ROBOTIC TECHNOLOGY EVOLUTION AND TRANSFER

PRESENTATION TO THE AMERICAN INSTITUTE OF AERONAUTICS AND ASTRONAUTICS - SOCIETY OF AEROSPACE TECHNOLOGY TECHNICAL COMMITTEE

JPL

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WHY TECHNOLOGY TRANSFER

PUBLIC LAW 96-480/STEVEN-WYDLER TECHNOLOGY INNOVATION ACT OF 1980

(1) TECHNOLOGY AND INDUSTRIAL INNOVATION ARE CENTRAL TO THE ECONOMIC, ENVIRONMENTAL, AND SOCIAL WELL-BEING OF CITIZENS OF THE UNITED STATES

(2) TECHNOLOGY AND INDUSTRIAL INNOVATION OFFER AN IMPROVED STANDARD OF LIVING, INCREASED PUBLIC AND PRIVATE SECTOR PRODUCTIVITY, CREATION OF NEW INDUSTRIES AND EMPLOYMENT OPPORTUNITIES, IMPROVED PUBLIC SERVICES AND ENHANCED COMPETITIVENESS OF UNITED STATES PRODUCTS IN WORLD MARKETS

(3) MANY NEW DISCOVERIES AND ADVANCES IN SCIENCE OCCUR IN UNIVERSITIES AND FEDERAL LABORATORIES, WHILE THE APPLICATION OF THIS NEW KNOWLEDGE TO COMMERCIAL AND USEFUL PUBLIC PURPOSES DEPENDS LARGELY UPON ACTIONS BY BUSINESS AND LABOR. COOPERATION AMONG ACADEMIA, FEDERAL LABORATORIES, LABOR, AND INDUSTRY, IN SUCH FORMS AS TECHNOLOGY TRANSFER, PERSONNEL EXCHANGE, JOINT RESEARCH PROJECTS, AND OTHERS, SHOULD BE RENEWED, EXPANDED, AND STRENGTHENED (U.S. CONGRESS, 1980:SEC. 2)

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CONCEPTS AND DEFINITIONS

THE CONCEPT OF TECHNOLOGY TRANSFER IS NOT A SIMPLE ONE:

- TO EXPLORE THE CONCEPT OF TECH-TRANSFER, A NECESSARY STEP IS TO CONSIDER THE IDEA OF TECHNOLOGY (Gee, 1974)
- MACHINES AND PHYSICAL TOOLS ARE COMMON REFERENTS FOR TECHNOLOGY (Doctors, 1963 Tornatzky et al 1983)
- ...ANY TOOL OR TECHNIQUE, ANY PRODUCT OR PROCESS, ANY PHYSICAL EQUIPMENT OR METHOD OF DOING OR MAKING BY WHICH HUMAN CAPABILITY IS EXTENDED (Schon, 1969)
- TECHNOLOGY IS THE MEANS OR CAPACITY TO PERFORM A PARTICULAR ACTIVITY (Gruber and Marquis, 1968)
- TECHNOLOGY HAS BEEN DEFINED SIMPLY AS THE APPLICATION OF SCIENCE (Gee, 1974)
- WHEREAS SCIENCE IS CONCERNED WITH THE INCREASE OF KNOWLEDGE AND UNDERSTANDING, TECHNOLOGY IS DIRECTED TOWARD USE...THE OUTPUT OF TECHNOLOGICAL ACTIVITY IS A PRODUCT, PROCESS, TECHNIQUE, OR MATERIAL DEVELOPED FOR SOME SPECIFIC USE. TECHNOLOGY...CAN INCORPORATE INVENTIONS...PATENTS ARE MORE COMMONLY THE OUTGROWTH OF TECHNOLOGY RATHER THAN OF SCIENCE (Gee)

CONCEPTS AND DEFINITIONS

VERTICAL TECH-TRANSFER

- ...A GENERAL PRINCIPLE IS APPLIED TO PRODUCE A NEW PRODUCT, DEVICE, OR PROCESS WITHIN A GIVEN SCIENTIFIC OR TECHNICAL DISCIPLINE, AND, GENERALLY WITHIN AN ORGANIZATIONAL ENTITY SUCH AS A SINGLE CORPORATION OR GOVERNMENT AGENCY (Doctors, 1969).
- ...THE VERTICAL FLOW OF TECHNOLOGY IS FROM A LABORATORY TO A GIVEN APPLICATION, IN A GIVEN DISCIPLINE (Essoglou 1975).

HORIZONTAL TECH-TRANSFER

- ...SECONDARY APPLICATIONS, WHEREIN TECHNOLOGY WHICH ORIGINATES IN ONE SECTOR (SUCH AS AEROSPACE) IS USED IN ANOTHER SECTOR (SUCH AS URBAN TRANSPORTATION OR HEALTH...) (Linhares, 1976).
- ...ONE TECHNOLOGY IS ADAPTED TO A DIFFERENT AREA OF APPLICATION, GENERALLY ACROSS INSTITUTIONAL LINES. AN EXAMPLE MIGHT BE SEEN IN ... THE USE OF A NEW METAL ALLOY DEVELOPED FOR A ROCKET ENGINE IN A BOILER FOR A STEEL MILL (Doctors, 1969).

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CONCEPTS AND DEFINITIONS
TECHNOLOGY TRANSFER

1) MOVEMENT OF TECHNOLOGY AFTER SOME TYPE OF ADAPTATION:

- "... THE PROCESS WHEREBY TECHNICAL INFORMATION ORIGINATING IN ONE INSTITUTIONAL SETTING IS ADAPTED FOR USE IN ANOTHER INSTITUTIONAL SETTING... MORE THAN THE MERE DISSEMINATION OF TECHNICAL INFORMATION, IT IMPLIES THE ADAPTATION OF NEW TECHNOLOGY THROUGH A CREATIVE TRANSFORMATION AND APPLICATION TO A DIFFERENT END USE" (Doctors, 1969).
- "... THE PROCESS OF EMPLOYING A TECHNOLOGY FOR A PURPOSE OTHER THAN THAT FOR WHICH IT WAS DEVELOPED... TECH TRANSFER FOCUSES ON THE UTILIZATION OF PREVIOUS RESEARCH" (Foster, 1971).

2) MOVEMENT OF TECHNOLOGY BOTH WITH AND WITHOUT ADAPTATION:

- WHEN SCIENTIFIC OR TECHNICAL INFORMATION GENERATED AND/OR USED IN ONE CONTEXT IS REEVALUATED AND/OR IMPLEMENTED IN A DIFFERENT CONTEXT, THE PROCESS IS CALLED TECHNOLOGY TRANSFER (Bar-Zakay, 1970).
- ... AN EFFORT TO BRING THE RESULTS OF RESEARCH AND DEVELOPMENT TO NEW USERS... TECHNOLOGY TRANSFER CALLS FOR THE TRANSFORMATION OF RESEARCH AND TECHNOLOGY INTO PRODUCTS, PROCESSES, OR SERVICES; OR TO THE APPLICATION OF RESEARCH DEVELOPED FOR ONE PURPOSE TO A SECONDARY PURPOSE (Myran, 1978).

FACTORS INFLUENCING TECH-TRANSFER

TECHNO-ECONOMIC FACTORS

- THE DEGREE OF GENERAL CONNECTION OF THE TECHNOLOGY TO THE FIRM'S EXISTING OPERATIONS WILL AFFECT THE DEGREE OF SUCCESS OF ADOPTION
- THE SPECIFICITY OF THE RELATIONSHIP BETWEEN THE TECHNOLOGY AND SOME EXISTING AND RECOGNIZED PROBLEM WILL AFFECT THE DEGREE OF SUCCESS OF ADOPTION
- THE DEGREE OF URGENCY OF THE PROBLEM TO WHICH THE TECHNOLOGY WAS RELATED WILL AFFECT THE DEGREE OF SUCCESS OF ADOPTION
- THE QUALITY OF INFORMATION RECEIVED FROM THE SOURCE ABOUT THE INNOVATION WILL AFFECT THE DEGREE OF SUCCESS OF ADOPTION
- MATURITY OF THE TECHNOLOGY WILL AFFECT THE DEGREE OF SUCCESS OF ADOPTION
- AVAILABILITY OF PERSONNEL TO IMPLEMENT THE TECHNOLOGY WILL AFFECT THE DEGREE OF SUCCESS OF ADOPTION
- AVAILABILITY OF FINANCIAL RESOURCES TO IMPLEMENT THE TECHNOLOGY WILL AFFECT THE DEGREE OF SUCCESS OF ADOPTION

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FACTORS INFLUENCING TECH-TRANSFER

ORGANIZATIONAL FACTORS

THE DEGREE OF TOP MANAGEMENT INTEREST IN THE PIECE OF TECHNOLOGY WILL AFFECT THE DEGREE OF SUCCESS OF ADOPTION

- THE DEGREE OF SUCCESS OF ADOPTION WILL BE INFLUENCED BY THE DIMENSIONS OF ORGANIZATIONAL CLIMATE OF THE ADOPTING ORGANIZATION
- THE DEGREE OF SUCCESS OF ADOPTION WILL BE HIGHER IN ORGANIZATIONS WHERE THE USE OF CONFRONTATION IN JOINT-DECISION MAKING IS HIGHER
- THE DEGREE OF SUCCESS OF ADOPTION WILL BE HIGHER IN ORGANIZATIONS WHERE THE USE OF SMOOTHING IN JOINT-DECISION MAKING IS LOWER
- THE DEGREE OF SUCCESS OF ADOPTION WILL BE HIGHER IN ORGANIZATIONS WHERE THE USE OF FORCING IN JOINT-DECISION MAKING IS LOWER

FACTORS INFLUENCING TECH-TRANSFER

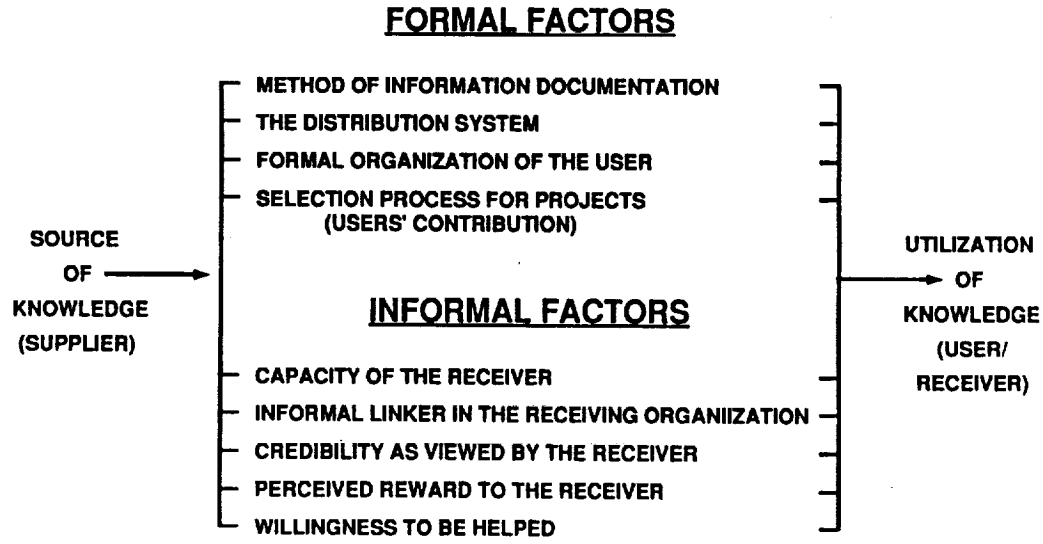
COMMUNICATION FACTORS

- THE LEVEL OF COMMUNICATION NEEDS IS DEPENDENT ON TECHNOLOGY MATURITY AND THE "GAP" BETWEEN BASIC RESEARCH AND READINESS FOR APPLIED RESEARCH OF THE TECHNOLOGY (COMMERCIALIZATION)

TECHNOLOGY MATURITY

- INCREASED MATURITY IMPLIES LESS RISK AND UNCERTAINTY FOR THE COMMERCIAL ADOPTER, AND, THEREFORE, GREATER PROBABILITY OF SUCCESSFUL TECHNOLOGY TRANSFER. THE MORE MATURE THE TECHNOLOGY, THE MORE LIKELY IS THE FIRM TO ATTEMPT TO TRANSFER AND COMMERCIALIZE IT

FACTORS AFFECTING TECH-TRANSFER



BARRIERS IN TECH-TRANSFER

- DIFFERENCE IN "ATTITUDES" CAN CONSTITUTE A "TRANSFER GAP"
  - THE GAP BETWEEN IDEA AND PROTOTYPE
  - THE COMMUNICATIONS GAP BETWEEN ORGANIZATIONS
  - THE DISPARITY BETWEEN THE BUYER'S CONCEPT OF WORTH OF NEW TECHNOLOGY AND THE SELLER'S OPINION OF ITS VALUE
  - THE REFUSAL OF BUYERS TO RECOGNIZE THAT OUTSIDE TECHNOLOGY CAN BE VALUABLE TO THEM
  - A BIASED INTERPRETATION OF THE RISK VERSUS RETURN AXIOM
  - A TENDENCY ON THE PART OF MANY ORGANIZATIONS TO DISCOURAGE THE SALE OF A TECHNOLOGY EVEN WHEN IT WOULD BE TO THEIR BENEFIT TO DO SO (Evans, 1976:29-30).
- TECH-TRANSFER ORGANIZATION RELATIONSHIP WITHIN THE COMPANY
  - TECH-TRANSFER FUNCTIONS SHOULD BE UNCOUPLED FROM THE MARKETING, PRODUCTION AND R&D DEPARTMENTS
    - IDEALLY, A COMPANY SHOULD BUILD A TECH-TRANSFER TEAM THAT OPERATES IN THE NEW BUSINESS DEPARTMENT, ALTHOUGH, OF COURSE, THE TEAM WILL INTERFACE WITH THE R&D, MARKETING, AND MANUFACTURING FUNCTIONS (Foster, 1971:111).
  - ORGANIZATION FOR TECHNOLOGY TRANSFER SHOULD BE BASED ON PAIRING PROBLEMS AND CUSTOMERS

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TYPES OF BARRIERS IN TECH-TRANSFER

- ENVIRONMENT BETWEEN THE R&D GENERAL SYSTEM (FEDERAL LAB, UNIV OR PRIVATE LAB) AND THE COMPANY GENERAL SYSTEM (USER TO WHOM THE TECHNOLOGY IS TO BE TRANSFERRED)
- ENVIRONMENT BETWEEN THE DEPARTMENTS AND DIVISIONS WITHIN THE LABORATORY OR COMPANY WHICH REPRESENT THE SUBSYSTEMS OF BOTH GENERAL SYSTEMS
  - BETWEEN THE GENERAL SYSTEMS
    1. NO FORMAL TRANSFER POLICIES
    2. COST BARRIERS
    3. TIME HORIZON CONFLICT
    4. INFRINGEMENT PROBLEMS
  - BETWEEN SUBSYSTEMS
    1. INERTIA BARRIER
    2. LACK OF AN INCENTIVE STRUCTURE
    3. COST BARRIER
    4. COMMUNICATION
    5. TIME BARRIER
    6. GEOGRAPHIC DISTANCE
    7. NON-EXISTENT TRANSFER MANAGEMENT STRUCTURE
    8. TECHNOLOGY BARRIER
  - BETWEEN ELEMENT
    1. LACK OF AN INCENTIVE STRUCTURE
    2. HIGH RISK OF BEING BLAMED FOR FAILURE
    3. INSECURITY OF RETAINING JOB IF NOT SUCCESSFUL
    4. MUTUAL DISRESPECT
    5. UNIQUE REQUIREMENTS OF EACH SUBSYSTEM
    6. UPDATING OF TECHNOLOGY NEEDS
    7. TIME BARRIER
    8. LACK OF TRANSFER ORGANIZATION MANAGERS

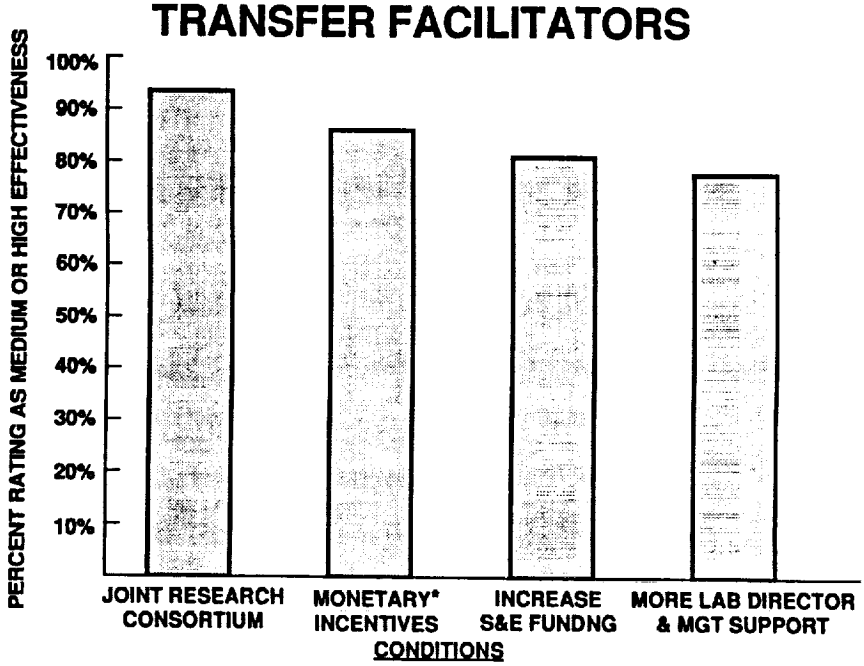
ENHANCING FACTORS TO TECH-TRANSFER

INTERPERSONAL RELATIONSHIP

... THE MECHANISM OF TECHNOLOGICAL TRANSFER IS ONE OF AGENTS, NOT AGENCIES; OF THE MOVEMENT OF PEOPLE AMONG ESTABLISHMENTS, RATHER THAN OF THE ROUTING OF INFORMATION THROUGH COMMUNICATION SYSTEMS (Burns, 1969:12).

THE NATIONAL REFERRAL CENTER, A SERVICE OPERATED UNDER THE LIBRARY OF CONGRESS, HEARTILY SUBSCRIBES TO THE CONVICTION THAT SCIENTIFIC AND TECHNICAL INFORMATION IS MOST EFFECTIVELY TRANSFERRED FROM PERSON TO PERSON, NOT FROM MEDIA TO PEOPLE (Timmons, 1978: 34).

KEY TECHNOLOGY TRANSFER FACILITATORS



THE ABOVE CONDITIONS WERE PERCEIVED BY THE RESPONDENTS TO BE THE GREATEST FACILITATORS OF TECHNOLOGY TRANSFER

* LACK OF INCENTIVES WAS A KEY BARRIER

ENHANCING ROLES IN TECH-TRANSFER

- TECHNOLOGICAL GATEKEEPER "EXPERT SCIENTIST TO THE WORLD OF SCIENCE"
  - IS ONE WHO CONTROLS A STRATEGIC PORTION OF THE TECHNICAL LEVEL OF THE COMMUNICATION CHANNEL (Brown, 1979) AND THE DIFFUSION OF INFORMATION WHICH IS A MULTI-STEP PATTERN
  - TECHNOLOGICAL GATEKEEPERS CREATE AWARENESS OF NEW PRODUCTS AND PROCESSES BY THEIR ABILITY TO ABSORB INFORMATION AND TRANSLATE IT INTO MORE UNDERSTANDABLE FORM NOT ONLY FOR THEIR COLLEAGUES BUT ALSO FOR TOP MANAGEMENT (Tornatzky et al 1983)
- TECHNOLOGICAL LINKERS "R&D MANAGERS"
  - OPERATES WITHIN THE ORGANIZATION WHICH RECEIVES THE KNOWLEDGE (Creighton, 1972)

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MAJOR BARRIERS AND HINDRANCES TO TECH-TRANSFER

1. A TENDENCY TO ASSUME WITHOUT PROOF THAT THERE IS A RECEIVER FOR THE TECHNOLOGY, THAT IS, THAT SOMEBODY ACTUALLY WANTS IT AND WILL ACCEPT IT
2. LACK OF INTEREST AND SUPPORT BY TOP MANAGEMENT, THAT IS, THOSE WHO MAKE POLICY AND CONTROL THE NECESSARY RESOURCES
3. LACK OF INTEREST OR EFFORT BY MANAGERS AT THE LEVEL WHERE TECHNOLOGY TRANSFER WILL ACTUALLY BE IMPLEMENTED
4. FAILURE TO FIX RESPONSIBILITY AND ACCOUNTABILITY FOR GETTING THE JOB DONE
5. LACK OF AWARENESS OF THE VALUE OF TECHNOLOGY TRANSFER
6. LACK OF FUNDING FOR THE TRANSFER EFFORT
7. LACK OF PERSONNEL ASSIGNED TO THE TASK OR LACK OF SUFFICIENT TIME AVAILABLE TO THOSE WHO ARE ASSIGNED TO THE TASK
8. LACK OF NECESSARY KNOWLEDGE AND TRAINING FOR THOSE ASSIGNED THE TASK
9. RESTRICTIONS ON MOBILITY OF PERSONNEL
10. INDIFFERENCE TO TECHNOLOGY TRANSFER

MAJOR BARRIERS AND HINDRANCES TO TECH-TRANSFER (Cont'd)

11. POWER GAMES INTENDED TO MAINTAIN OR PROMOTE PERSONAL AMBITIONS, SUCH AS JOB PROTECTION, COMMERCIAL INTEREST, POLITICAL AMBITIONS, STATUS, OR CONTROL OF THE WORK SITUATION. USUALLY TAKES THE FORM OF SECRECY. (Hawthorne 1978)
12. POOR INTERPERSONAL RELATIONS – THE PARTIES REACT NEGATIVELY TO EACH OTHER
13. EXPECTATIONS OF ONE PARTY ARE NOT SHARED BY THE OTHER PARTIES
14. LACK OF CONTINUED ORGANIZATIONAL COMMITMENT TO THE EFFORT
15. PROMISING MORE THAN CAN BE DELIVERED
16. SOMEONE TAKING OFFENSE, WHERE NONE WAS INTENDED, AT A SUGGESTION THAT SOME ACTIVITY THEY ARE RESPONSIBLE FOR COULD BE IMPROVED
17. CULTURAL DIFFERENCES: ETHNIC, REGIONAL, NATIONAL, OR ORGANIZATIONAL
18. EMPLOYMENT SENIORITY SYSTEMS OR FEATHERBEDDING
19. DOCUMENTS TOO TECHNICAL FOR THE POTENTIAL USER TO UNDERSTAND
20. EXCESSIVE GOVERNMENT REQUIREMENTS FOR PRODUCT TESTING AND APPROVAL

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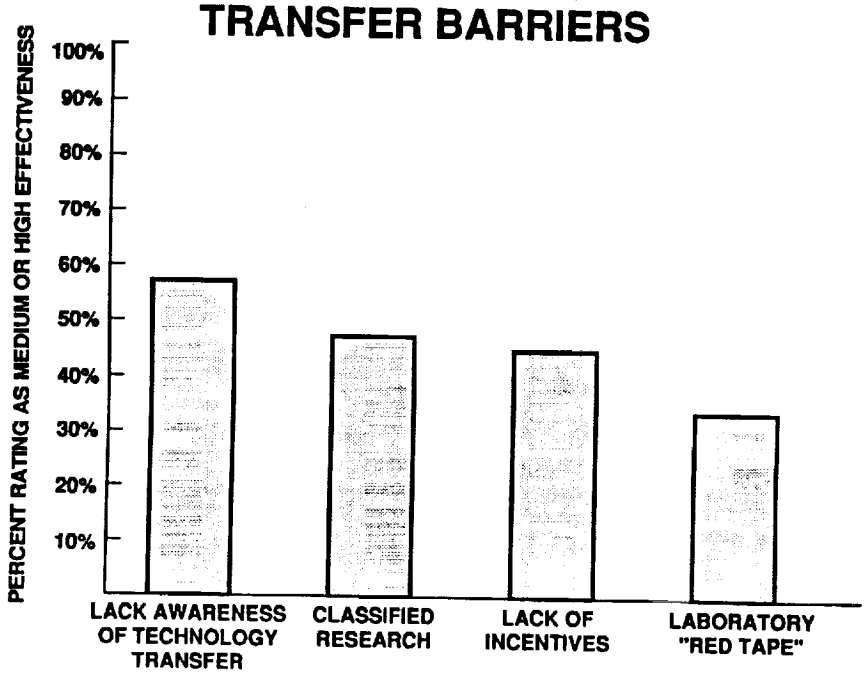
KEY TECHNOLOGY TRANSFER BARRIERS



THE ABOVE CONDITIONS WERE PERCEIVED BY THE RESPONDENTS TO BE THE GREATEST BARRIERS TO TECHNOLOGY TRANSFER

BAR-ZAKAY TECH TRANSFER EVOLUTION MODEL (1970) (Cont'd)

STAGE	DONOR	BOTH	RECIPIENT
(ADAPTATION)			
		DECISION: GO/NO GO	
IMPLEMENTATION		RECRUIT RESOURCES	
	CONSIDER CAPITAL AND HARDWARE		CONSIDER PEOPLE AND EMOTIONS
	OVERCOME PREJUDICE		BUILD COHESIVE ORGANIZATION
	PROVIDE TRAINING		PROVIDE SUPPORTING ELEMENTS
	OVERCOME RESISTANCE TO CHANGE		ENSURE BUREAUCRATIC SUPPORT
		RUN PILOT OPERATION	
		DECISION: GO/NO GO	
MAINTENANCE		RUN FULL-SCALE OPERATION	
	DELEGATE AUTHORITY		ENSURE COMPATIBILITY WITH SUPPORTING ELEMENTS
	ASSIST IN TROUBLE-SHOOTING		EVALUATE SIDE EFFECTS
	IDENTIFY DIVERSIFICATION POSSIBILITIES		PERFORM CONCURRENT R&D
	EVALUATE NET BENEFITS		EVALUATE NET BENEFITS
		EVALUATE SUCCESS	
		DECISION: GO/NO GO	

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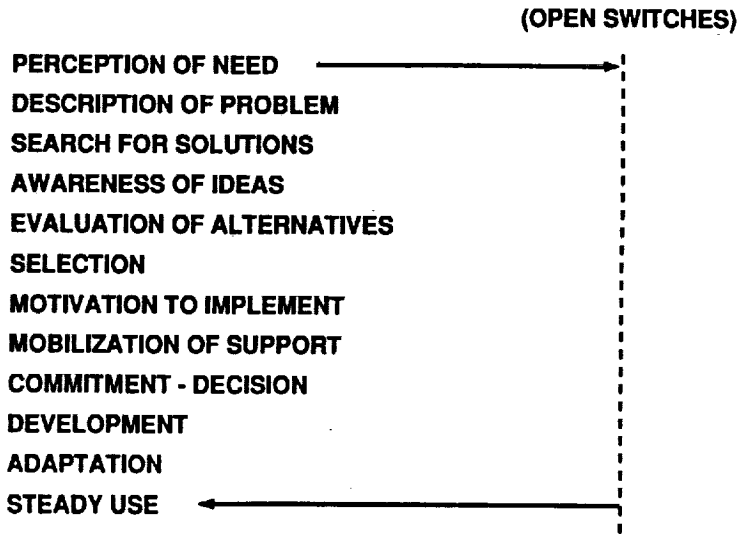
BARRIERS THAT RESULTS IN PROJECT ATTRITION OR NO TRANSFER

GAUNTLET OPEN SWITCH MODEL



TECHNOLOGY DEVELOPMENT STAGES

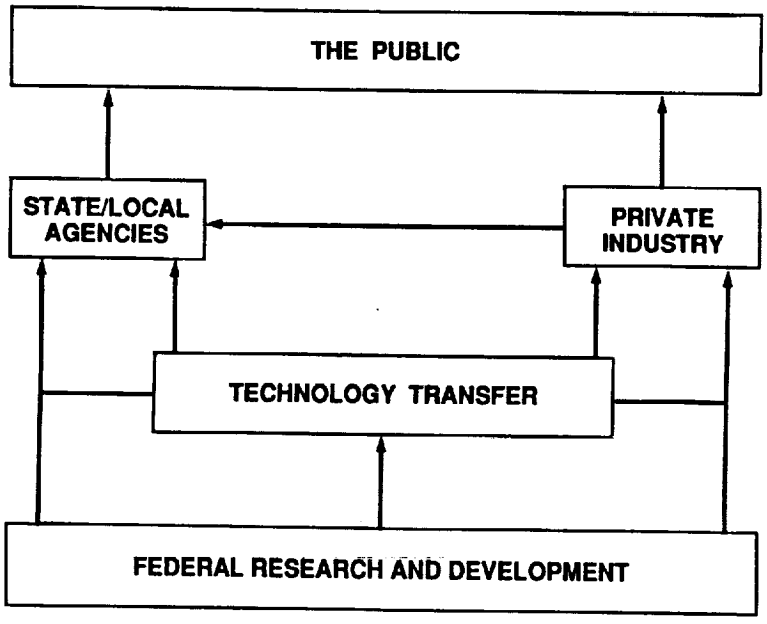
TECHNOLOGY PROGRAM

1. BASIC PRINCIPLES OBSERVED AND REPORTED
2. CONCEPTUAL DESIGN FORMULATED
3. CONCEPTUAL DESIGN TESTED ANALYTICALLY OR EXPERIMENTALLY

USER

4. CRITICAL FUNCTION/CHARACTERISTIC DEMONSTRATED
5. COMPONENT/BRASSBOARD TESTED IN RELEVANT ENVIRONMENT
6. PROTOTYPE/ENGINEERING MODEL TESTED IN RELEVANT ENVIRONMENT
7. ENGINEERING MODEL SPACE QUALIFIED

TECHNOLOGY TRANSFER SYTEM



STRATEGIES FOR PROMOTING TECH-TRANSFER TO PRIVATE SECTOR

TECHNOLOGY TRANSFER STRATEGY	PURPOSE	TRANSFER MECHANISMS
PASSIVE	TO MAKE INFORMATION ACCESSIBLE TO THOSE INDIVIDUALS AND ORGANIZATIONS SEARCHING FOR SOLUTIONS TO CUSTOMER/SOCIETY PROBLEMS	TECHNICAL DATABASES NTIS PROFESSIONAL JOURNALS TRADE PUBLICATIONS CONFERENCES WORKSHOPS
ROLE-DIRECTED	TO ACTIVELY PROMOTE AWARENESS OF NEW TECHNOLOGY TO INDIVIDUALS OCCUPYING BOUNDARY-SPANNING ROLES IN ORGANIZATIONS	PROFESSIONAL JOURNALS AND SEMINAR PRESENTATIONS TARGETED TO CERTAIN DISCIPLINES TRADE PUBLICATIONS AND SEMINAR PRESENTATIONS TARGETED TO INDUSTRY GROUPS OR NATIONAL ASSOCIATIONS TECHNOLOGY FAIRS INDUSTRY TEAMS
ORGANIZATION DIRECTED	TO ACTIVELY PROMOTE THE ADOPTION OF NEW PRODUCT OR PROCESS CONCEPTS TO INNOVATOR FIRMS IN AN INDUSTRY	TRANSFER OF R&D PERSONNEL DEMONSTRATION PROJECTS PERSONAL CONTACTS ONSITE VISITS JOINT VENTURES TAX INCENTIVES

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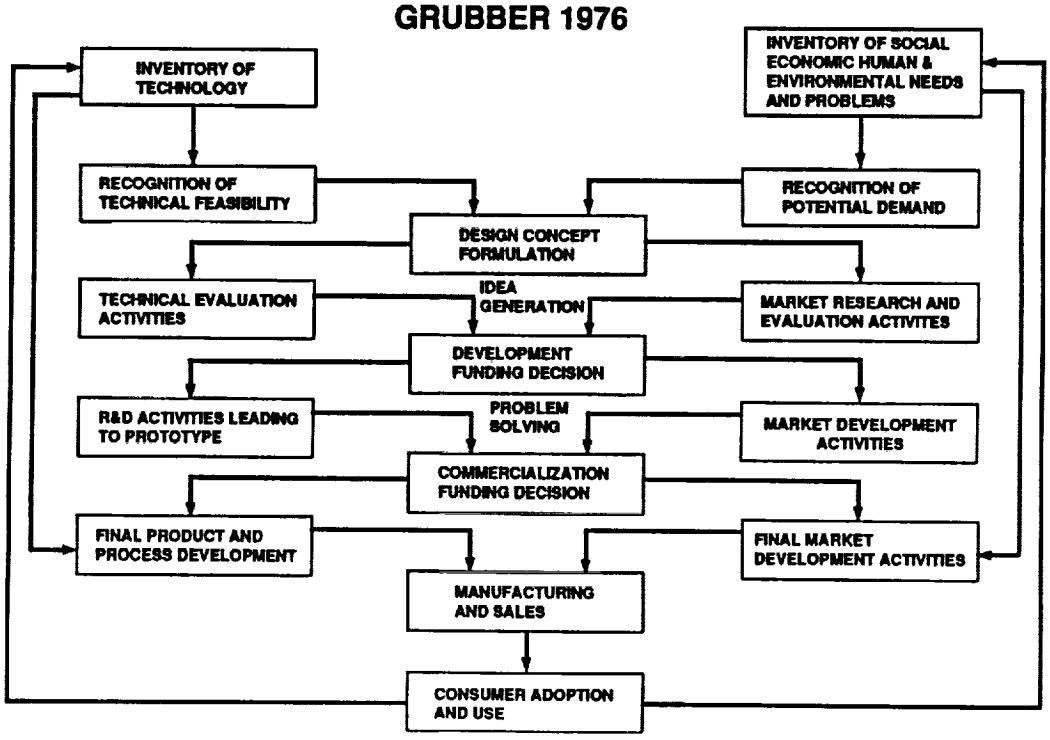
EVOLUTION PROCESS TO TECH-TRANSFER

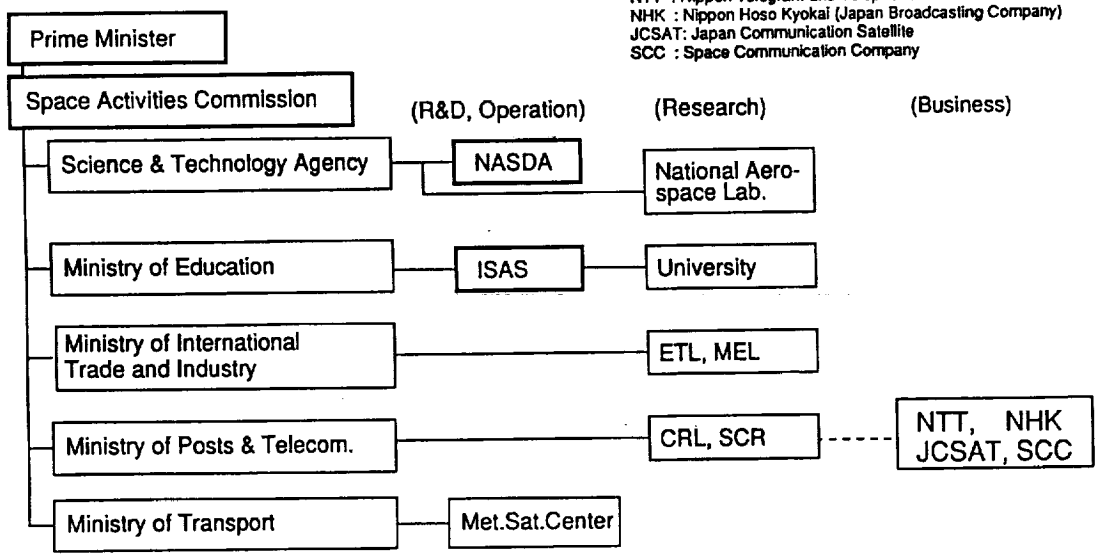
GRUBBER 1976



Japanese Space Related Organizations

NASDA 宇宙開発事業団

NASDA: National Space Development Agency of Japan
ISAS : Institute of Space and Astronautical Science
ETL : Electro-Tecnical Laboratory
MEL : Mechanical Engineering Laboratory
JSUP : Japan Space Utilization Promotion Center
USEF : Institute of Unmanned Space Experiment Flyer
CRL : Communication Research Laboratory
SCR : Space Communication Research Institute
NTT : Nippon Telegram and Telephone
NHK : Nippon Hoso Kyokai (Japan Broadcasting Company)
JCSAT: Japan Communication Satellite
SCC : Space Communication Company



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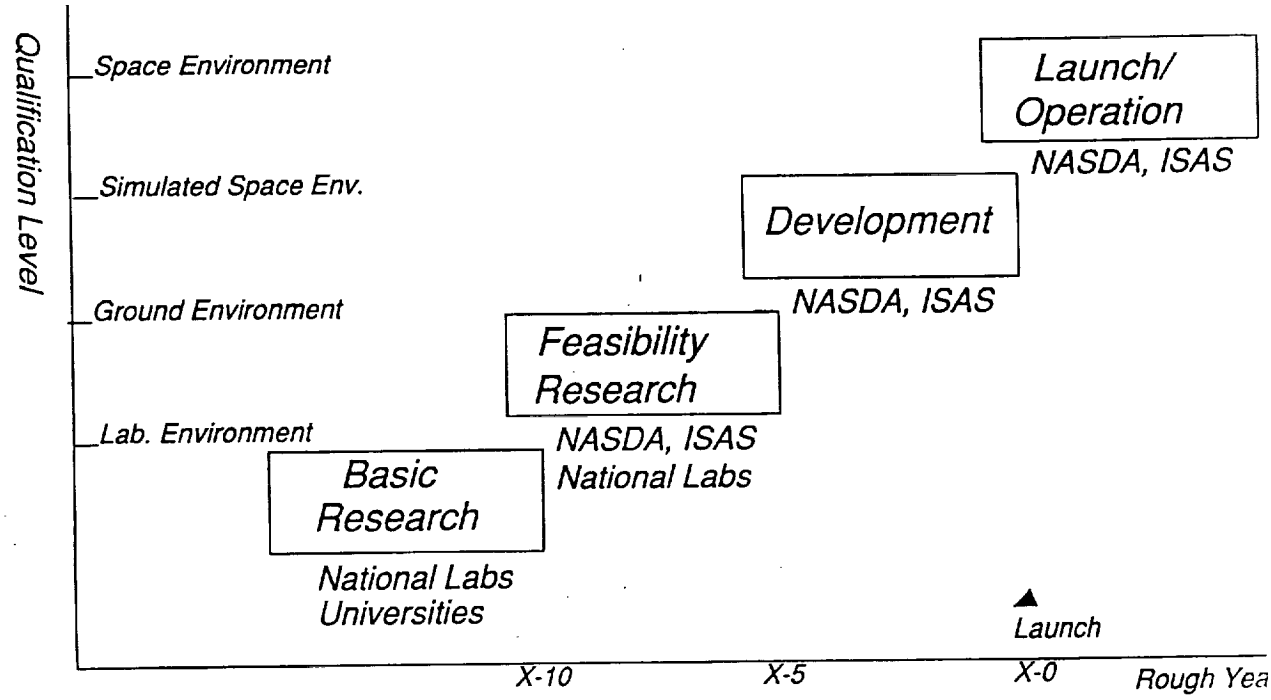
R & D of Space Technologis

NASDA 宇宙開発事業団



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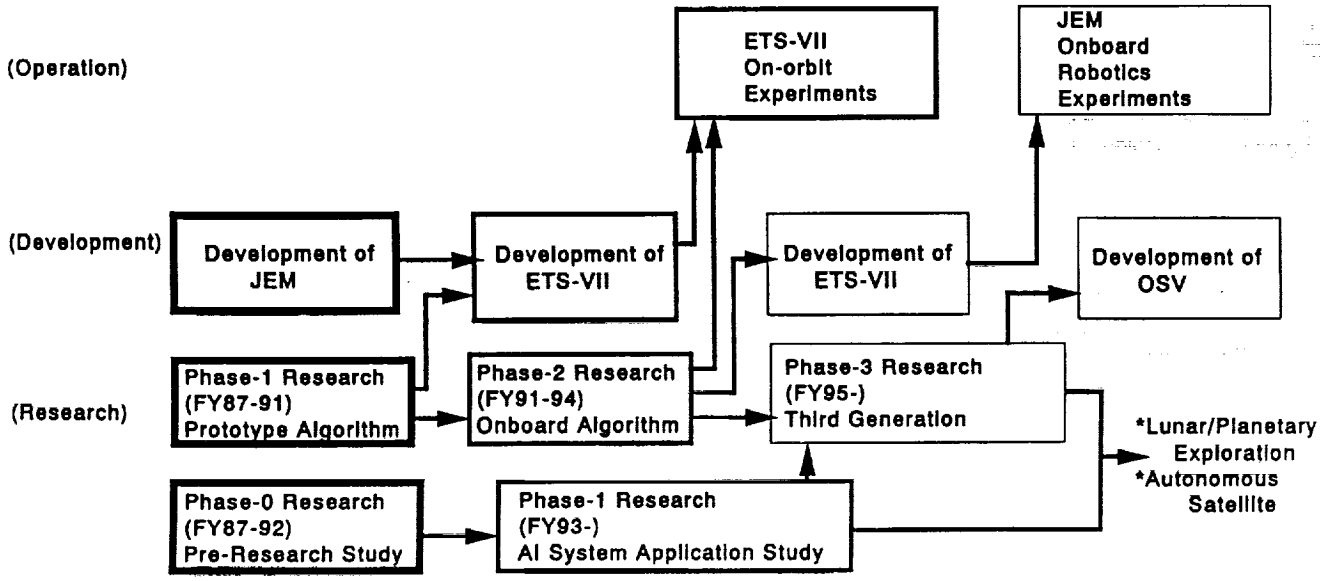
NASDA's Space Robotics and AI

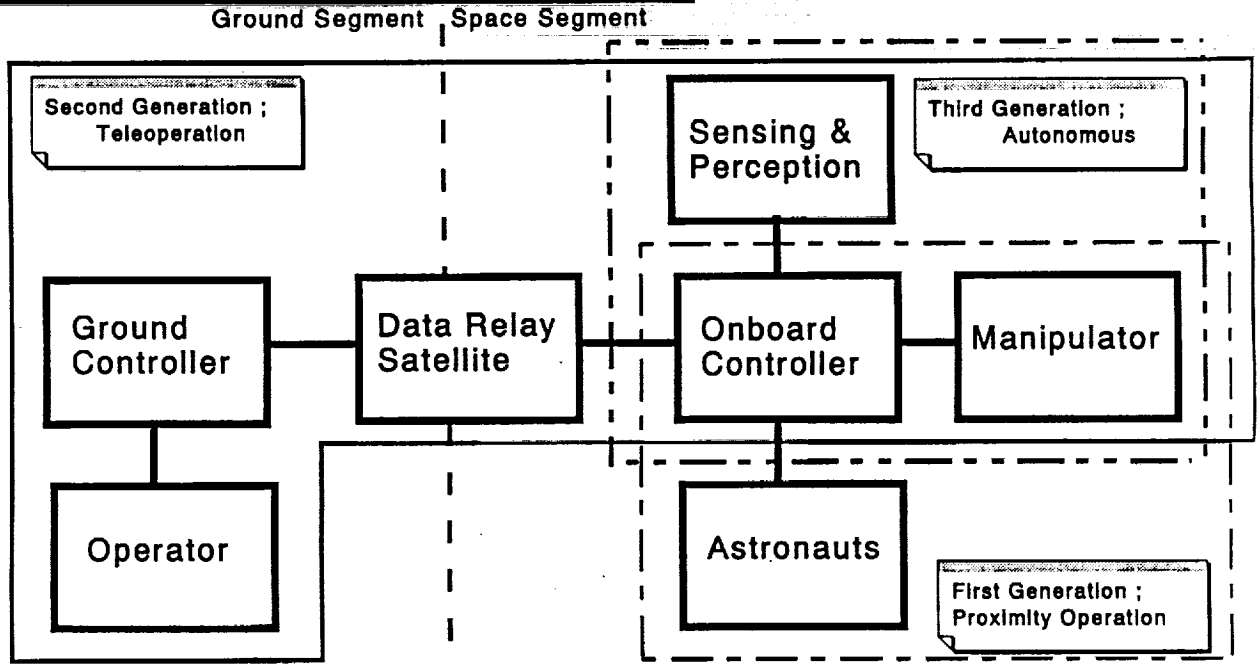
NASDA
National Space Development Agency of Japan

■ R&D Plan



Generation of Space Robots

NASDA
National Space Development Agency of Japan



ENVIRONMENTAL CONDITIONING FOR TECH-TRANSFER