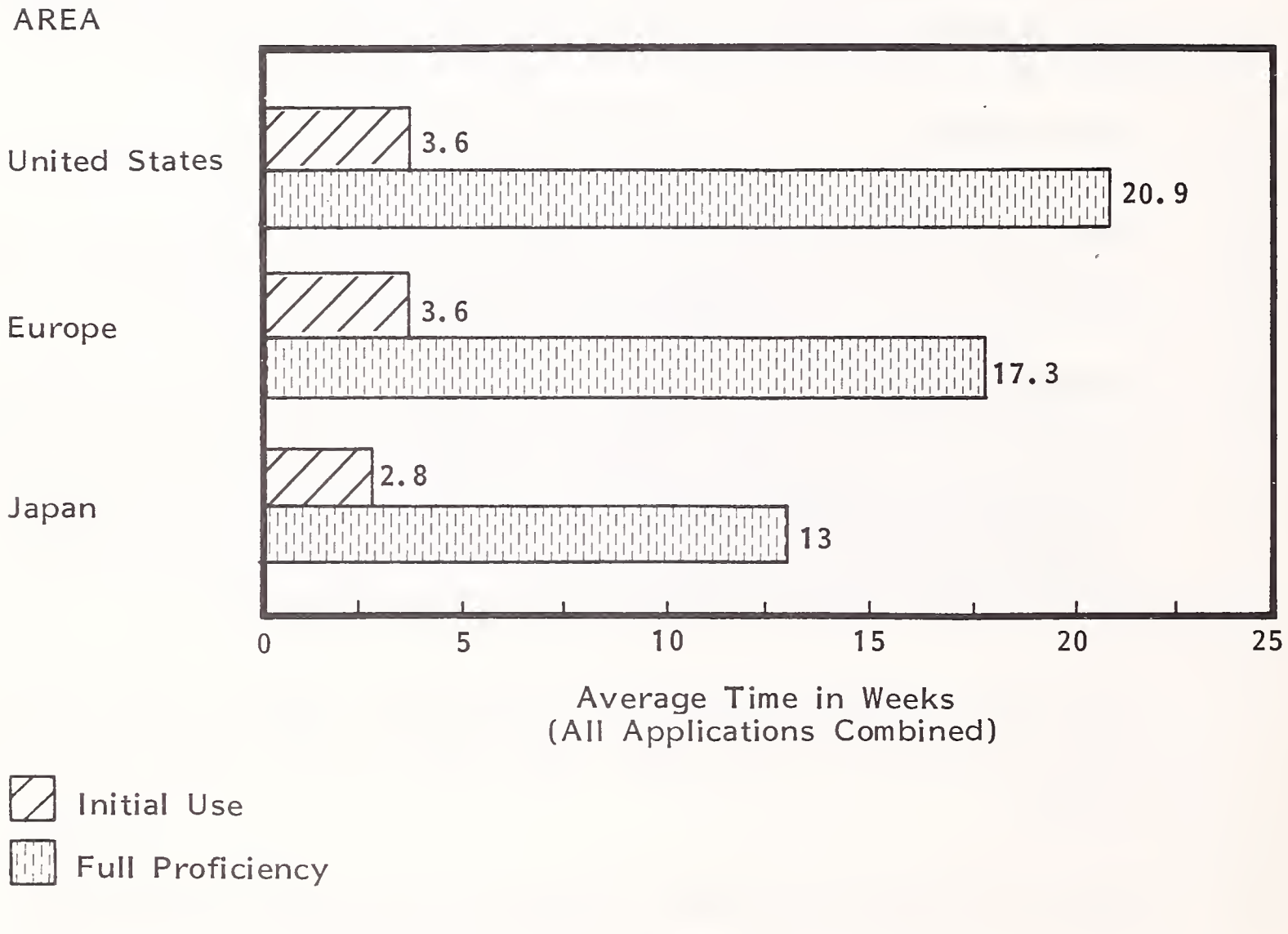
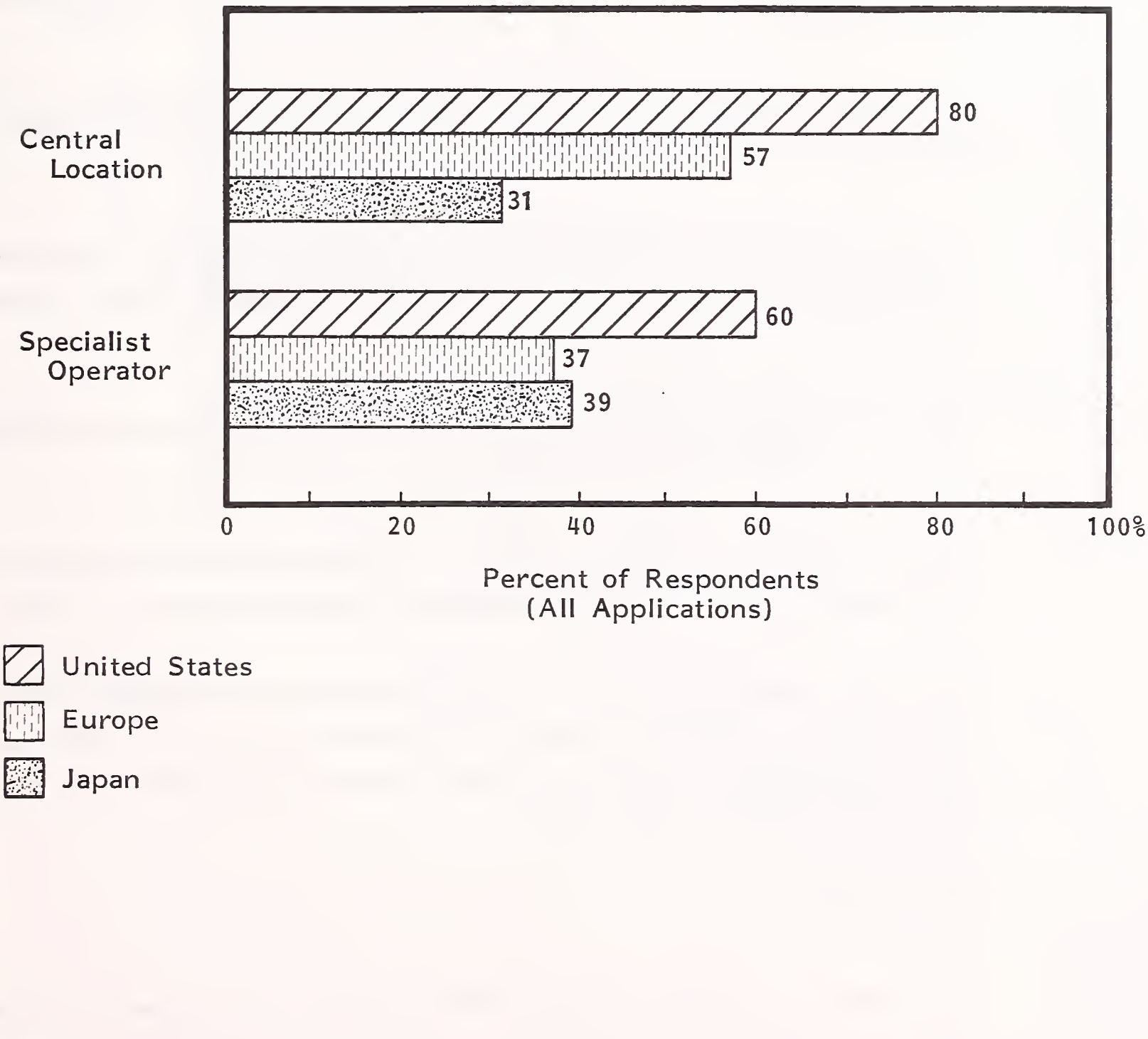


EXHIBIT III-12

RESPONDENT RATINGS
LOCATION AND OPERATORS OF WORKSTATIONS



result from the fact that a significant percentage of the workstations are connected to large host computers which typically allow more flexibility in graphic display connection than smaller processor-based turnkey systems.

- The U.S. reported the highest percentage of dedicated or specialist CAD/CAM system operators. Approximately 60% of the European and Japanese respondents reported the use of engineer or nondedicated operators. This result is especially interesting in light of their lower reported time to train these operators. This would indicate that their training is very effective as well as taking a shorter period of time since the majority of their system operators are not dedicated.

- The overall productivity improvements expected and received are shown in Exhibit III-13.

- Japanese respondents were the only ones reporting a lower than anticipated improvement in productivity. All the Japanese respondents to this question were users of custom-built in-house systems.

- Respondent ratings of software adequacy at the present time and anticipated adequacy in 1986 are shown in Exhibit III-14.

- U.S. and European respondents reported a reasonably good satisfaction level at the present time with marked improvements in adequacy expected by 1986.

- The Japanese respondents showed a much lower level of satisfaction with very little anticipated increase in adequacy expected over the next five years. Again, these responses were very strongly influenced by the high percentage of users of in-house developed systems.

6. INTEGRATION

- The integration of the CAD and CAM functions is an issue of growing importance to the users in all geographic areas. The respondent ratings on the status of integration are shown in Exhibit III-15.

EXHIBIT III-13

RESPONDENT RATINGS
CAD/CAM SYSTEM PRODUCTIVITY IMPROVEMENT

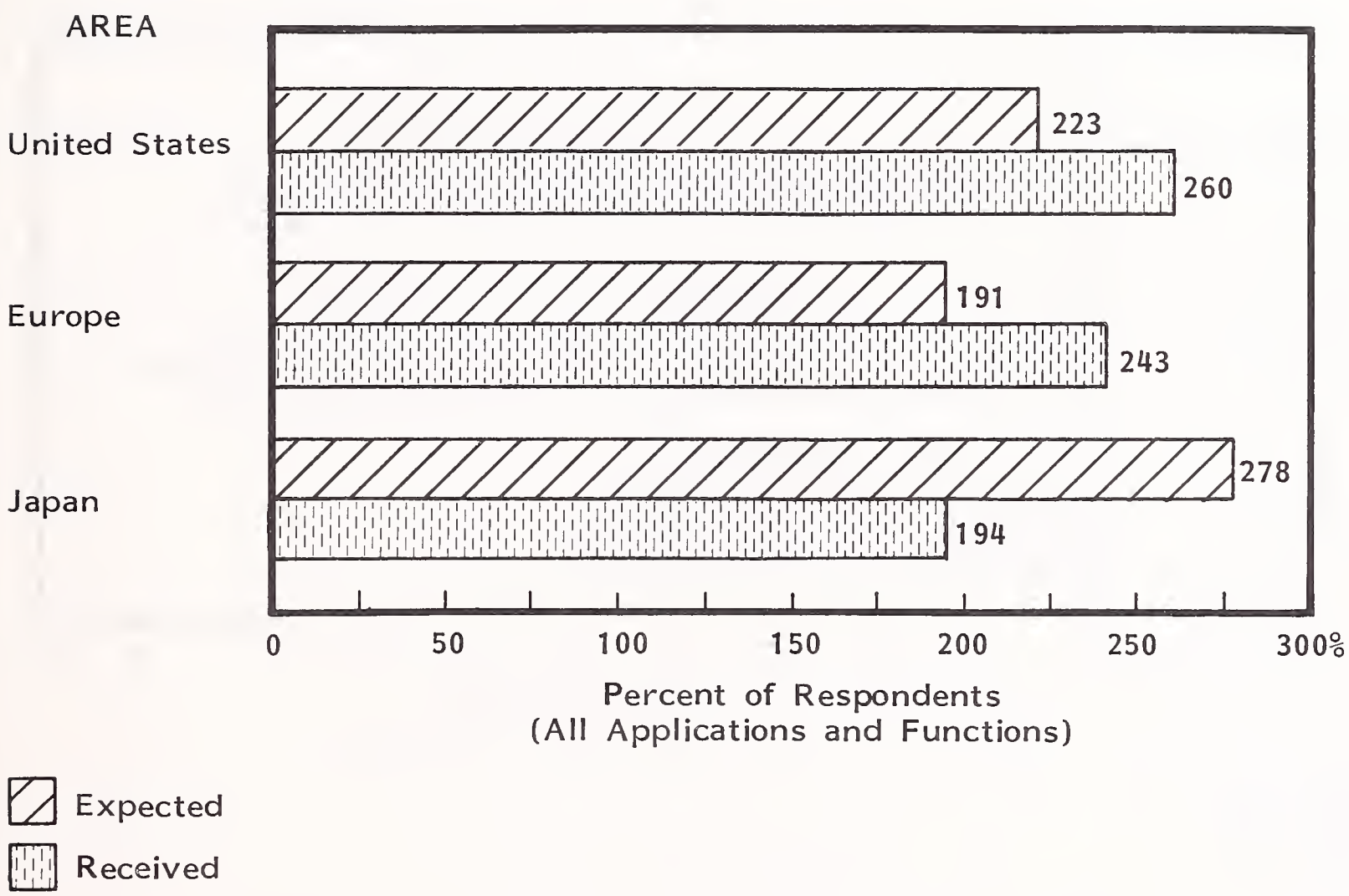
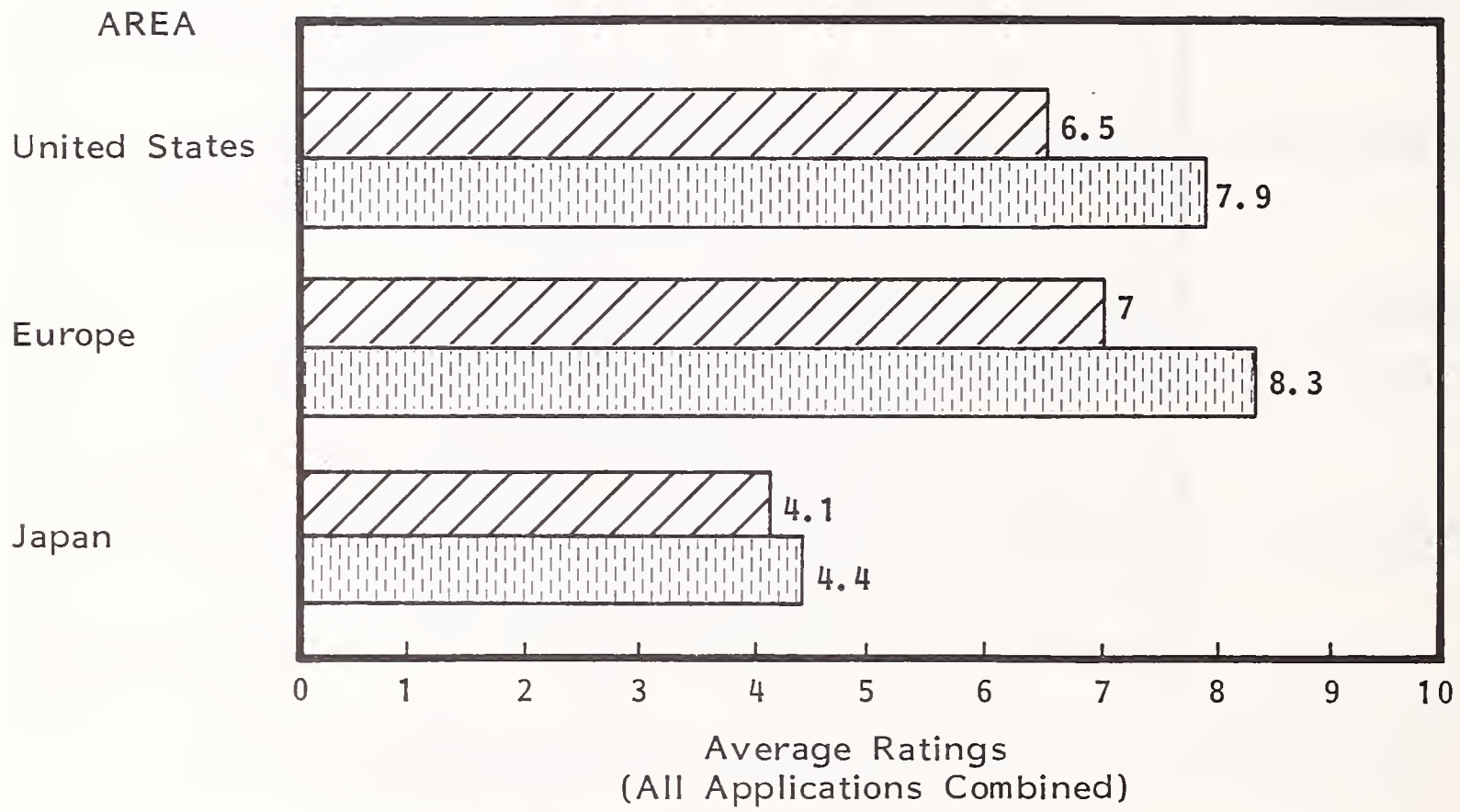


EXHIBIT III-14

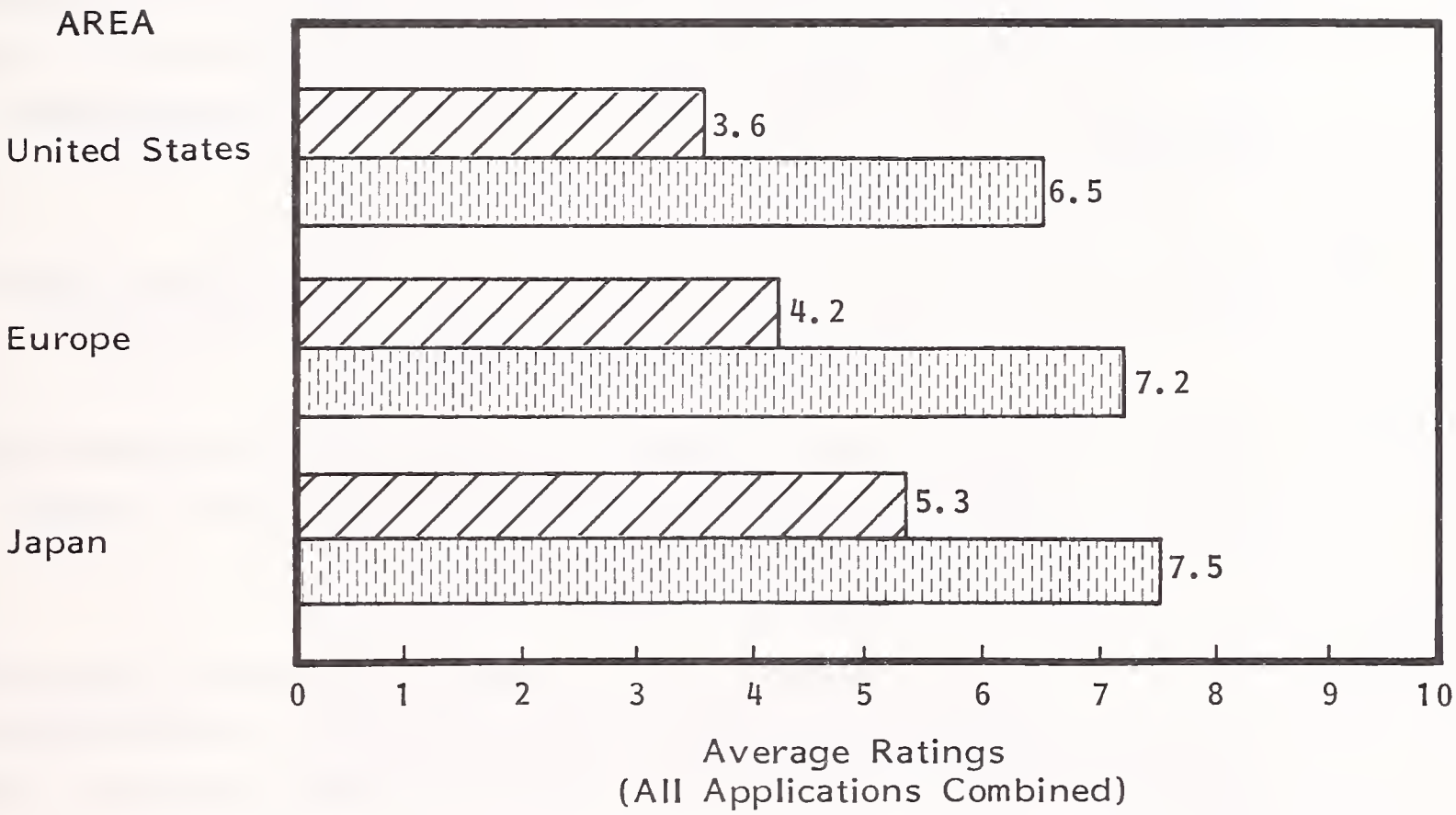
RESPONDENT RATINGS
SOFTWARE ADEQUACY



SCALE: 1 = Very Poor, 10 = Excellent

EXHIBIT III-15

RESPONDENT RATINGS
STATUS OF CAD/CAM INTEGRATION



SCALE: 1 = No Progress, 10 = Completely Integrated

- Japanese respondents reported a higher level of integration at the present time than respondents from the other geographic areas.

- While U.S. users report the lowest level of integration of all areas in 1981, the expected level in 1986 in the U.S. is projected to be very close to the levels for the other geographic areas.

- It should be pointed out that the European responses are skewed by the higher proportion of mechanical application respondents. The heavy use of NC machine tools in Europe and the level of integration of these applications with CAD systems is estimated to result in an average rating increase of 0.5 to 1.0 over the rating that could be expected with a more even distribution of applications.

- Ratings of the obstacles to the integration of CAM with CAD are shown in Exhibit III-16.

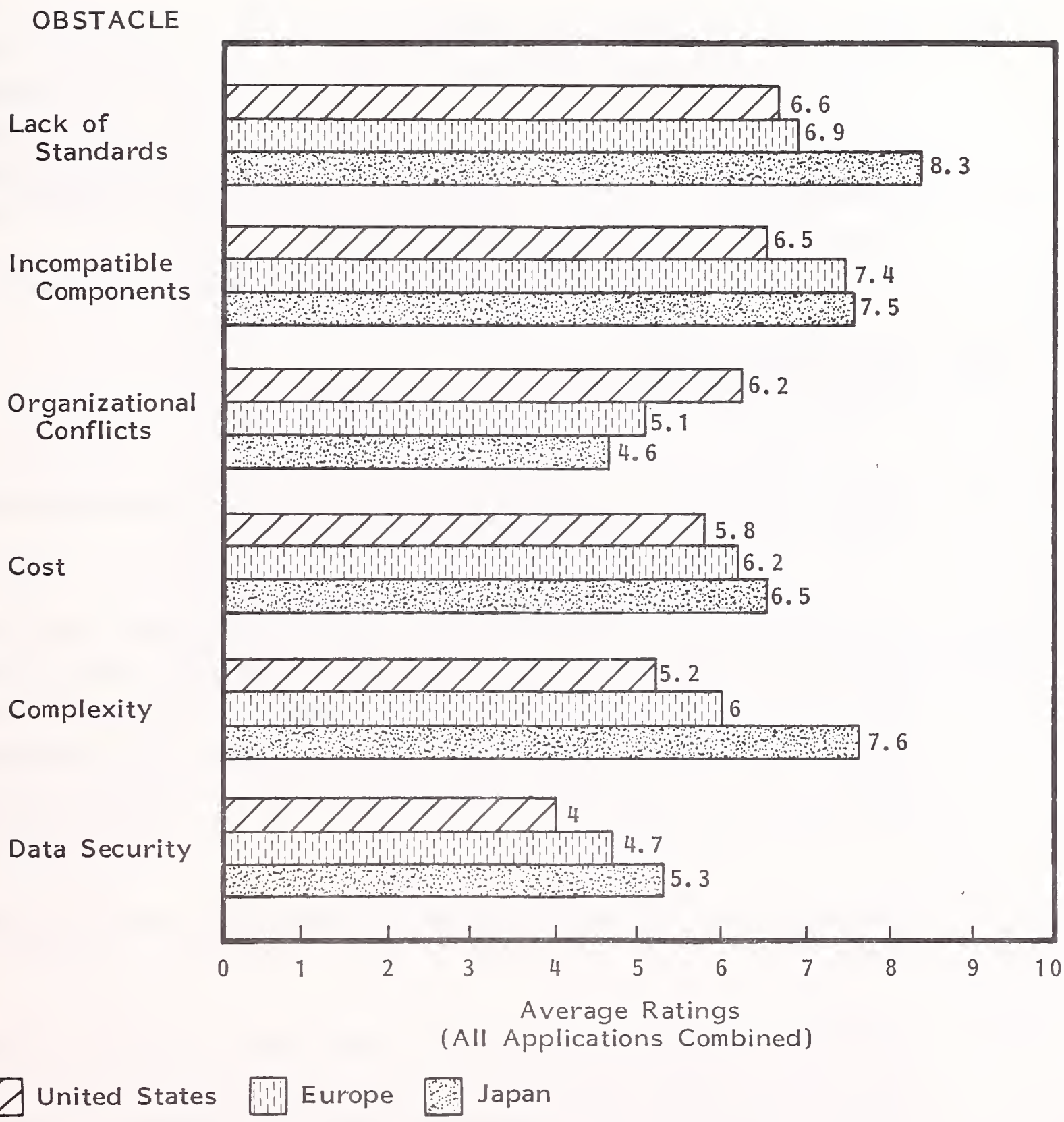
- Japanese respondents showed the most concern over the lack of standards, due primarily to their heavier requirements for linking systems from a variety of suppliers together and to central mainframes.

- The U.S. respondents expressed the most concern of the three geographic areas over organizational conflicts. One interpretation of this difference could be the differences in organizational and management philosophies in the different areas.

- Japanese respondents rated the complexity of integration as a much more significant obstacle than U.S. and European respondents. This could be a result of the higher level of integration existing in Japan which would give Japanese users a more realistic idea of the problems involved in integration.

EXHIBIT III-16

RESPONDENT RATINGS
CAD/CAM INTEGRATION OBSTACLES



SCALE: 1 = No Obstacle, 10 = Major Obstacle

7. MAINTENANCE

- Ratings of the quality of hardware and software maintenance are shown in Exhibit III-17. Software appears to be more of a maintenance problem than hardware in the U.S. and Europe.

- The U.S. and European respondents reported that they would base approximately one third of their total purchase decision for future CAD/CAM systems on the quality of maintenance service a vendor provides, while Japanese respondents reported that they would base over 90% of the decision on quality of maintenance. It must be assumed that they were considering all other factors, such as cost and capabilities, to be equal.

B. ELECTRONICS ISSUES

- Ratings of the adequacy of CAD/CAM systems for printed circuit board (PCB) design are shown in Exhibit III-18.

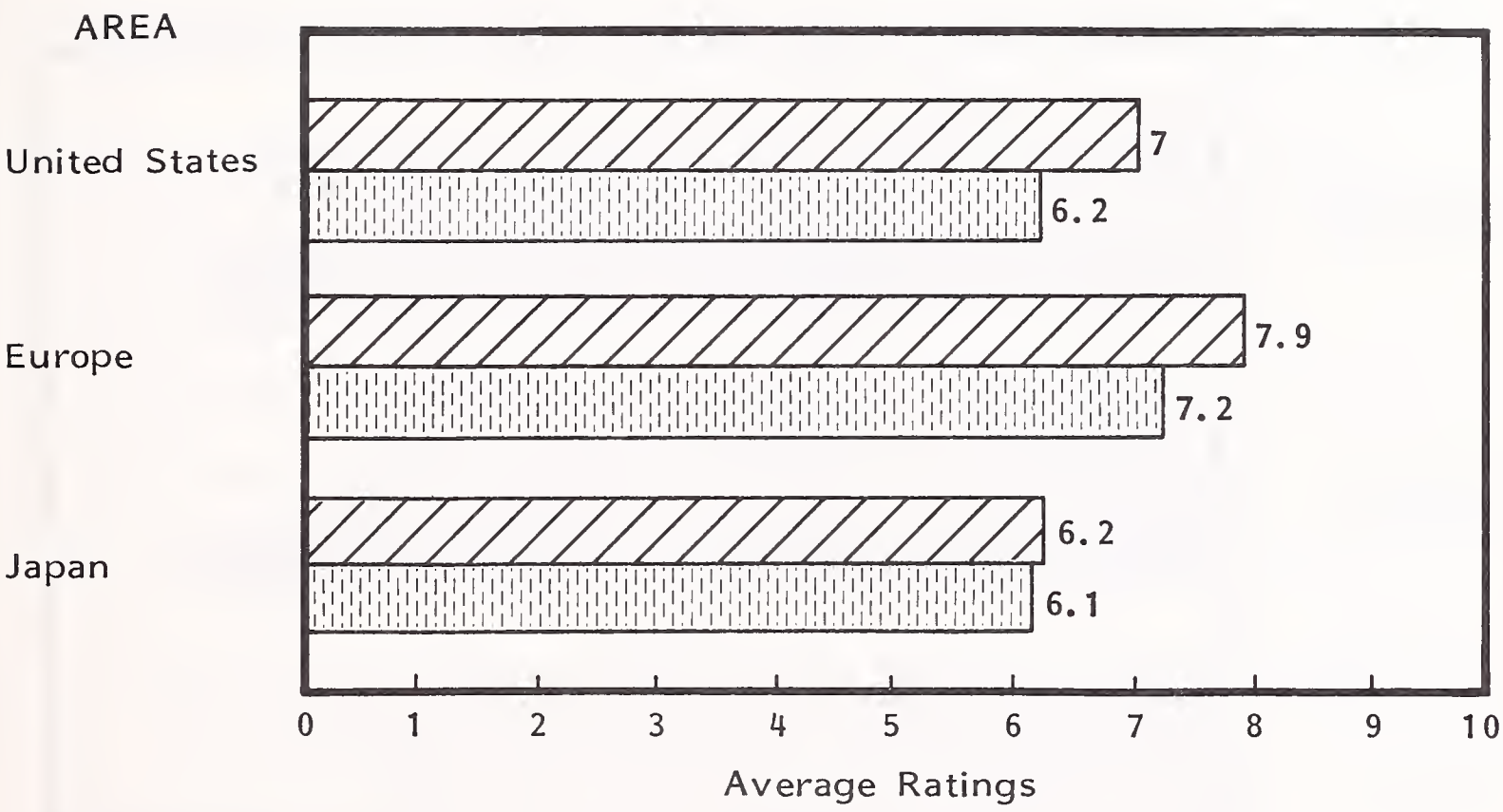
- It is interesting to note that European respondents felt that the current systems would decline in adequacy by 1986 while respondents in the U.S. and Japan assumed that the capabilities and hence systems adequacy would increase. This shifting of perceptions does not appear to be a statistical artifact and an examination of the detailed data and comments did not produce any clear reasons for this trend.

- The importance of libraries for printed circuit board design is shown in Exhibit III-19.

- The favored methodologies for integrated circuit design are shown in Exhibit III-20. The geographic differences in favored methodologies and the mixed opinion of respondents within a geographic area are representative of industry conditions in 1981. These conditions and hence the preferred methodologies

EXHIBIT III-17

RESPONDENT RATINGS
QUALITY OF MAINTENANCE

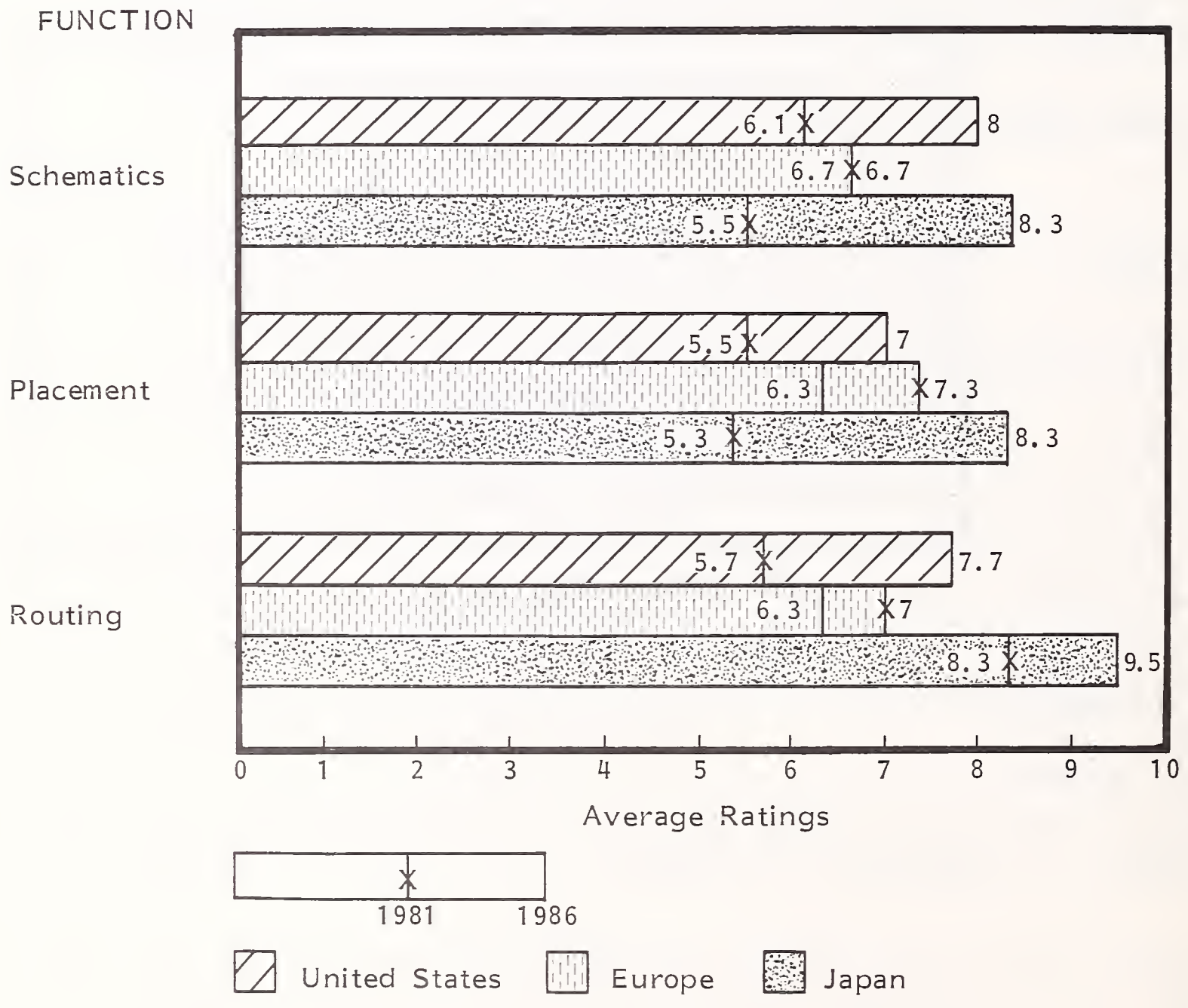


SCALE: 1 = Inadequate, 10 = Superior

EXHIBIT III-18

RESPONDENT RATINGS

ADEQUACY OF SYSTEMS FOR PRINTED CIRCUIT BOARD DESIGN



SCALE: 1 = Inadequate, 10 = Completely Adequate

EXHIBIT III-19

IMPORTANCE OF LIBRARIES FOR PRINTED CIRCUIT BOARD DESIGN

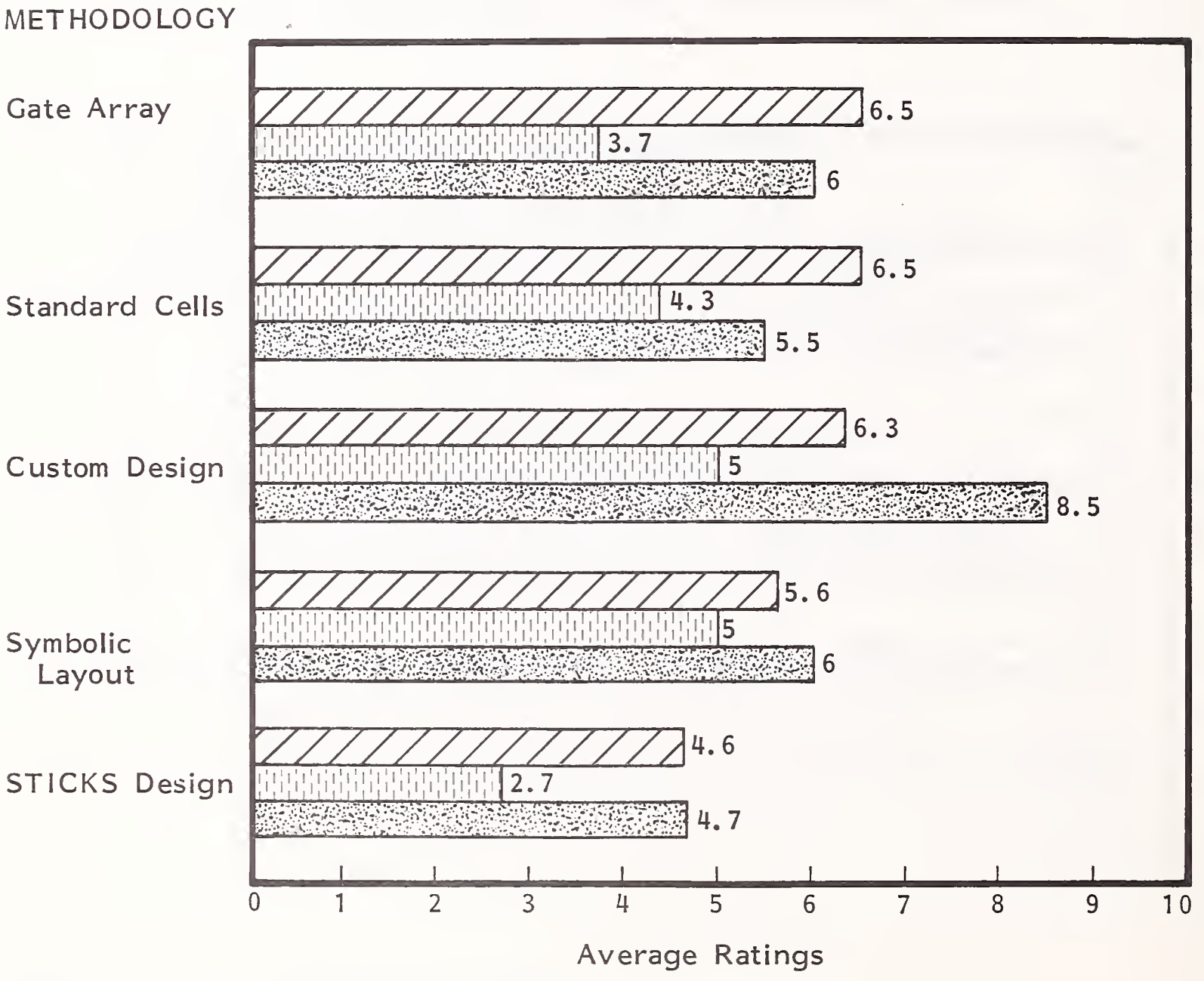
LIBRARIES	UNITED STATES		EUROPE		JAPAN	
	1981	1986	1981	1986	1981	1986
Schematic Symbols	8.5	9.1	10	10	6.0	8.3
Component Parts	8.1	8.9	10	10	9.5	10
Component Outlines	7.6	8.4	10	10	7.0	8.3
Hybrid Chips	6.1	8.0	10	10	9.0	10
Circuit and Logic Simulation	4.9	8.0	10	10	8.3	8.3
Mechanical Shape	6.1	7.6	7.7	7.7	5.0	7.3

AVERAGE RATINGS: 1 = NOT REQUIRED, 10 = CRITICALLY IMPORTANT

EXHIBIT III-20

RESPONDENT RATINGS

FAVORED METHODOLOGIES FOR INTEGRATED CIRCUIT DESIGN



SCALE: 1 = Least Favored, 10 = Most Favored

are changing rapidly due to increasing device complexity and international competition.

- Custom design is clearly the favored methodology of Japanese respondents, while European and U.S. respondents show a requirement for multiple design methodologies.

- Ratings of the adequacy of CAD/CAM systems features for integrated circuit design are shown in Exhibit III-21.

- Again, the European responses showed the same perceived decline in system adequacy as was expressed for printed circuit board design. An examination of the detailed data resulted in no apparent reason for this rating.

C. MECHANICAL AND ARCHITECTURAL ISSUES

- The respondent ratings of the importance of selected CAD/CAM system functions for mechanical and architectural applications are shown in Exhibit III-22.

- The need for true three-dimensional geometry and modeling capabilities such as finite element modeling were rated very highly by respondents in all three areas. European respondents saw the greatest need for these capabilities in 1981.

- Dynamic motion was rated significantly lower by U.S. respondents.

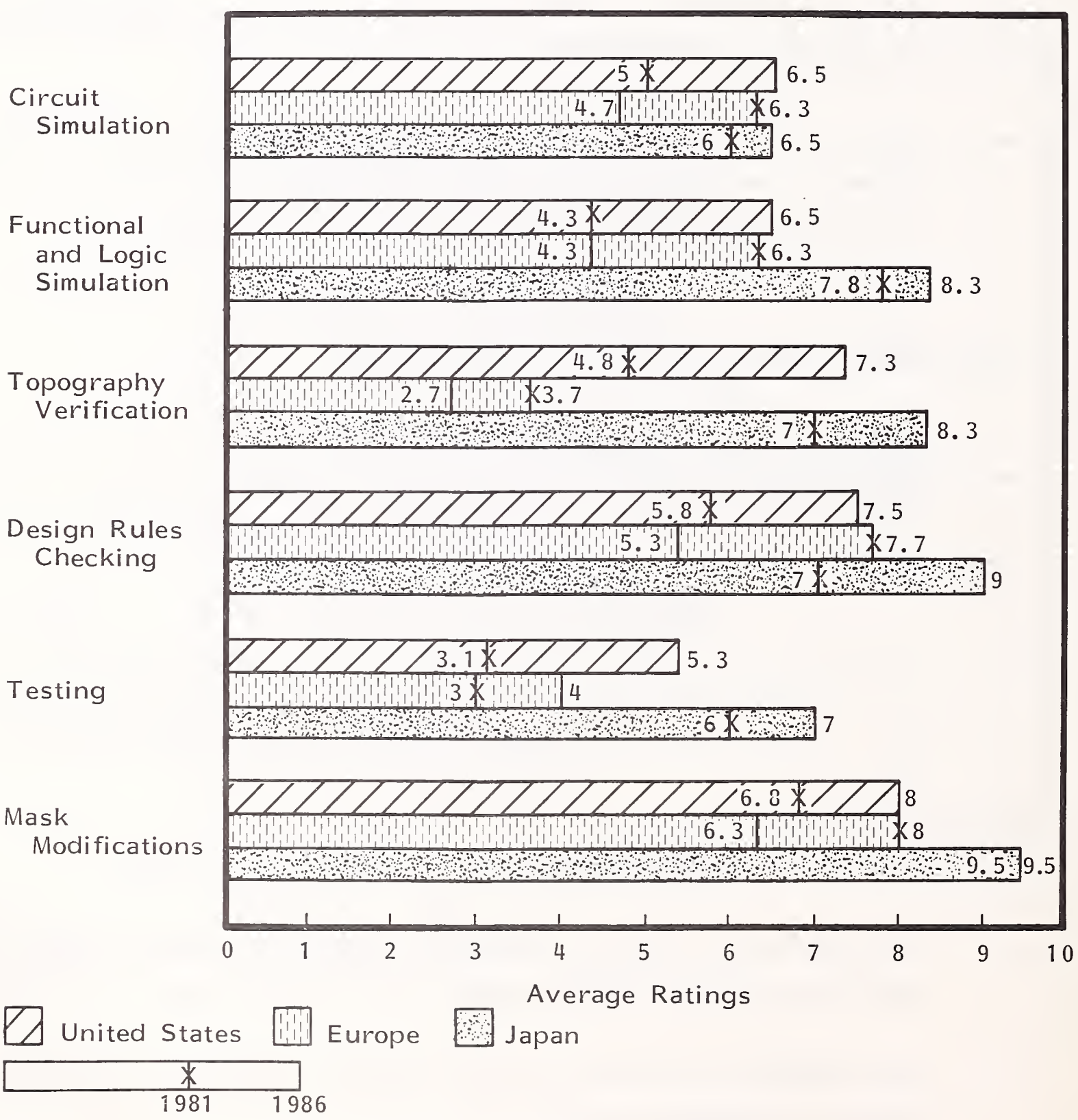
- The importance of selected CAD/CAM systems functions for mechanical applications is shown in Exhibit III-23.

- The importance of numerical control program generation is dramatically evident in all geographic areas.

EXHIBIT III-21

RESPONDENT RATINGS

ADEQUACY OF SYSTEMS FEATURES FOR INTEGRATED CIRCUIT DESIGN

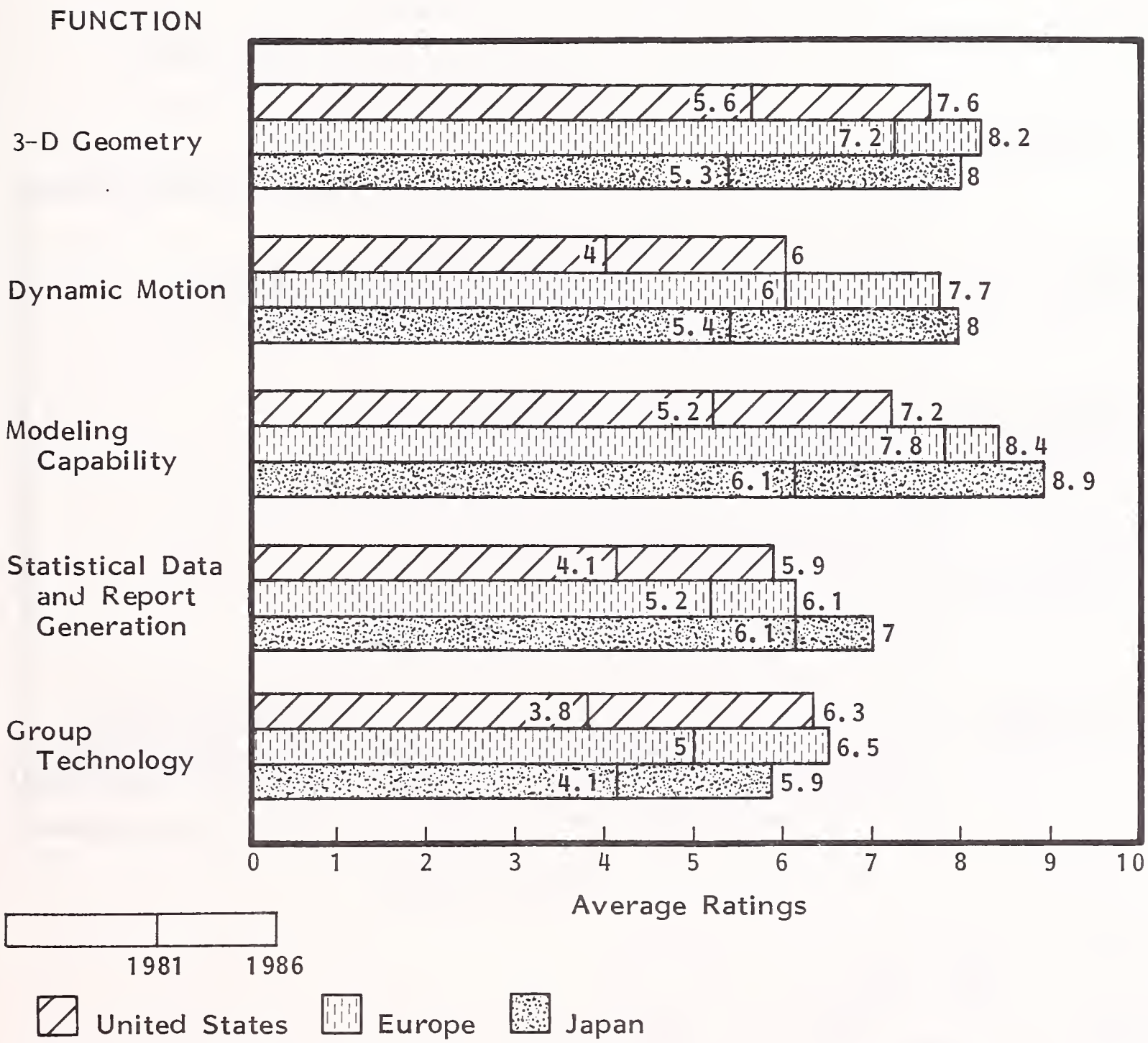


SCALE: 1 = Inadequate, 10 = Fulfills Needs

EXHIBIT III-22

RESPONDENT RATINGS

IMPORTANCE OF SELECTED CAD/CAM SYSTEM FUNCTIONS
(MECHANICAL AND ARCHITECTURAL APPLICATIONS)



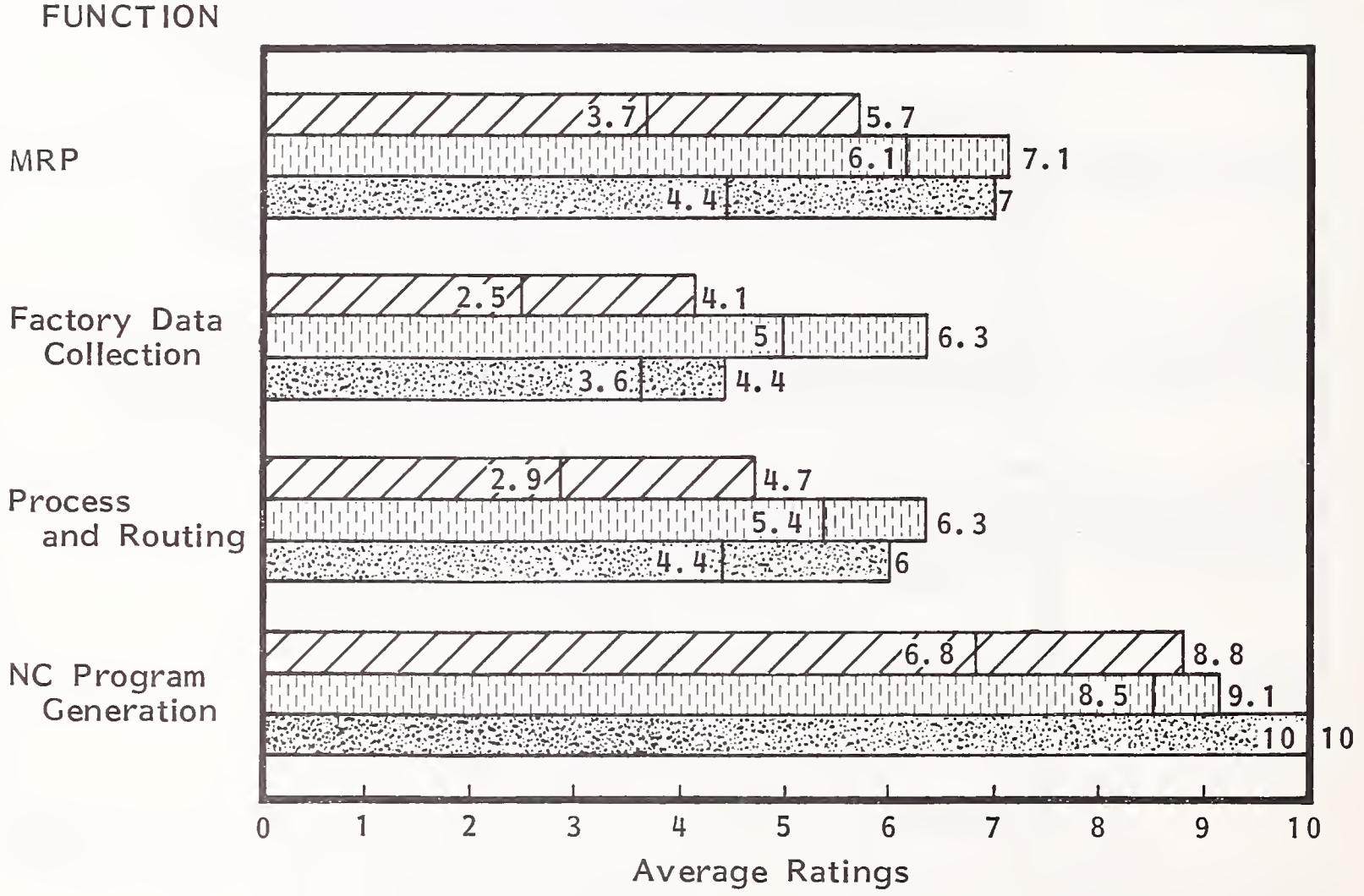
SCALE: 1 = No Requirement, 10 = Vital

EXHIBIT III-23

RESPONDENT RATINGS

IMPORTANCE OF SELECTED CAD/CAM SYSTEM FUNCTIONS

(MECHANICAL APPLICATIONS ONLY)



SCALE: 1 = No Requirement, 10 = Vital

- The U.S. ratings for the other CAM applications indicate a lower level of development of automation of the manufacturing planning and control processes and hence a lower level of perceived need.

- The Japanese respondents' rating of factory data collection appears to be a contradictory result considering the high level of activity in developing automated manufacturing systems in Japan; in fact, this low rating results from a statistical problem caused by the small sample size. Two respondents (one a ship builder) rated the importance very low which was sufficient to significantly skew the average rating. Without these responses, the average rating for Japan on factory data collection would have been slightly higher than the European ratings.

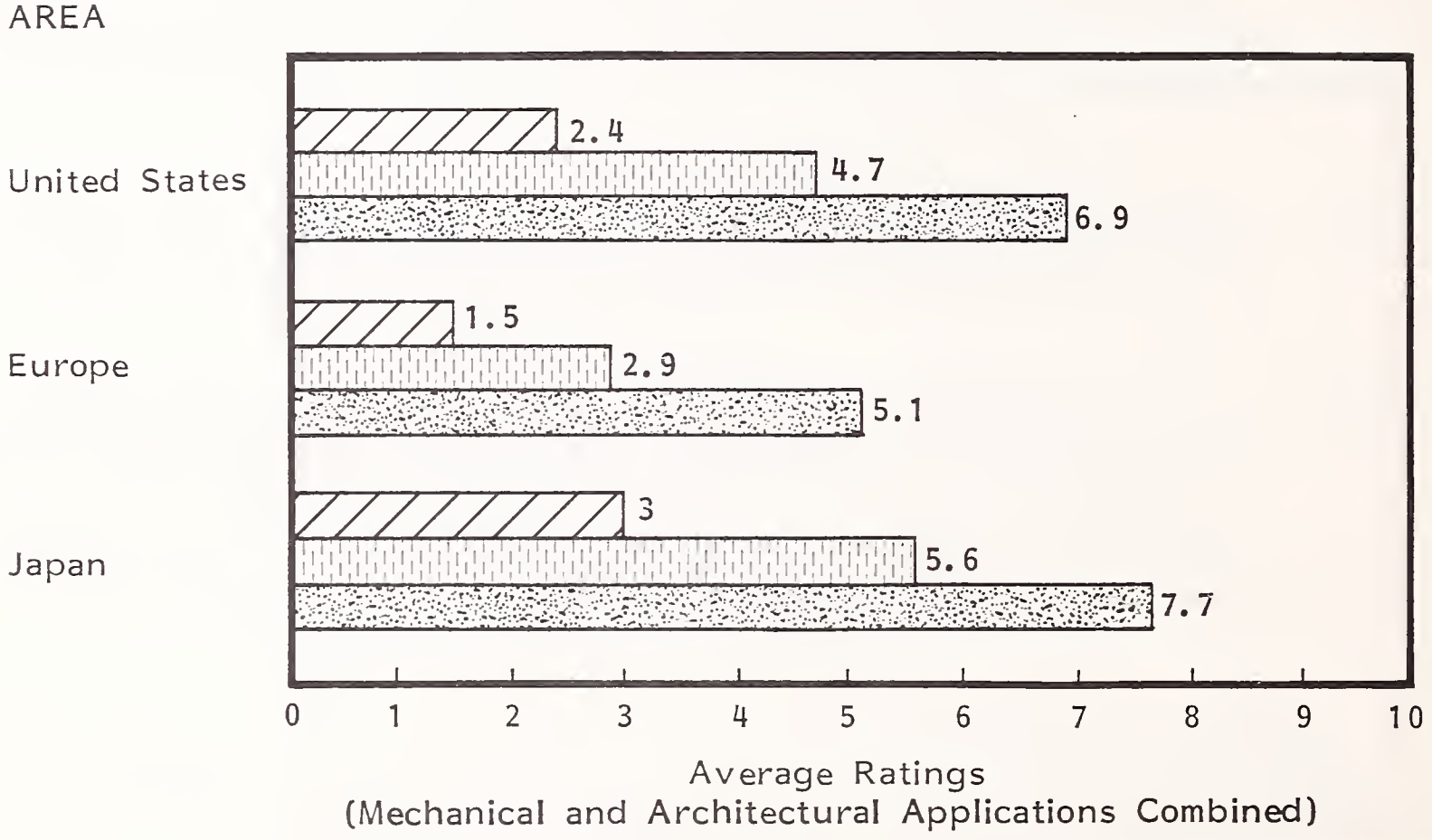
- Mechanical and architectural users were asked to rate the likelihood of conventional drawing obsolescence. Their responses are shown in Exhibit III-24.

- U.S. and Japanese respondents agreed very closely but European users showed a significantly less optimistic outlook. Part of this attitude may be attributable to the difficulty of intercountry transfers of information via electronic media.

EXHIBIT III-24

RESPONDENT RATINGS

LIKELIHOOD OF CONVENTIONAL DRAWING OBSOLESCENCE



SCALE: 1 = Impossible, 10 = Certain

IV CONCLUSIONS AND RECOMMENDATIONS

IV CONCLUSIONS AND RECOMMENDATIONS

- There are clearly areas of significant difference between the various geographic areas that must be considered by both users and vendors.

- These differences could either pose critical barriers or represent major new opportunities for multinational firms.

- The importance and meaning of most of the differences observed in the INPUT study cannot be generalized because an issue that poses a problem to one company may be seen as an opportunity by another.

- Many of the differences are caused by an uneven distribution of the extent of utilization of CAD and CAM technology across geographic areas.

- INPUT predicts that there will be no significant reduction in these differences until the late 1980s because of the large number of companies who are either not using CAD/CAM today or are just now starting up the learning curve.

- Multinational companies should use the information presented in this report to identify issues which must be investigated in greater detail in the context of their particular requirements.

- Assuming consistent or uniform conditions in different geographical areas could seriously impact vendor plans to enter new markets or user plans to establish corporatewide systems.

- Issues may take on entirely different meanings from one country to another; for example, the priority of CAD and CAM applications and functions to be integrated as well as the techniques and level of integration may vary widely.

- It is important to also clearly identify and investigate nontechnical reasons for differences such as cultural (attitudes, philosophies, and customs), corporate (practices and policies), regulatory, and economic.

- These factors may not be as easily measured as technical ones, but they could be more important.

- Even if a company is not planning any international activity in the near future, it should closely follow CAD/CAM activities in other countries.

- The international transfer of technology is increasing rapidly, but it is still fragmented enough that major opportunities or solutions can be easily overlooked.