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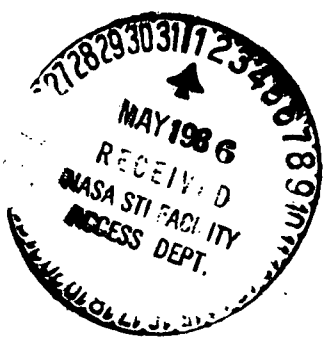
SUMMARY RESULTS OF THE INDUSTRY CONFERENCE ON THE COMMERCIAL USE OF SPACE

Dr. Reuse and R. P. Thuerbach

Translation of "Zusammengefasste Ergebnisse aus dem Industriegespraech ueber die Kommerzielle Nutzung der Raumfahrt," Industry Conference on the Commercial Use of Space, BMFT (Federal Ministry for Research and Technology), Bonn, West Germany, June 25, 1985, pp. 1 - 29.



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16. Abstract The future intentions of the Federal Republic of Germany in the area of the commercialization of space are presented. It is shown that significant advances in microgravity research, particularly in the areas of materials science, composite materials, physical chemistry, crystal growth, biology, and process engineering will have an effect on future plans for establishing sponsoring organizations to guide commercial interests in German space research. An organizational and functional outline of a proposed sponsoring organization to promote space commercialization under German supervision, including the objectives, the target group to be served, and the administrative structure, is presented. The role of the DFVLR (German Aerospace Research Establishment) and the BMFT (German Ministry for Research and Technology) as sponsoring organizations representing the interests of the German government is shown.

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SUMMARY RESULTS OF THE INDUSTRY CONFERENCE ON THE USE OF SPACE

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1. The political intent which the German Federal /1*
Republic wishes to assume as one of the leading spaceflight nations having a major role in the field of peaceful use of spaceflight, particularly in the area of research and development during weightlessness (microgravity), was supported on all sides during the talks. Prompt action by all involved is required to assure that microgravitation knowledge, developed at German universities and research institutions with support from the BMFT (Federal Ministry for Research and Technology) and in some faculties seen as the world's foremost in advanced knowledge, be of use to German industry.

Particularly with the advent of the German space lab missions and COLUMBUS participation in the space station, it has been possible for the Federal Government to create perspectives to orient industry over the long-term with regard to use of spaceflight technologies. Sufficient, relatively economical spaceflight opportunities are available for necessary short and medium term on-going FuE-works. The DFVLR (German Aerospace Research Establishment), as well as various universities, and so-called "Centers of Excellence" are prepared to help industry with knowledge and--as far as possible--with technical resources.

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*Numbers in the margin indicate pagination in foreign text.

During the talks, the BMFT encouraged industry to use these services more than before and to participate in developing organizational structures still needed for further commercialization of spaceflight.

The following points were established from the speeches held by experts during the talks: /2

2.1 The Fu-E works for development of new metallurgical procedures and composite materials during weightlessness have produced impressive results to date and promise interesting potential for future uses. The chief interest lies in investigation of gravity-influenced melting and solidification effects in order to transfer knowledge to terrestrial technologies. Among other items, long term goals include:

-- Control of melting and welding processes
-- Production of highly homogenous multi-phase substances using controlled conversion of knowledge gained from separation procedures.

Research interests also involve selected manufacturing procedures and products, which cannot be carried out to a satisfactory degree under normal earth conditions, as for example:

-- Fused metallurigcal production of substances refined with dispersions, for example, for turbine blades
-- Production of greater volumes of amorphous metal substances using non-crucible melting and solidification (to avoid contamination).

Subsequent manufacturing in space is planned particularly for turbine blade development (ceramic/metal-composite materials), whereby turbines with substantially

higher working temperatures and, as such, better efficiency are the goal.

German industry started relatively early to perform its own experiments in the field of research and development of metals and composite substances during weightlessness. Important joint projects involving industry, universities, and research institutes are being prepared.

2.2 A broad fundamental research program in the area of /3 physical chemistry and process engineering during weightlessness has been under way for some time. Questions have arisen from this program which will be interesting for commercial use later. Some of the areas affected are:

-- Friction loss during pneumatic transfer of powders and granules,
-- Measuring corrosive substances without a container,
-- Procedures at the critical point,
-- Homogeneity of glasses,
-- High purity coating of electrodes under the conditions of microgravity (dispersion electrolysis) to obtain highly refined surfaces, and
-- diffusion-controlled procedures.

Industrial manufacturing in space in the area of physical chemistry and process engineering is not foreseeable at present . On the other hand, however, much experience is being gained for technological development of manufacturing processes on earth, particularly for procedures whose diffusion mechanisms are not yet sufficiently understood.

Recently, industry's interest in FuE works in the field of physical chemistry and process engineering during microgravity has increased markedly. This can be seen

from the fact that various corporate leaders have assigned their leading scientific staff to deal with the questions arising from microgravity and to make contacts with research groups making advances in this area. This should be continued and expanded. In the meantime, scientific organizations, as for example the Bunsen Society, have placed great emphasis on research during microgravity.

2.3 The experiments done to date to produce inorganic crystals, particularly in the semiconductor sector, during microgravity have shown which potential space experiments expand our understanding of complex processes in which gravity-influence effects are involved. Because of their /4 high price/weight relationship, single crystals represent a target group of materials which could be produced in space, if this were to prove to be of advantage. In accordance with the present state of knowledge, the following are true:

-- The manufacturing defect ratio of crystals can be reduced considerably during microgravity.
-- Micro-nonhomogeneities in doping substance distributions can be held down in semiconductor crystals during microgravity.
-- The first Spacelab mission determined Marangoni-convection as the cause of doping material streaking in silicon during terrestrial processes.

Additional knowledge which will be of further importance to industrial development is expected.

2.4 Exact knowledge about formation of organic single crystals, in particular of large-molecule proteins, is one of the keys to new or continued development of medications. The structure of large-molecule proteins can be investigated only by X-ray structure analysis and/or with neutron rays.

Suitably large single crystals must be available for this process. The availability of such single crystals is usually the element determining time needed for protein structure research.

Scientists from the University of Freiburg recently succeeded in producing crystals from salt solutions during microgravity for two selected proteins (beta-galactosidase, lysozomes). These proteins were up to 1000 times larger than any produced to date under terrestial conditions and have attained worldwide attention, also from international pharmaceutical concerns. Due to insufficient experimentation, it is as yet unclear whether the procedure will work universally for all types of proteins. As far as it is the case, however, that microcrystals can occur /5 under terrestrial conditions, the Freiburg scientists encourage experiments during weightlessness which increase crystal dimensions to those necessary for X-ray analysis.

The pharmaceutical industry should begin taking greater advantage of the potential available at German universities in the field of protein research during microgravity. American and French pharmaceutical concerns are very active in this area.

3. From the talks regarding accumulation of the necessary new structures for commercial use of microgravity it could be ascertained that the formation of Microgravity Inc. in March of this year by Kayser-Threde would provide in the meantime for promotion of service to potential users in one particular area (small spaceflight experiments with high-altitude rockets and autonomous shuttle payloads). A positive movement in this direction has begun on the market in other areas and by other promoters.

A market study sponsored by BMFT and carried out by Kienbaum with the assistance of DFVLR, entitled "Measures for Industrial Marketing of Spaceflight Opportunities," was introduced and discussed in detail. One important result of the study was the suggestion to found a sponsoring organization to promote commercial use of spaceflight throughout the German economy. The sponsoring organization would act as a professional and profit-oriented service to communicate ideas for industrial use of spaceflight and carry out industrial space projects focused chiefly on gravitation. This suggestion was widely agreed upon by potential consumer industries, banks, and the spaceflight industry.

Participants were of varying opinions regarding /6 whether such a sponsoring organization should be initiated and supported by the spaceflight industry or the consumers, and what the relationship of the partners should be. In any case, the sponsoring organization, as suggested in the Kienbaum concept, ought to be open to international participation and operate on the international market under German supervision. Further, participants were in agreement that the sponsoring organization should be founded and directed in accordance with commercial criteria and participation and, as far as possible, be economically independent. A number of participants advocated direct participation of the Government or indirect participation through the DFVLR, which would have an initiative function. The BMFT is basically willing to assume this role. If possible, it does not wish to do so in the form of direct participation, but rather as a supporter of the necessary initial conditions in the framework of existing opportunities.

The BMFT hopes, and this was emphasized again at the close of the talks, that the idea of a representative

organization supporting commercial use of spaceflight be realized by the time the second industrial talks are to take place at the end of September 1985.

/7

INDUSTRIAL USE OF SPACEFLIGHT

RESULTS AND EXPERIENCE GAINED FROM CONTACTS BY KIENBAUM WITH GERMAN INDUSTRY

REPORT

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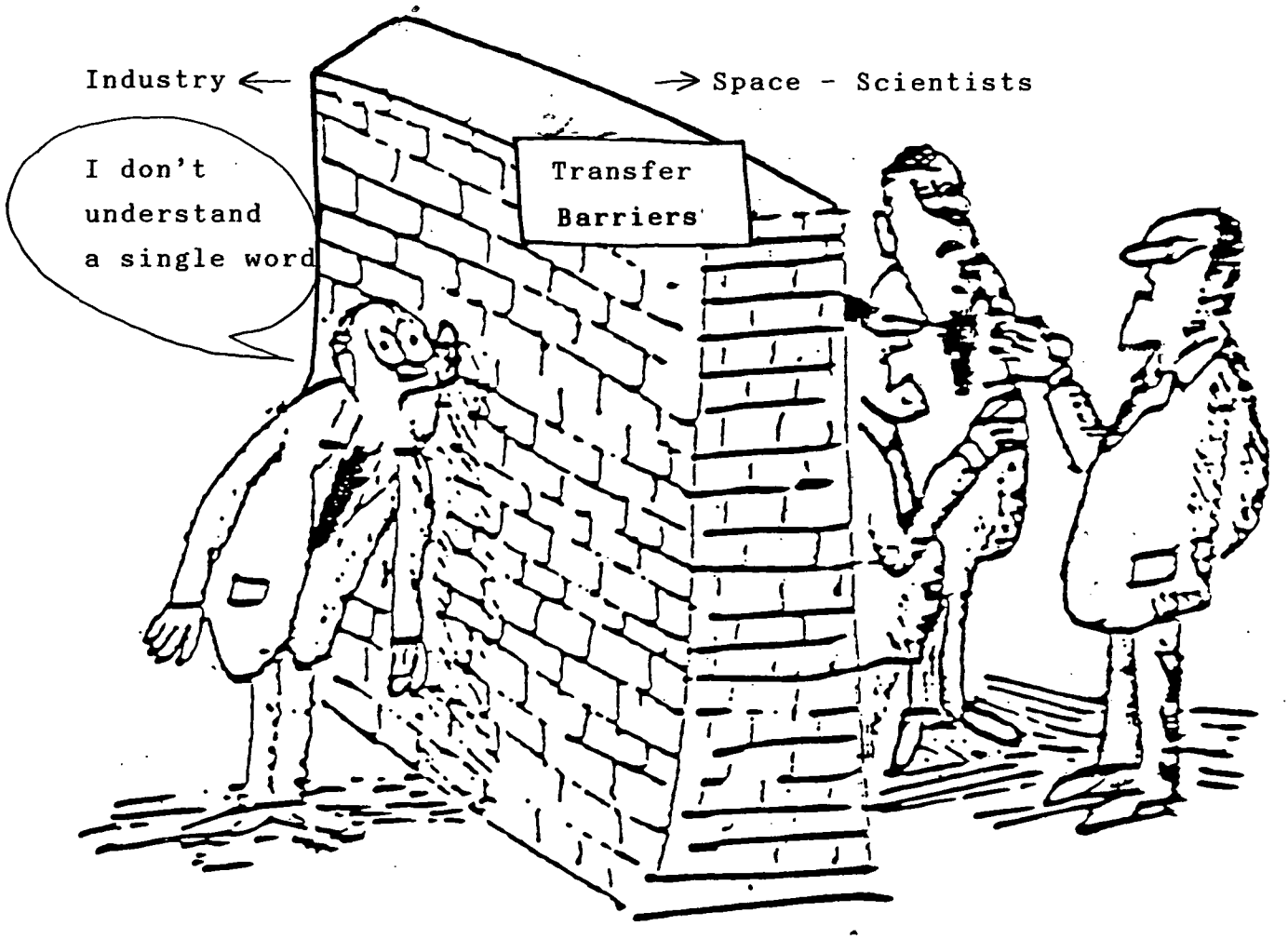
PRESENTED TO

INDUSTRY CONFERENCE, JUNE 25, 1985
AT THE BMFT, BONN, BUILDING 1, HALL 2

/8

The dreams of yesterday
are the hopes of today
and the realities of tomorrow

Robert H. Goddard



INTIMIDATED EXPERT LISTENING IN DESPERATION AT THE LANGUAGE BARRIER

Central Questions

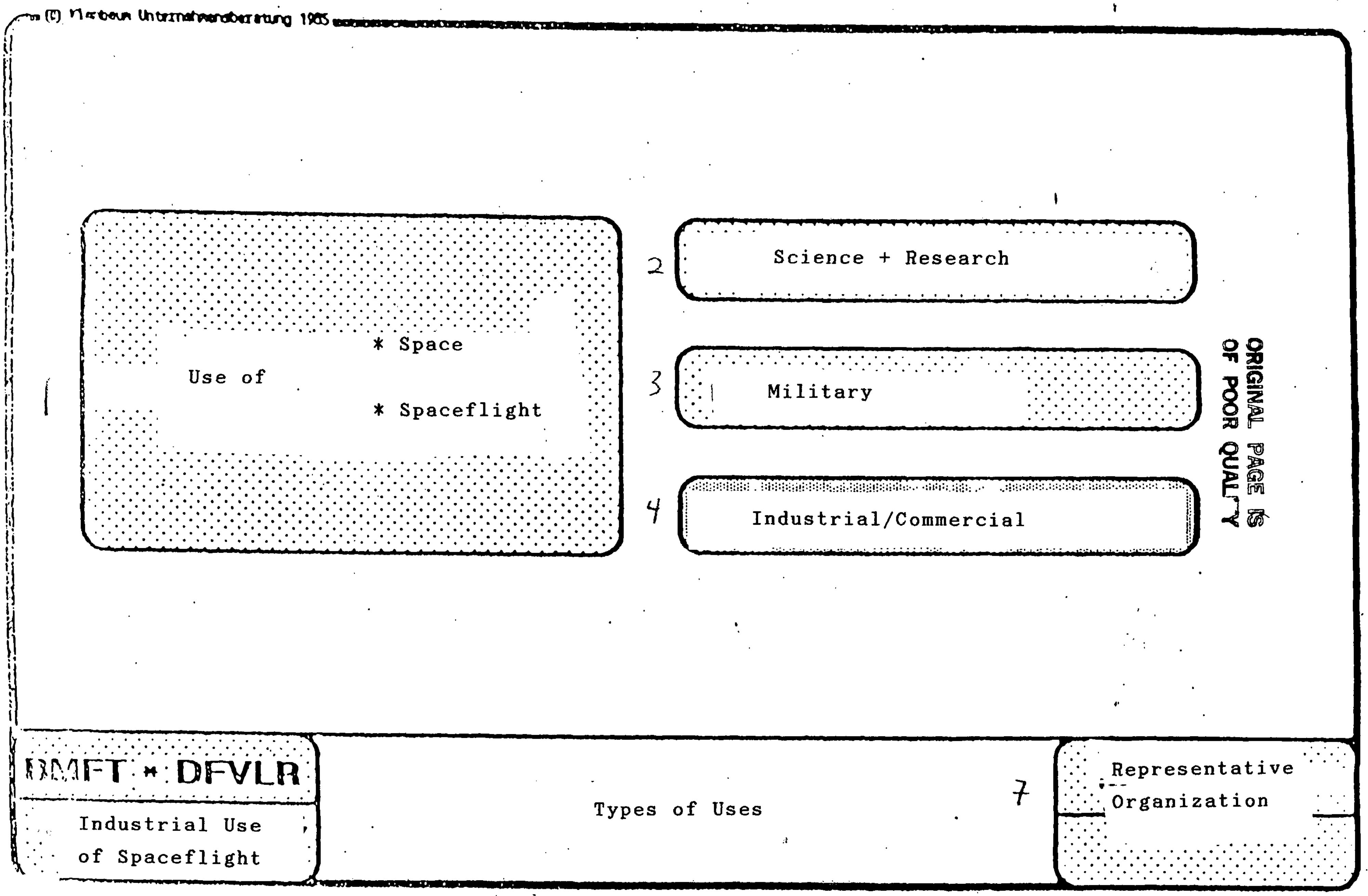
-- Was is to be marketed?
(Service offered by spaceflight to industry)

-- To whom are we marketing?
(Target group)

-- Which uses are possible for industry?

-- How are we to market?
(Means and instruments)

-- Which parameter conditions are necessary for successful marketing?
(Conditions for and organization of space use)



A

Dimensions of Use — Use of Space / of Spaceflight

for example for Exploration for Astronomy
for example for Spaceflight Technology, UG-Experiments

B

Use Opportunities for Industry and Science

		Examples
1	Direct Participation in Spaceflight Technology Spaceflight - Industry Suppliers - Industries	System Producers Electronics Firms MSR - Firms Material Producers
2	Technology - Return of Spaceflight	Patents/Licenses/Know-how from Spaceflight Technology
3	Use of Special Space Environment	Space Research/Science **Remote Sensing Technology** Communication Navigation Space as Laboratory Bio-sciences Material Sciences

D

BMFT + DFVLR

Industrial Uses of Spaceflight

Dimensions of Use

F

Sponsoring organization

Spaceflight services lie in the following areas:

* Space Research / Space Sciences

* Remote Sensing Technology

* Communication and Navigation

* "Space as Laboratory"

  Research, development (and production) in the field of reduced gravity influence, especially in the disciplines of

  -- Material Sciences and Technologies
  -- Process Engineering
  -- Bio-sciences
  -- Pharmacology
  -- Chemistry / Physical Chemistry

* Functional Spaceflight Technology

  (Prerequisite for all previously mentioned fields)

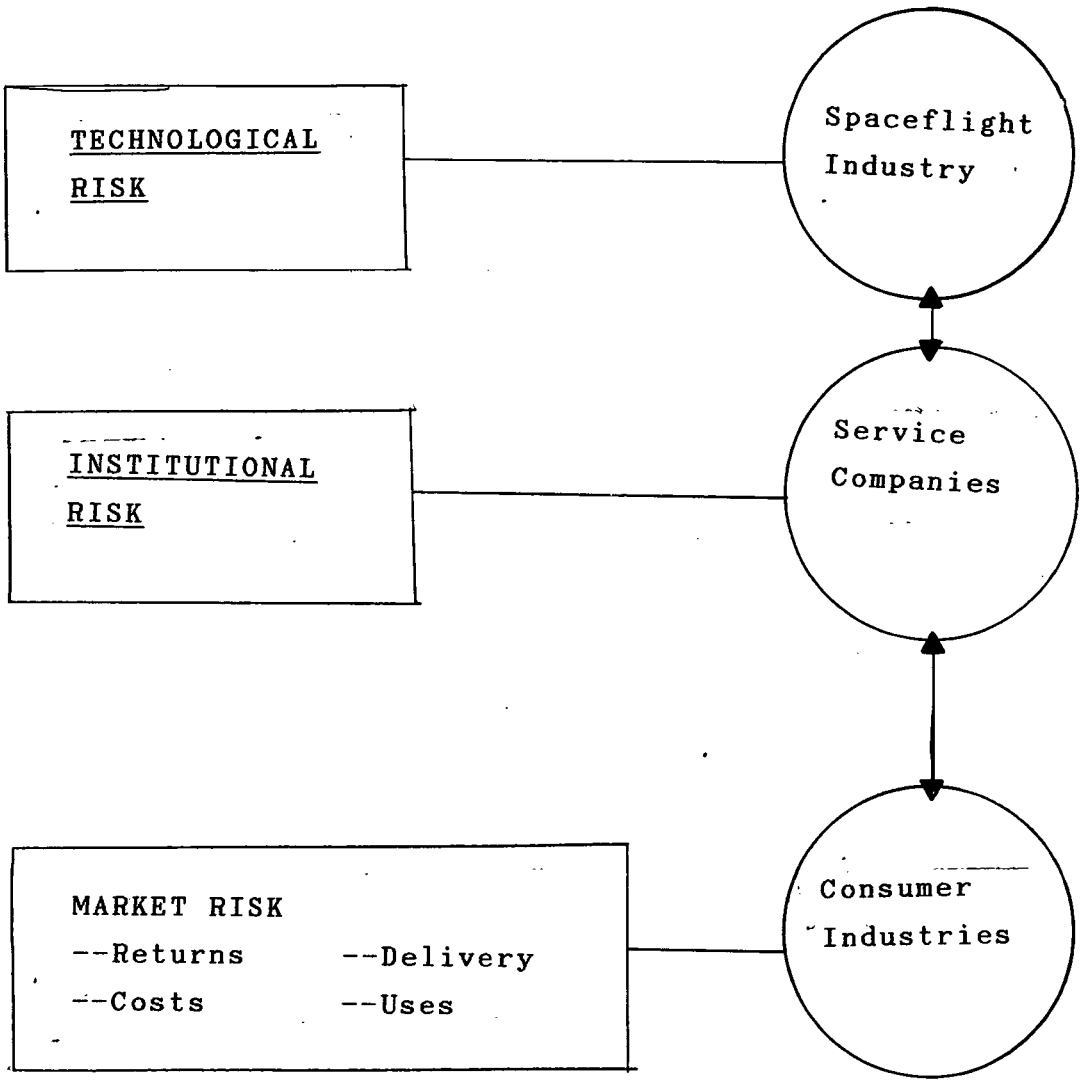
Flight Opportunities	Flight Time	Module	Course of Experiment	Flight Cycle Data	Consultant	Price
Drop Tower	5-10"	Texus-Experiment-Module	Automatic	ad hoc Agreement w/NASA		
Parabolic Flights	25-30"	Texus-Experiment-Module	Automatic	ad hoc		
Balloon Probe Microbes	60-70"	Texus-Experiment-Module	Automatic	ad hoc		
Rocket Flights	5-6	Texus-Experiment-Module	Automatic/ Controllable	at present 2 Flights/yr.		
Shuttle GAS	10d	MAUS-Instruments	Automatic	ad hoc		
Spacelab	10d	Racks with Installations for various Disciplines	Automatic/ Controllable	ad hoc		
Middeck	10d	19" Rack Installations				
EURECA	approx. 6 Months	as desired	Automatic/ Controllable	each Shuttle Flight		
Space Station	unlimited	TBD	Automatic	upon request		
BMFT * DFVLR			TBD	Continuous (90-day Intervals)		
Industrial Use of Spaceflight	Synopis of Contemporary Experimentors					µG-Experiments

-- Procedures and processes can be investigated under conditions of nearly complete weightlessness. The information gained in the process can serve to improve corresponding procedures and processes on earth in their efficiency or in their yield (product).

-- Processes can be used, and products can be manufactured which can be applied or produced only under conditions of nearly complete removal of the earth's gravitational pull.

-- Products with economically or qualitatively better yields can be manufactured using known procedures.

WHEREIN LIE THE RISKS?



EMPIRICAL BASIS /17

200 COMPANIES
25 MULTIPLIERS

INCLUDING 75 TELEPHONE INTERVIEWS
INCLUDING 40 PERSONAL CONTACTS
INCLUDING 12 COMPANY PRESENTATIONS

PLUS PRESS COVERAGE
AND SPEECHES
FOR PARTICIPANTS
AT THE SYMPOSIA

STATUS: 06/1985

Conclusions /17

The following conclusions may be derived from the information and results discussed above:

1. Objective talks with industry must be continued. It is clear that short-term successes represent the exception at best, but that a continuous process will lead to successes if the anticipated uses are proven to be viable.

2. Complementary measures, such as seminars or fairs, should be considered case by case, although, in light of experience (for example, Hannover, Zurich), these do not represent the chief source for industrial talks.

Accompanying public relations measures appear to be useful.

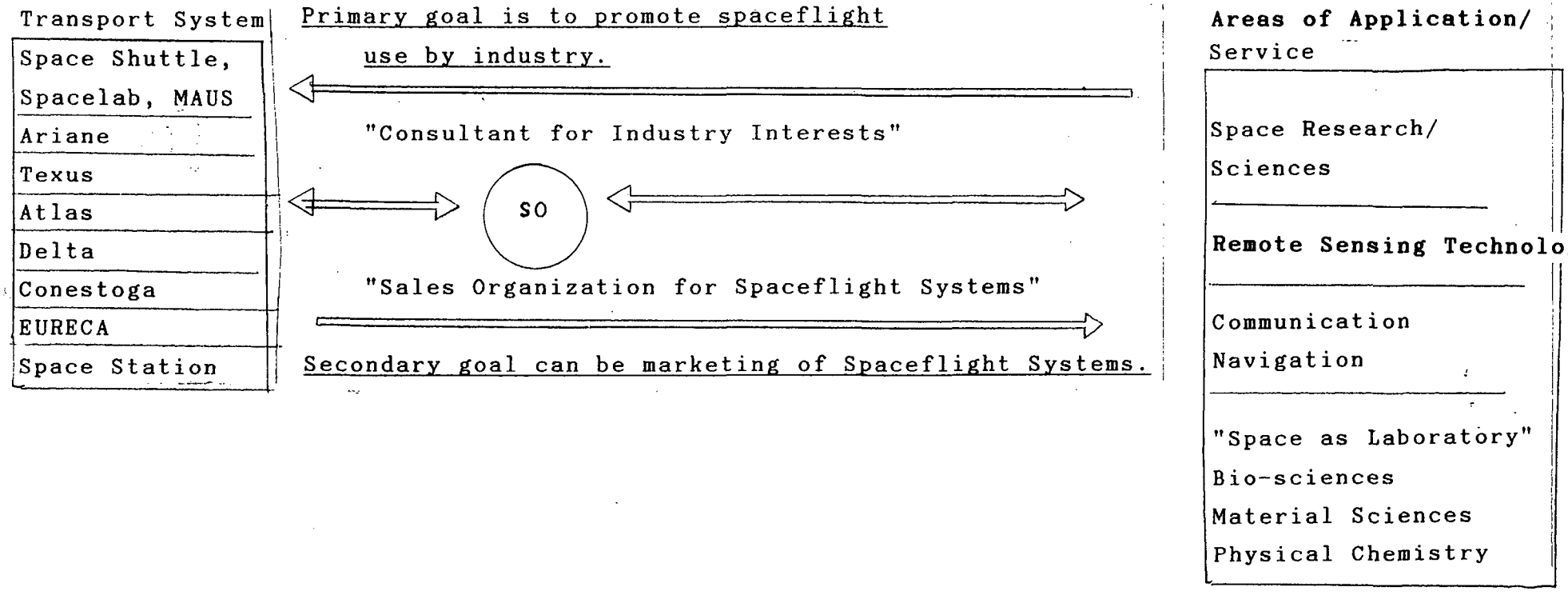
3. On the basis of available information indicating /19 that American and company-based interests are actively pursuing marketing activities involving commercial use of spaceflight, a coordination system must be developed and implemented.

4. Most urgent of all is finalization of plans and rapid implementation of a design for the sponsoring organization, which can assume marketing activities and handling of projects in the future.

Model of Sponsoring organization (SO):

Professional marketing and execution of cooperation with consumer industries and space transport systems for promotion of industrial spaceflight use.

All necessary services to this end are to be produced externally or internally with the goal of long-term profit.



Industrial Use of Spaceflight	Model of Sponsoring organization	Sponsoring organization

Areas of Application/ Service		Organizations (Examples)
Remote Sensing Technology	→	EOSAT Spot Image
Communication Navigation	→	gesat Intelsat Detekon
Launch Services	→	arienespace NASA
Ground Services	→	DFVLR

"Space as Laboratory"
Bio-sciences
Material sciences
Physical Chemistry

→ ? →

DFVLR	MBB-Erno
NASA	Dornier
Esa	McDonnel--D.
Kayser-Threde	

BMFT * DFVLR		Sponsoring organization
Industrial Use of Spaceflight	Examples of Existing **Supplier--Sponsoring Organizations**	

Model of Sponsoring organization

Professional marketing and implementation of cooperation of consumer industries and transport systems of spaceflight for promotion of industrial spaceflight use.

All necessary services to this end are to be produced externally or internally with the goal of long-term profit.

Professional Marketing →	Strong capability for diffusing the idea of spaceflight and concrete opportunities of spaceflight use in the consumer group
Acceptance →	Organizational and expert acceptance by the consumer industry
Credibility/ Neutrality →	Extensive neutrality to various system offerings
Independence →	**Securing of this independence by separating sponsors (partners) and management of the sponsoring organization**
Cooperation →	Good contact and possibility of rapid access to research projects and other external resources necessary for project development
Know-how →	Professional leadership and development of projects
Industrial Thinking →	**Market and profit-oriented thinking by sponsoring organization's leadership**

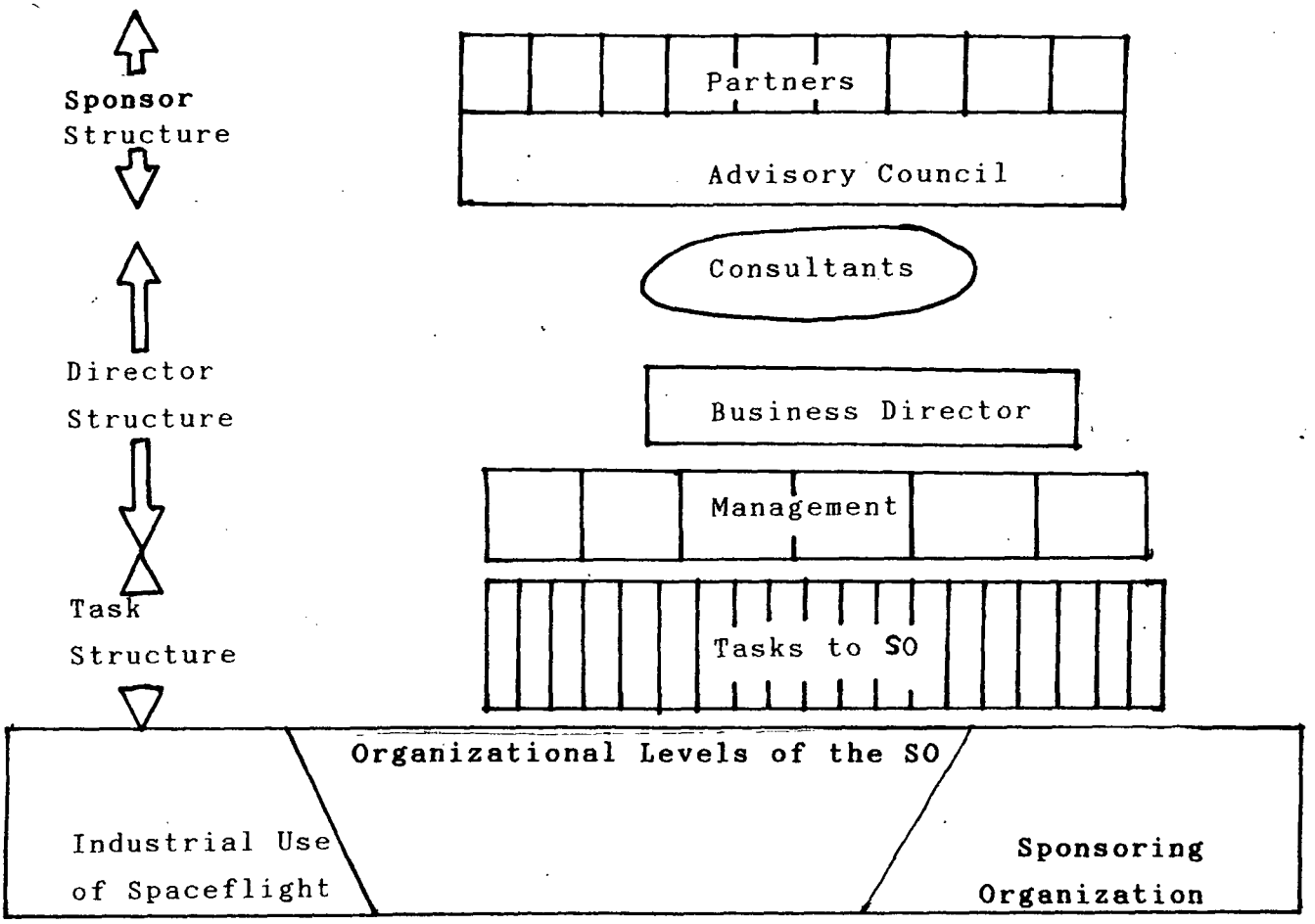
Necessary Characteristics of SO

Industrial Use of Spaceflight

Representative Organization

Configuration Elements	Characterization	
1. Self-reliance	not self-reliant	self-reliant X
2. Durability	temporary	long lasting X
3. Performance	all-encompassing X	specialized
4. Task Versatility	high X	low
5. Number of Sponsors	one sponsor	several sponsors X
6. Supplier Number	one sponsor	several sponsors X
7. Number of SO's	one SO X	many SO's
8. Regionality	national	international X

Industrial Use of Spaceflight	Organizational Configuration	Sponsoring Organization


Sponsor Structure
Director Structure
Task Structure
Partners
Advisory Council
Consultants
Business Director
Management
Tasks to SO
Organizational Levels of the SO
Industrial Use of Spaceflight
Sponsoring Organization

Information/Marketing

* Publicity
* Selection/Discussion with Potential Customers
* Information on Possibilities of Spaceflight Use (Delivery of Know-how--Evaluation, Research/Development, and Production in Space
* Presentation of Peripheral Conditions and Advantages of Research/Development and Production in Space (Space Flight Systems and Programs, Project Plans and Conditions, etc.)

Technical and Scientific Advising Project Management

* Suggestions for Possible Research Development, and Production Sales
* Cooperation between Project Partners (for example, DFVLR, Research Institutes, Spaceflight Industry
* **Transfer of Tasks for: Scientific and Technical Consultation (Development of Testing Procedures and Equipment, Selection of Flight Opportunities, etc.)**
* **Ground Preparation and Flight Support Program**
* Result Evaluation

Administration

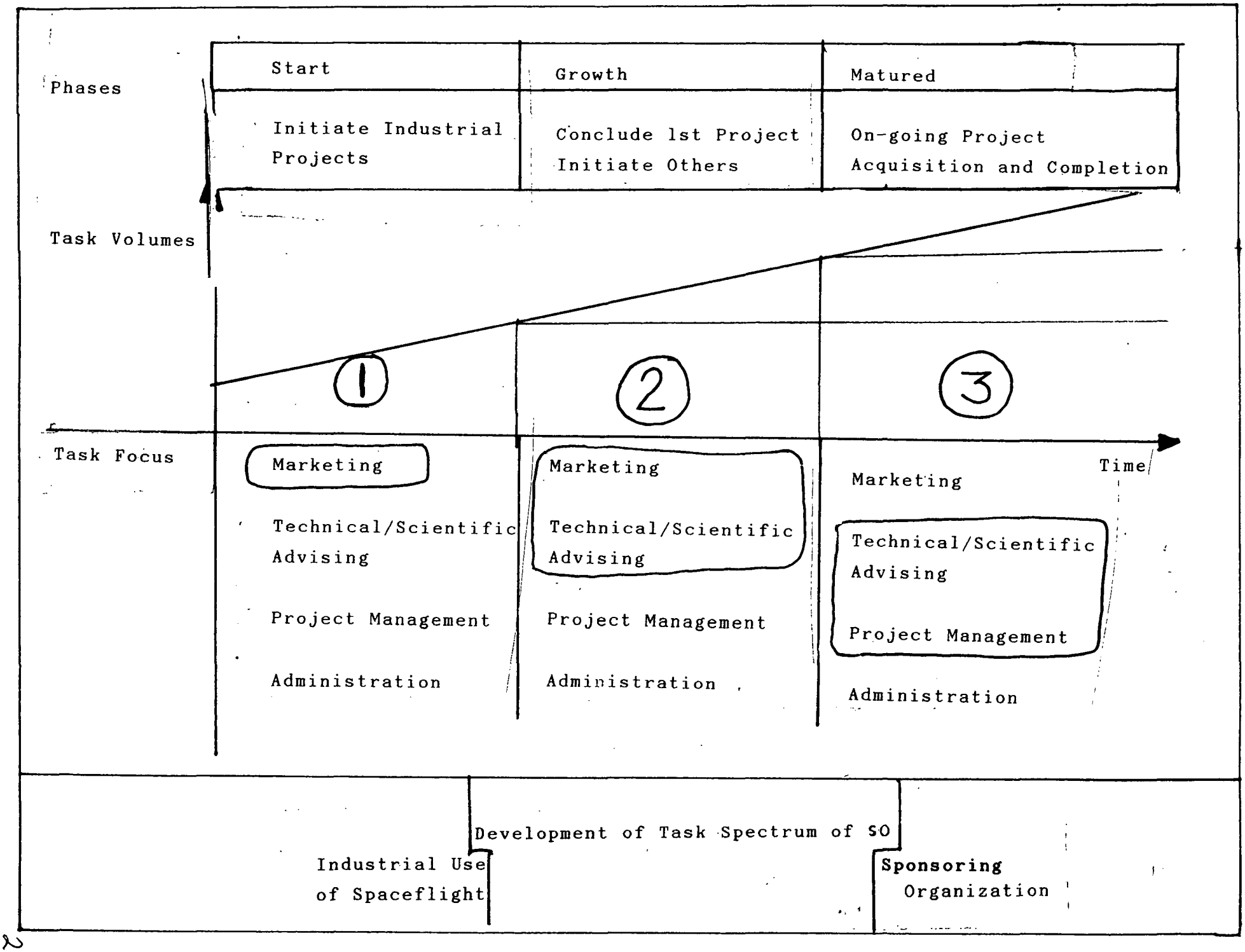
* Legal/Contract Consultation
* Financial Consultation
* Other Services
* **Internal** Administration

BMFT • DFVLR

Industrial Use of Spaceflight

Chief Tasks of SO

Sponsoring Organization

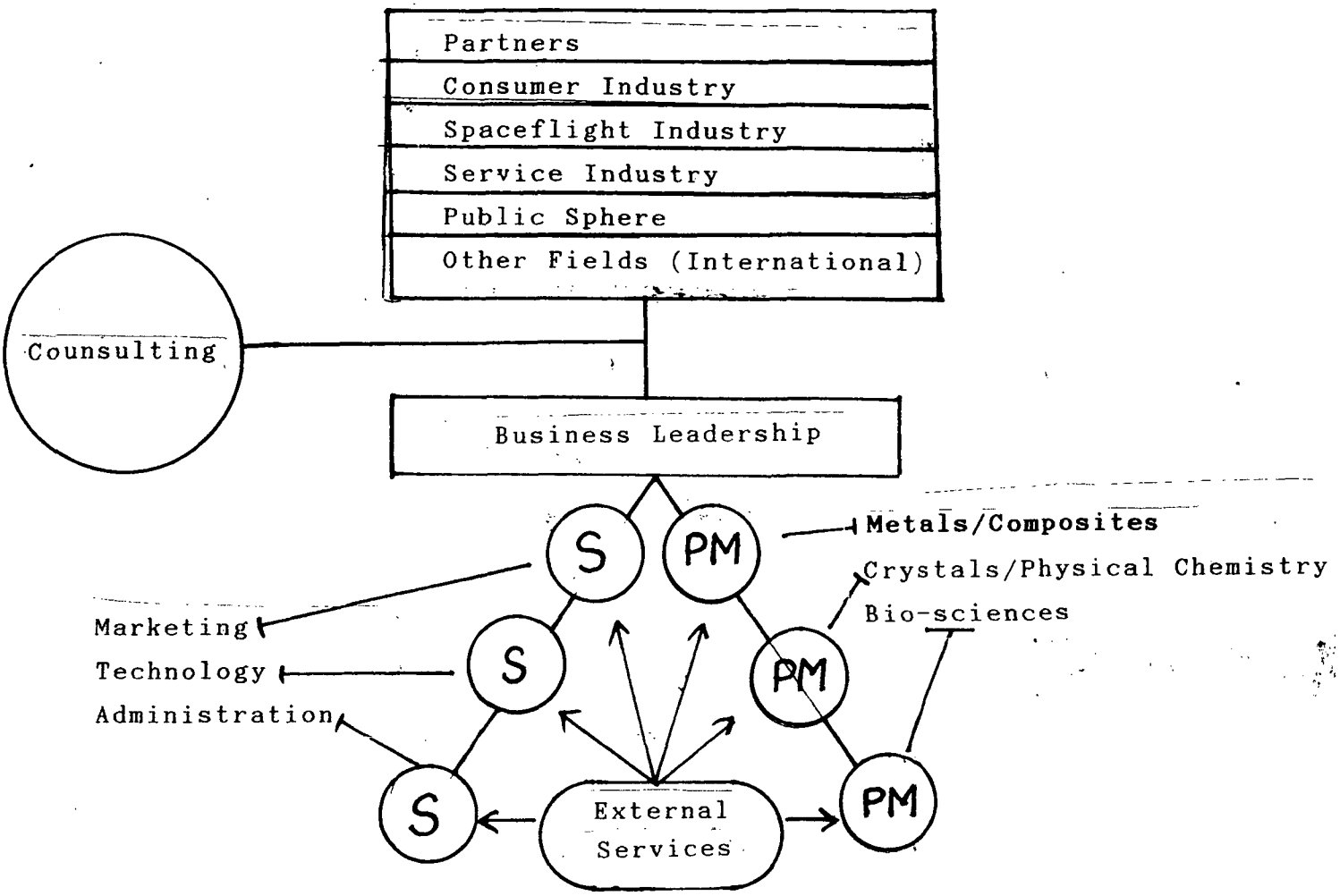

Phases
Start
Growth
Matured
Initiate Industrial Projects
Conclude 1st Project Initiate Others
On-going Project Acquisition and Completion
Task Volumes
1
2
3
Task Focus
Time
Marketing
Technical/Scientific Advising
Project Management
Administration
Marketing
Technical/Scientific Advising
Project Management
Administration
Marketing
Technical/Scientific Advising
Project Management
Administration
Development of Task Spectrum of SO
Industrial Use of Spaceflight
Sponsoring Organization

Organization Concept

Separation of Representatives and Management

Establishing Professional Project Management

Use of Existing Research and Service



for example for:

* Scientific Questions → Research Institutes, DFVLR
* Contract Questions, Financing → DFVLR, Credit Institutions
* Integration Spaceflight Systems → Spaceflight Industry, Operation and Evaluation
* DFVLR Marketing → Consulting

Industrial Use of Spaceflight	Organization Concept	**Sponsoring** Organization

Market Volume: Trends to 2000

(in Billions of US$)

I. Satellite Technology	
Communication	15 - 20
Earth Observation	2
II. Infrastructure	
Ground Support	0.9-1.7
Space Transport	0.8-1.0
Service in Orbit	0.8-2.2
III. Space as Laboratory	
Research, Development and Production:	
Pharmaceuticals	20
Other Materials	5
Total	44 - 53