Business Administration

Lecture No. 20: Process/Organization/Performance of Product Development

1.Research and Development

2.Process of Product Development

3.Organization of Product Development

4.Performance of Product Development

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So far・・・Management of Production system

cost management　work improvement　process/inventory management

quality management　personnel/labor management　facility management

purchasing management

Another core function in manufacturing companies・・・

research & development/product development

process and organization of product development

development period (lead-time)

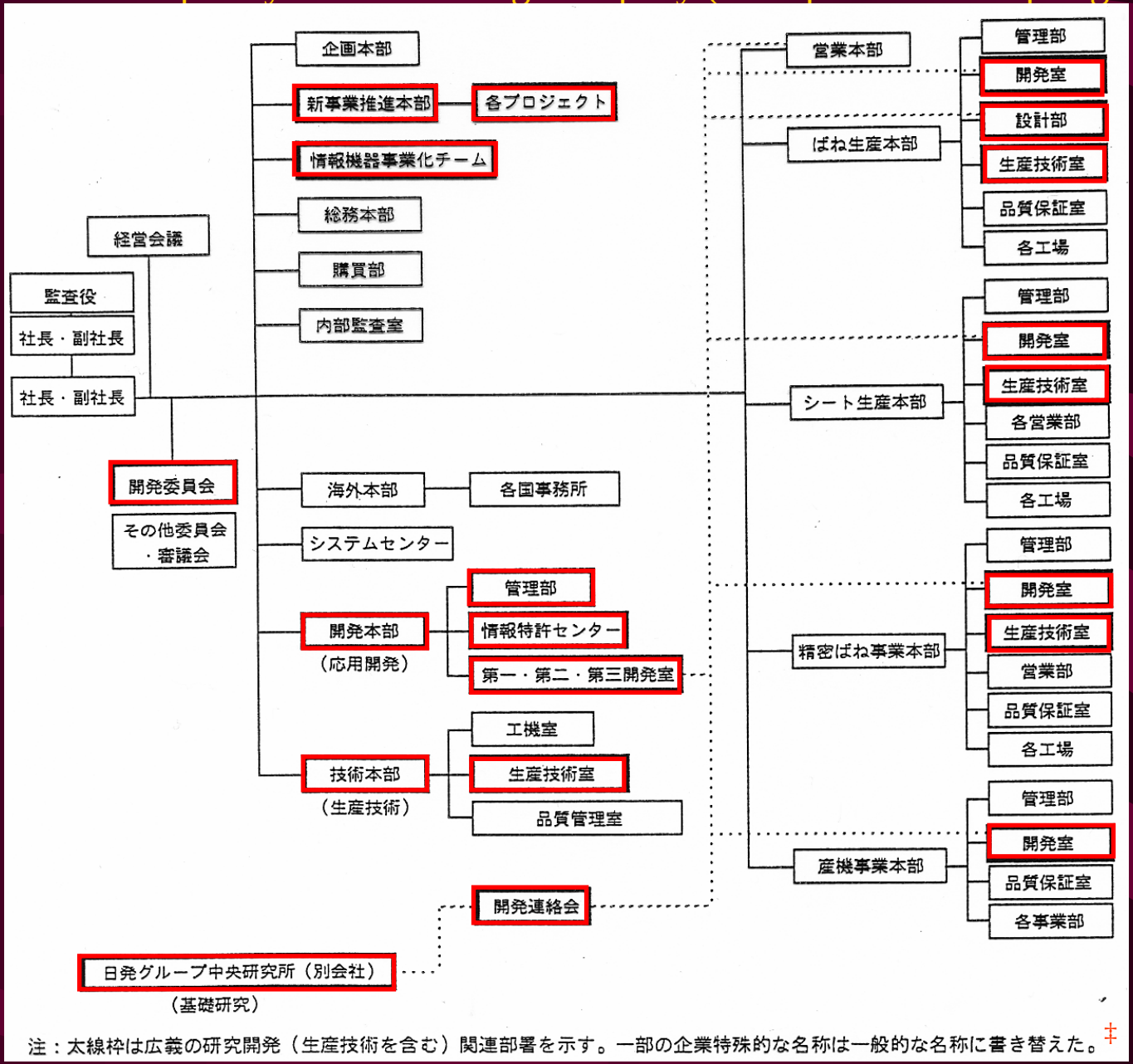
development efficiency (development productivity)

product capability (design quality)

Problem of measurement and system for management/improvement

Main focus to be placed on new product development activities at the level for an individual product

R & D Organization of Contemporary Manufacturing Company (example of NHK Spring Co.)



Author making (reference: 'Company overview''Corporate profile'1993')

Reference: Takahiro Fujimoto 'Introduction to Production Mmanagement' Nihon Keizai Shimbun, Inc. 2001 (Ⅱp166)

1.Research and Development

Many of contemporary manufacturing companies **have a research and development sector within themselves,**
investing a few odd percent to ten odd percent of their sales amount to R&D activities.

Organizational R&D activities by manufacturing companies
･･･begun nearly in early 20th century

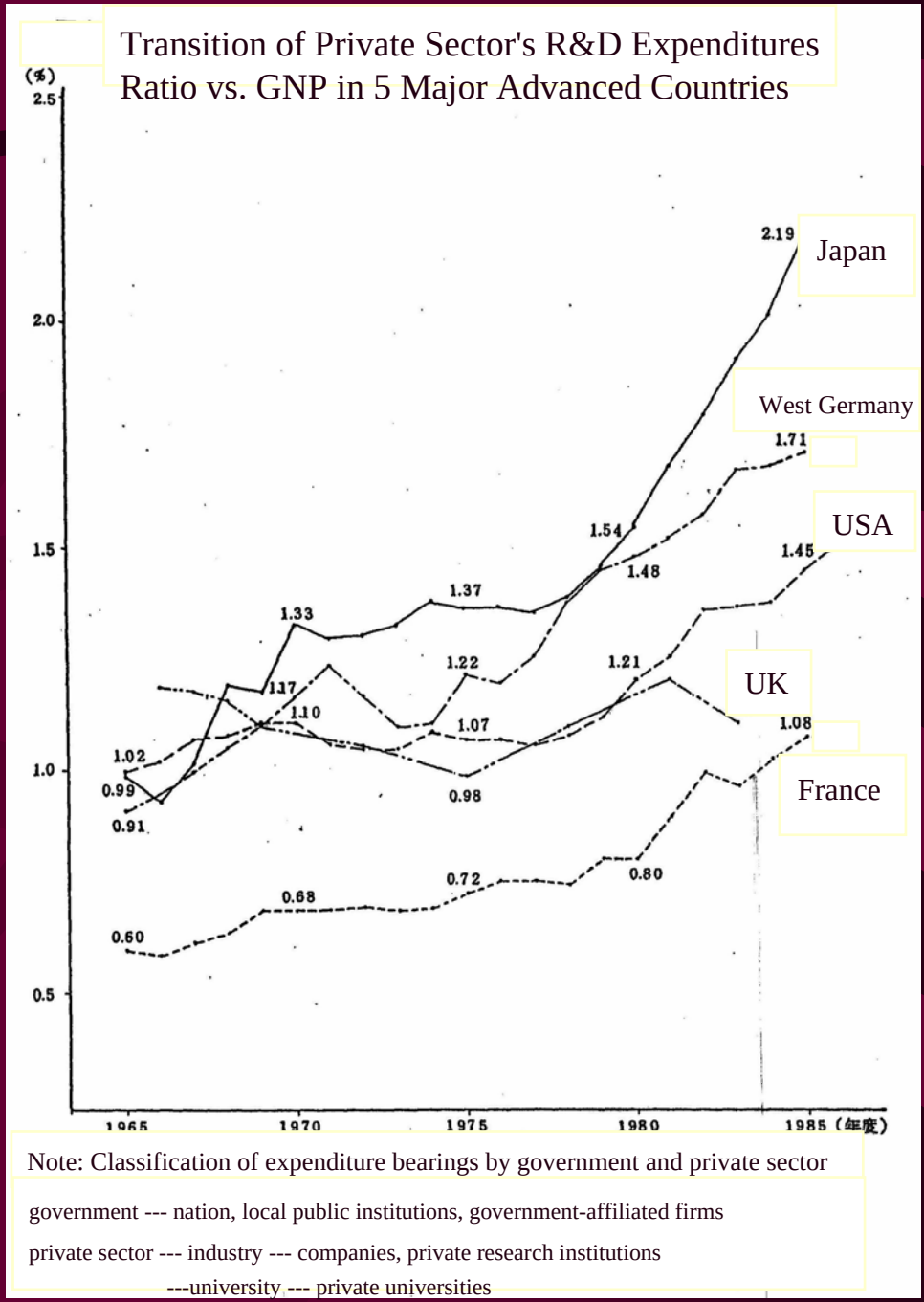
Clue to a research center within a company was in a gigantic chemical maker in Germany in 1870s.

In early 20th century, GE, Dupont, Bell Telephone, Kodak, etc.

In major countries, R&D cost expended by companies (industries) occupies nearly 70% of their national R&D costs in total.

R&D Expenditures of Japan

Its ratio vs. GNP is still at the highest level in the world. (more than 3%)



Note: Classification of expenditure bearings by government and private sector

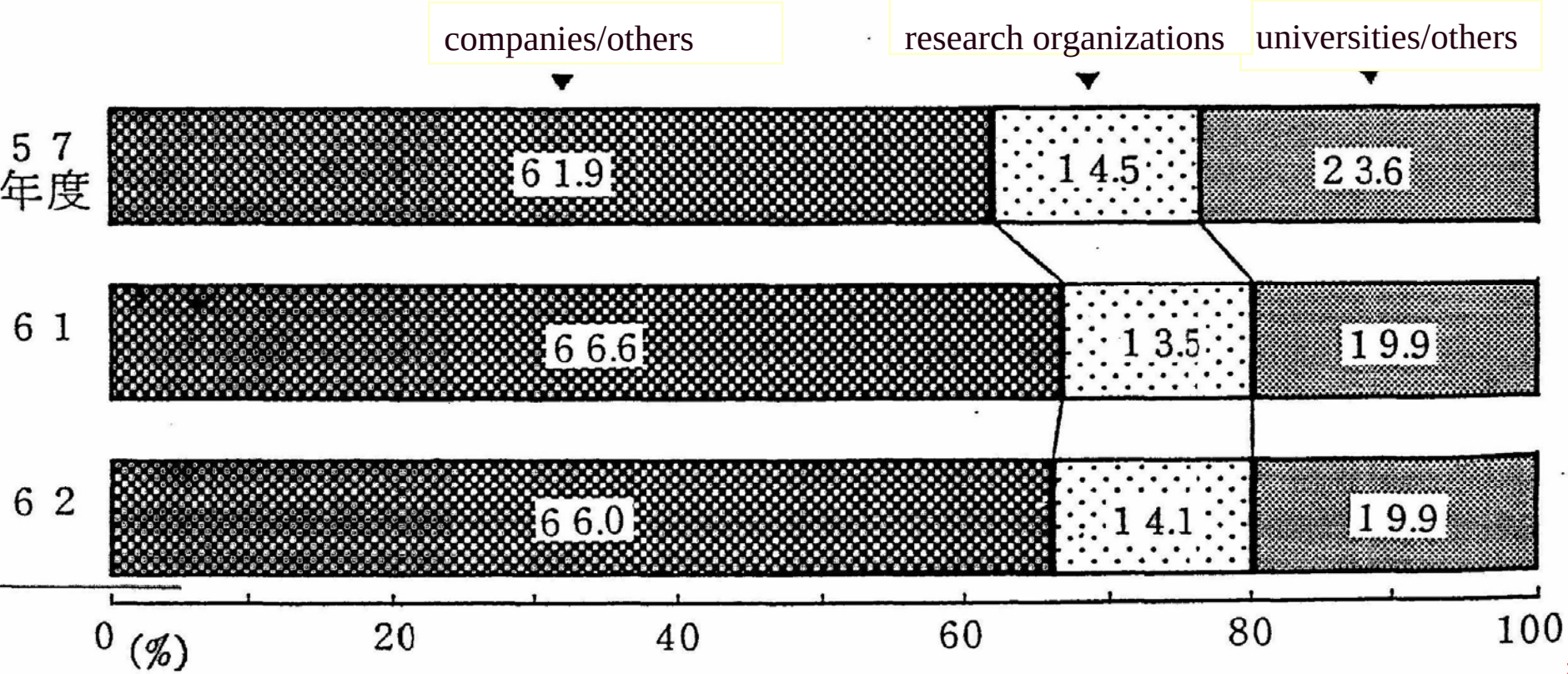
government --- nation, local public institutions, government-affiliated firms

private sector --- industry --- companies, private research institutions

---university --- private universities

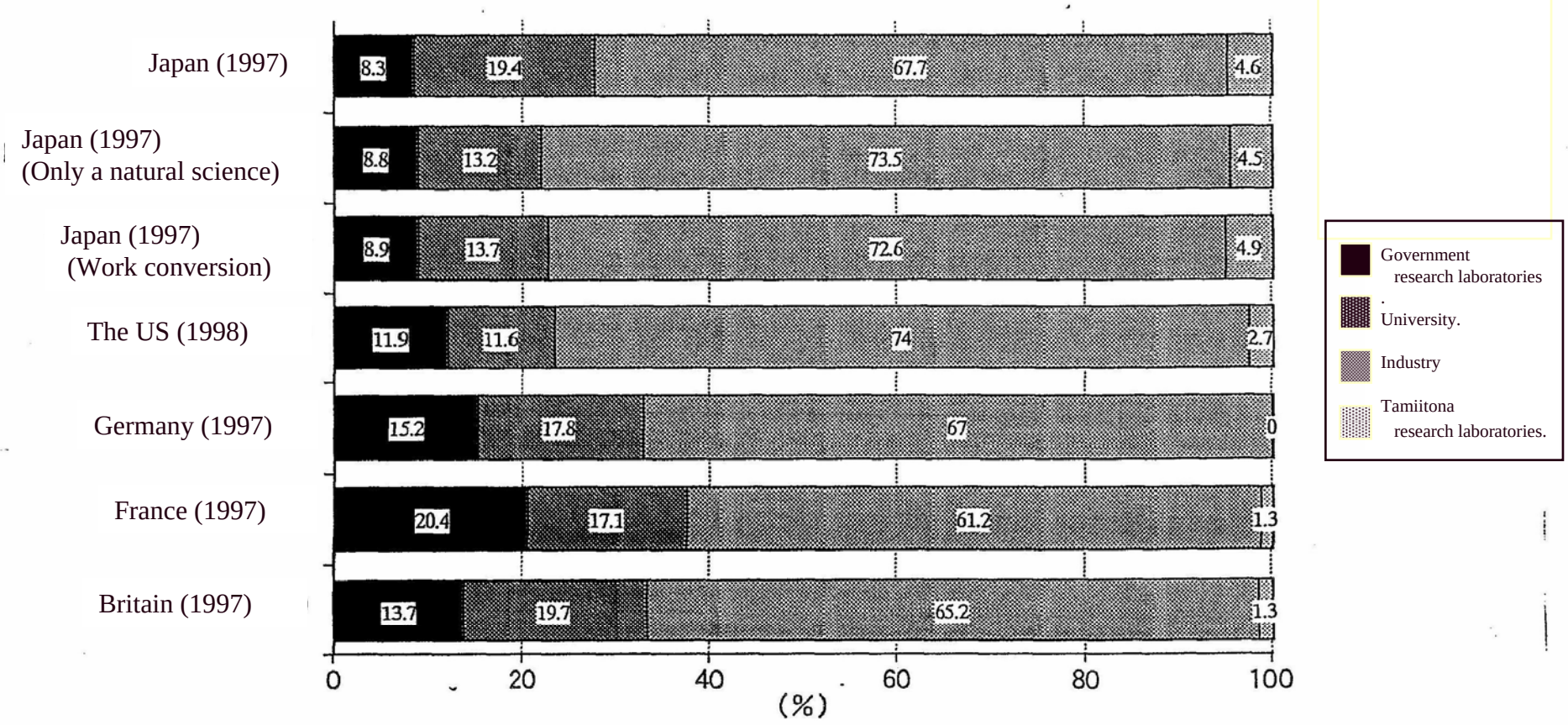
Private Companies Share 2/3 of Nation's Research Cost

Constituent Ratio of Research Cost by Research Entity



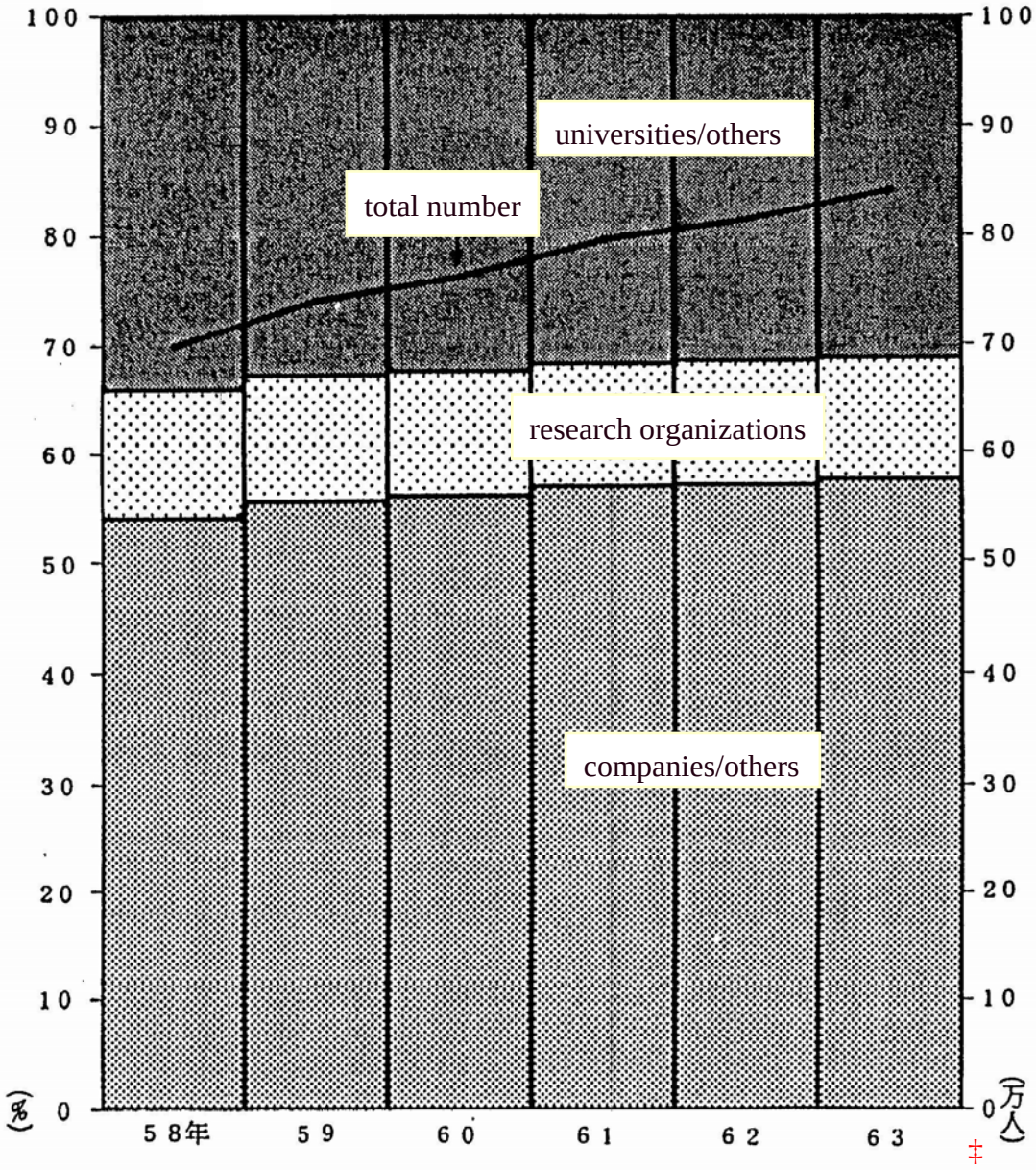
'Survey Report on Scientific and Technological Research' MIC Statistics Bureau 1988

Constituent Ratio of Research Cost by Organization in Major Countries



注）1. 国際比較を行うため、各国とも人文・社会科学を含めている。
尚、日本については自然科学のみと専従換算の値を併せて表示している。
2.（1）負担では政府と外国以外を民間とした。
3. 米国の値は暦年で暫定値、ドイツの値は暫定値である。また、ドイツの（2）使用の
「民間研究機関」の研究費は、「政府研究機関」に含まれている。
資料：科学技術白書（平成１１年版）。日本（専従換算値）及びフランスはOECD「MAIN SCIENCE AND TECHNOLOGY INDICATORS」。

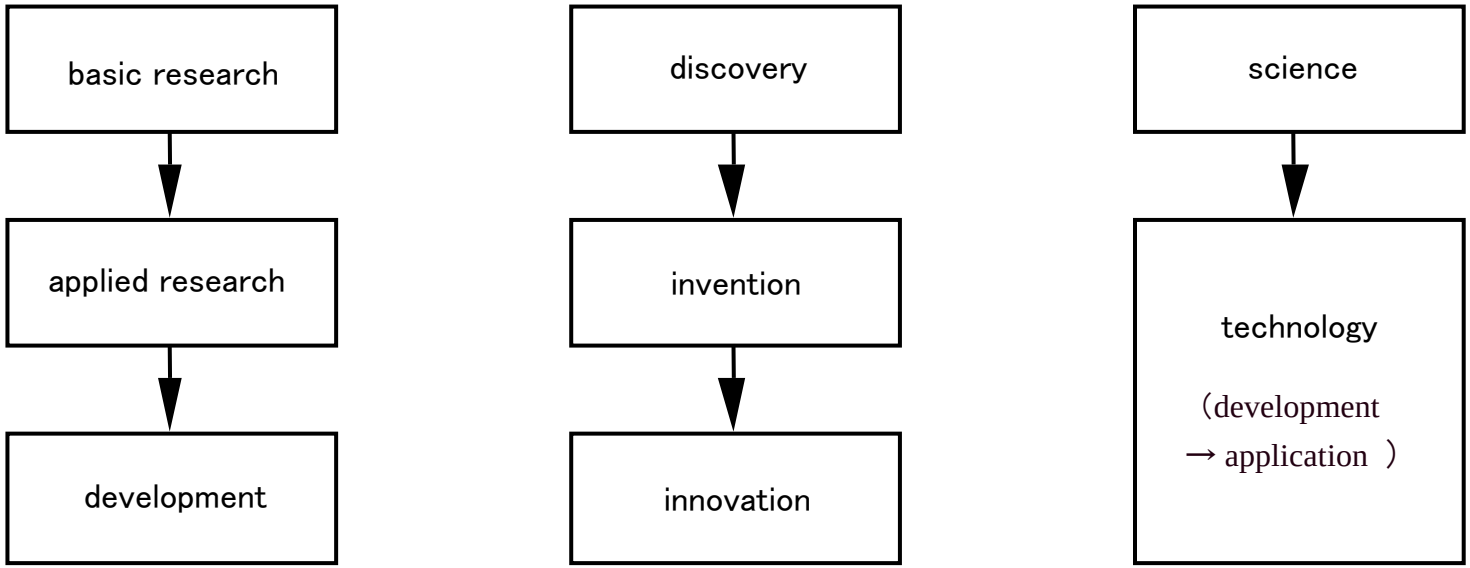
Transition of Number of Employees Affiliated with Research



'Survey Report on Scientific and Technological Research' MIC Statistics Bureau 1988

Various Concepts Concerning Research and Development

diagram　Concept of R&D/Innovation/Science and Technology



Note: ☐ to indicate knowledge stock, → flow of knowledge/information

And "innovation " can be considered as a concept including "invention".

Takahiro Fujimoto 'Introduction to Production Management' Nihon Keizai Shimbun, Inc. 2001 (Ⅱp167 figure.13.2)

(1)"Research" (R) and "Development" (D)

"**Development**" ＝ on the assumption to **commercialize/commoditize** design of new product/new process, trail product, experiment, etc.

"**Research**" ＝ procurement of new knowledge not directly linked to commercialization

"**Basic Research**" ＝ targeted at procuring scientific knowledge itself relative to natural/social phenomena

"**Applied Research**" ＝ activity to apply procured knowledge to reality

(2)"Discovery" and "Invention"

“Discovery”＝ procurement of new knowledge concerning natural/social phenomena

“Invention” ＝ to create idea, sketch, trial product, etc. concerning product, process, and others, that have potentialities to be put into practical use (commercialized)

“Innovation” ＝ to bring something into the first "**commercialization**", not just limiting to mere trial product or sketch

"**Product technology innovation**" (product innovation)
"**Process technology innovation**" (process innovation)

(3)"Science" and "Technology"

"**Science**" ＝ structure of rational knowledge concerning a general relation of cause and effect between each phenomenon

"**Technology**" ＝ structure of rational knowledge concerning a relation of cause and effect between concrete Mono (artificial article) and its function

It was in the early 20th century that the relationship between science and technology became close.
Scientists expressed their achievements in words by writing theses, while **technologists** did in Mono's.

In reality, things do not necessarily proceed on such **linear tracks** as "basic research →applied research →development", "discovery → invention → innovation ", "science → technology".

2. Process of Product Development

“**Product development**”＝ corporate activity to **create** "**product design information**" for new products to be sold in market

to include, in a broad term, preparations for process design and production process

Example of automobile･･･ product development of a car being a relatively complicated consumption good

Product Development Process of Automobile

"**Development project**" ＝ bundle of a series of developmental activities to develop a specific model a bundle of developmental activities a few hundred people, over 3-4 years

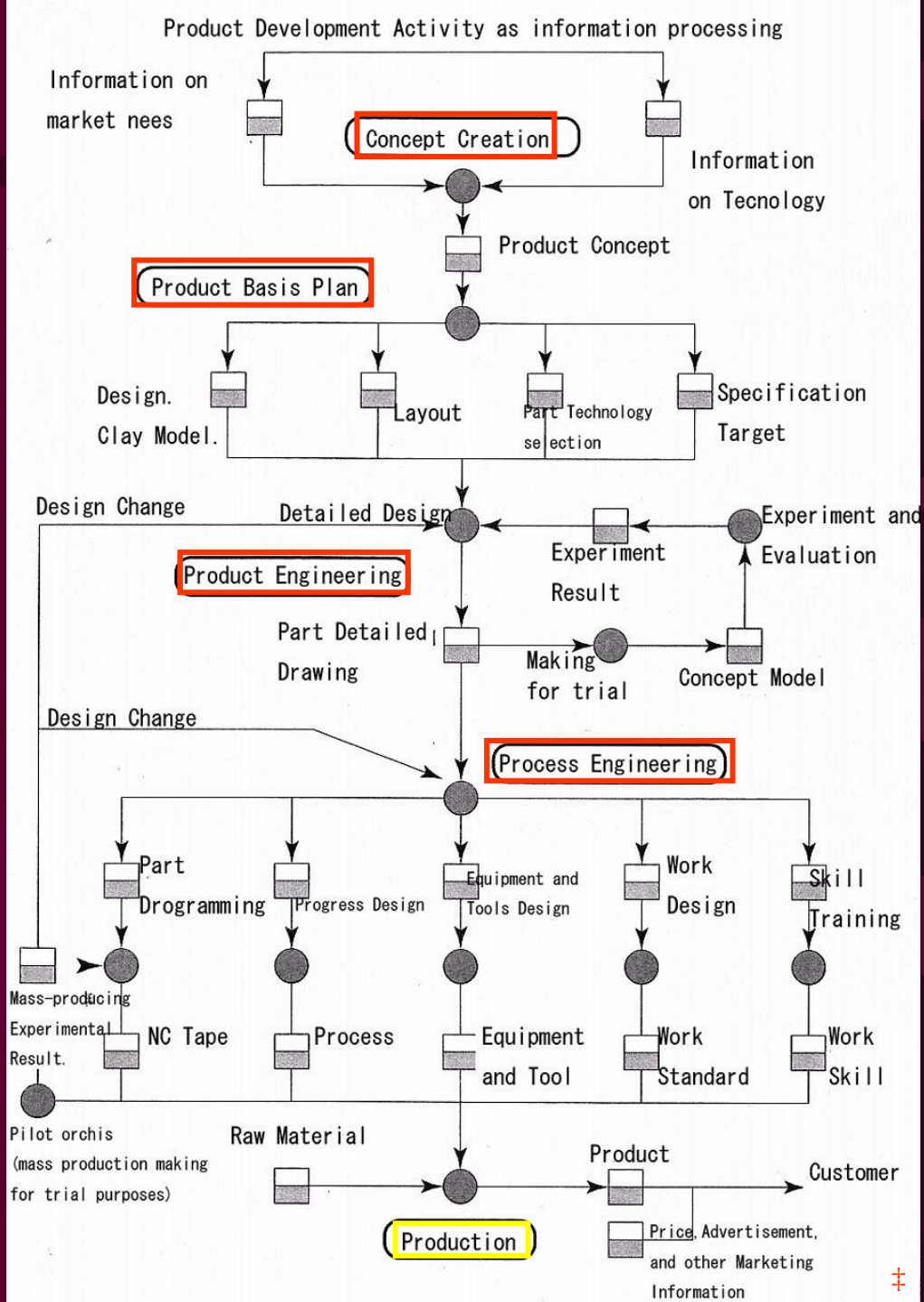
Planning stage

"**draw up concept**"
"**product basic plan**"

Full-fledged development stage (engineering)

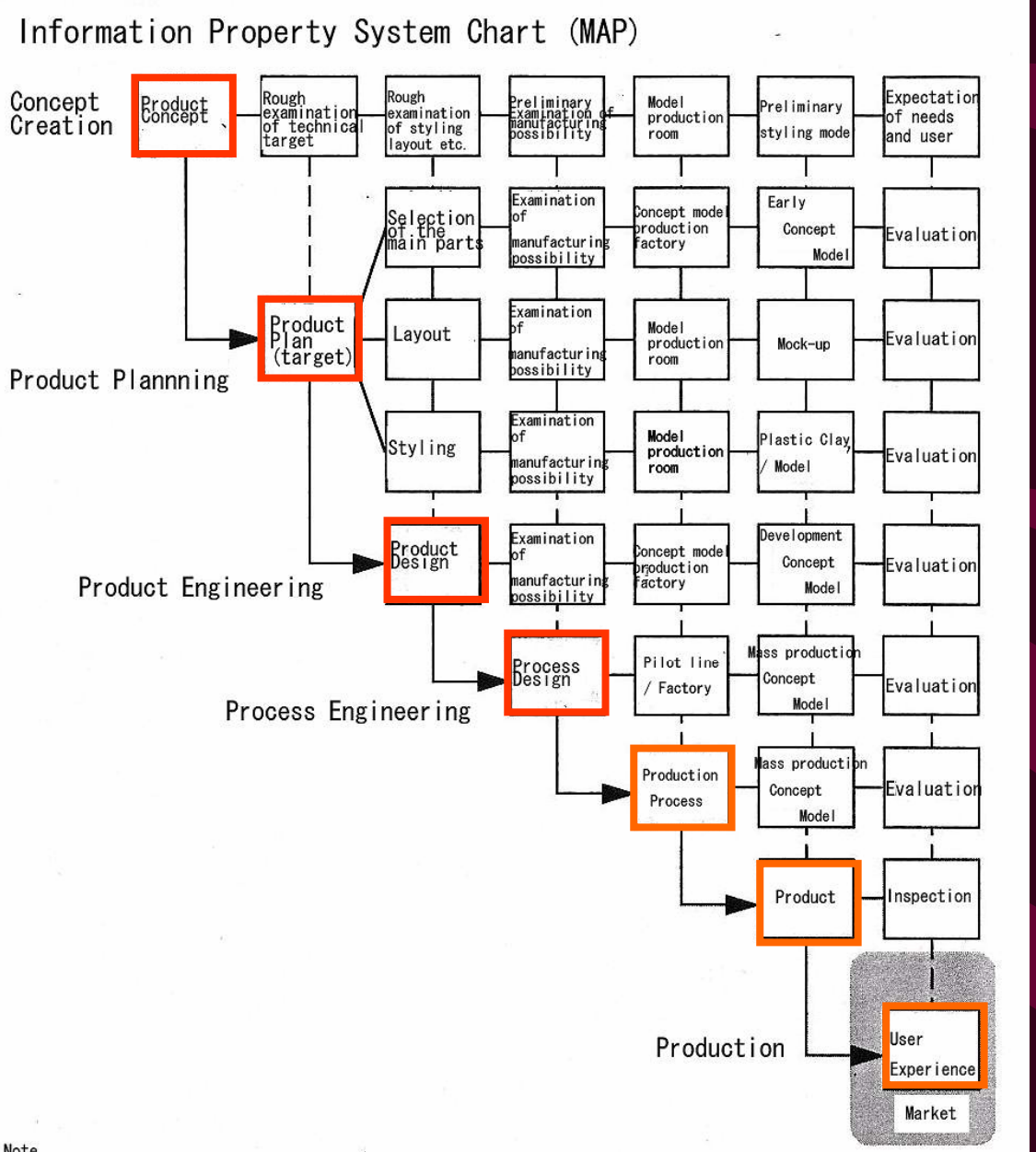
"**product engineering**"
"**process engineering (production preparation)**"

Product Development as Information Production Process



Takahiro Fujimoto
'Introduction to Production Management'
Nihon Keizai Shimbun, Inc. 2001
(Ⅱp174 figure.13.3)

Product development is a process to create design information asset through a problem-solving cycle.



Note

The relation of horizontal direction shows the problem solving cycle. The relation of the vertical direction shows the improvement of knowhow or the information property. Not only the information property of adjacent but also all of the same line and the same row the information properties is assumed to be related with a specific information property in this map potential. Moreover, the row of the product planning is related at three cycles concerning the styling, the selection of the main parts and the layout.

(1) Drawing Up Concept

"**Product concept**" =

vision concerning how to **solve customer problem** and thereby achieve **customer satisfaction** with that new product

Specify **target customers**, and plot a rough framework on needs information and customer satisfaction,

which can be expressed in variety of ways, such as sentence, sketch, key word, rough product specification, etc.

Example: Eunos Roadster --- "**Jinba Ittai (= man-horse unity)**"

(2) Product Basic Plan

"**Basic design**" = "**function design**", and rough "**structural design**"

Translation of "product concept"

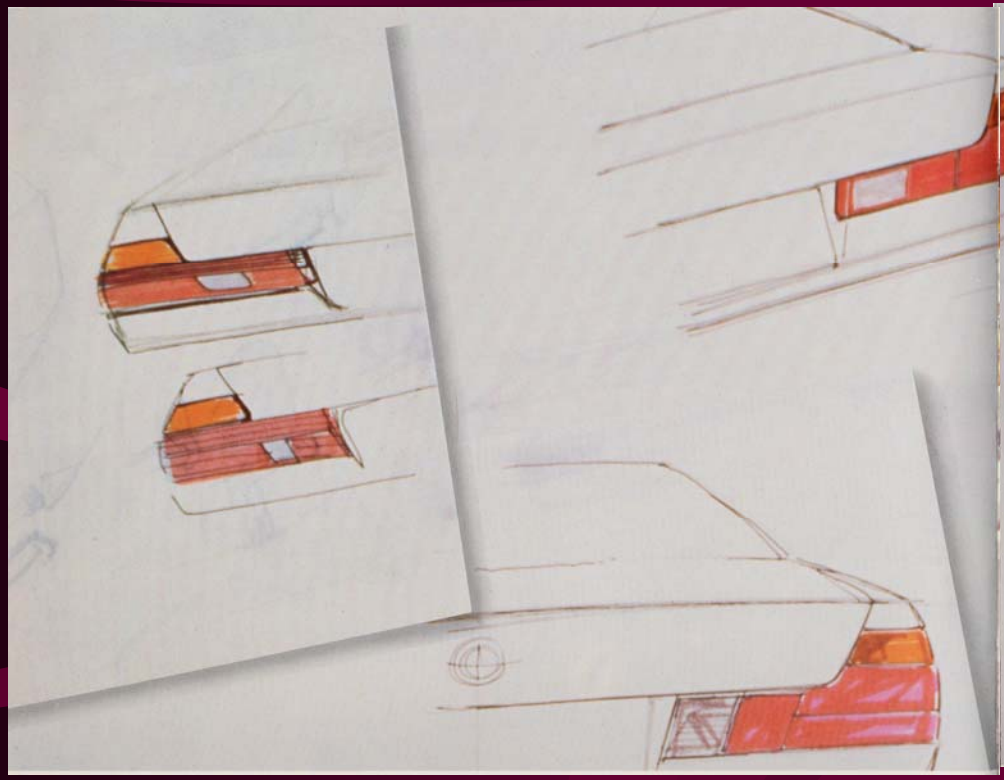
Such as **styling**, layout, **product specification**, **design format for parts**, etc.

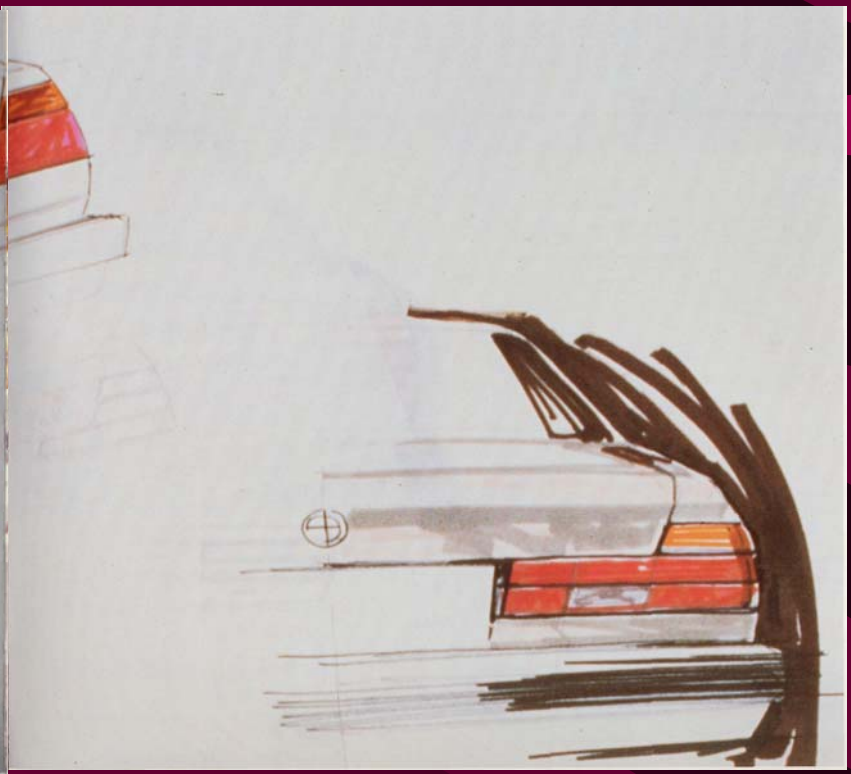
Approval of top management

Example of Eunos Roadster

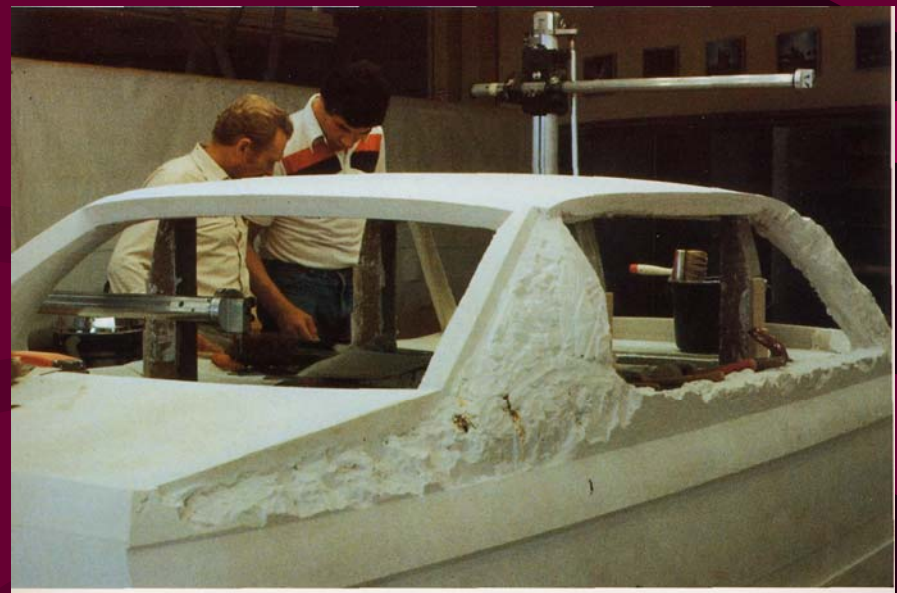
technological translation of "Jinba Ittai (man-horse unity)“
shorter axle interval, tight indoor layout, weight distribution prioritizing swirling performance, suspension form with emphasis on running capability

Exterior Design Sketch

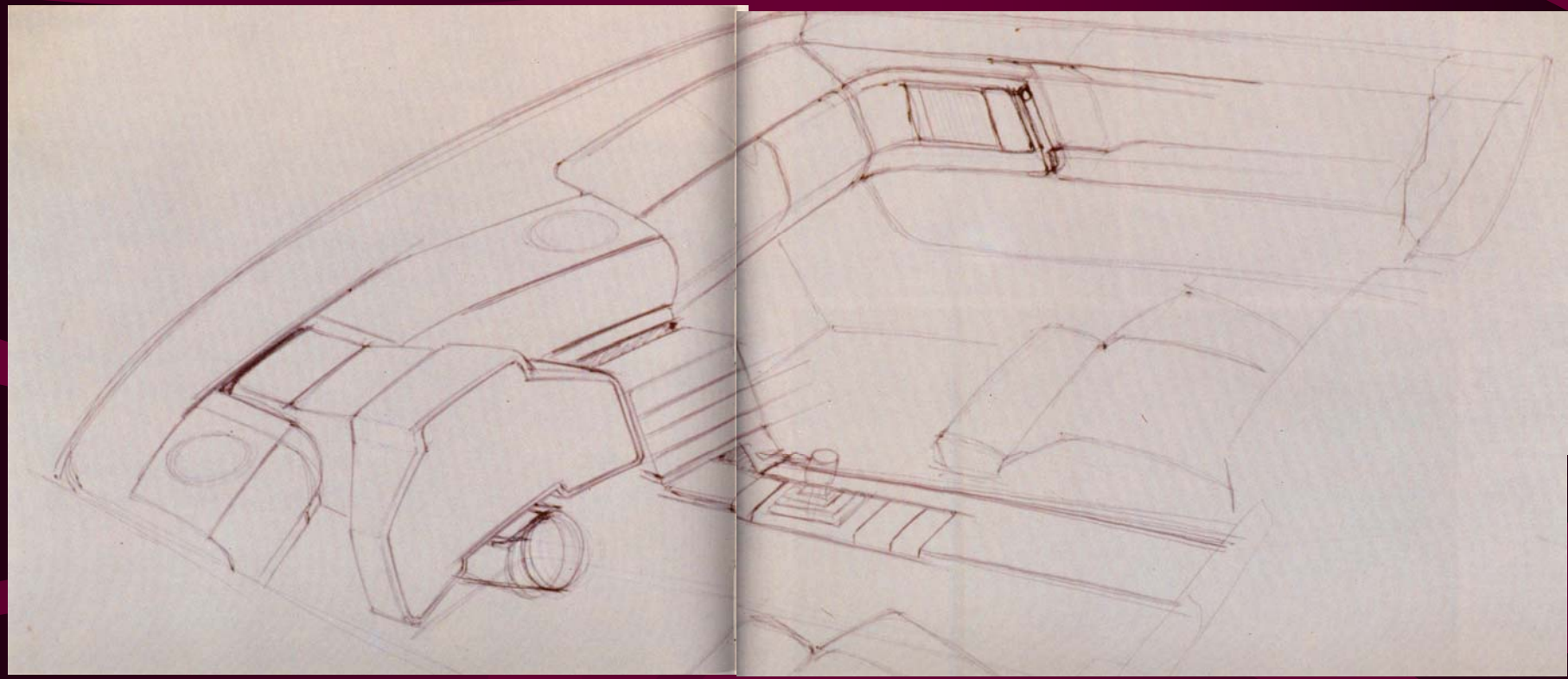


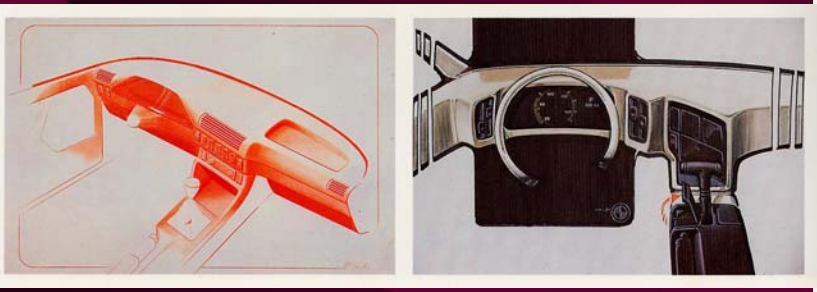


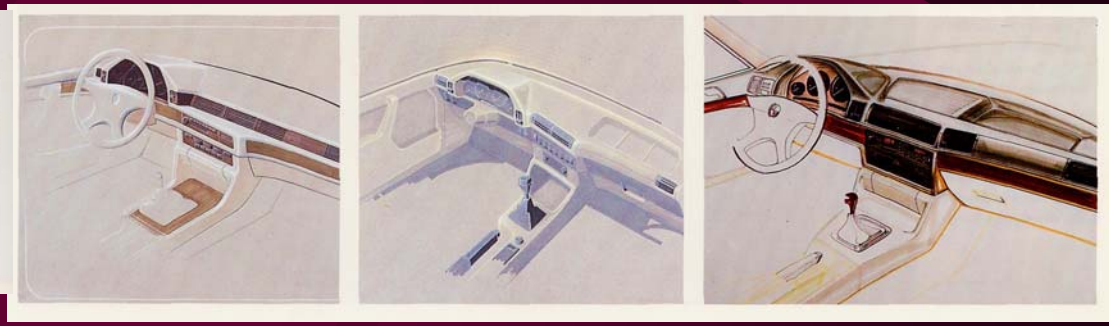
Exterior Design: clay model in 3 dimensions



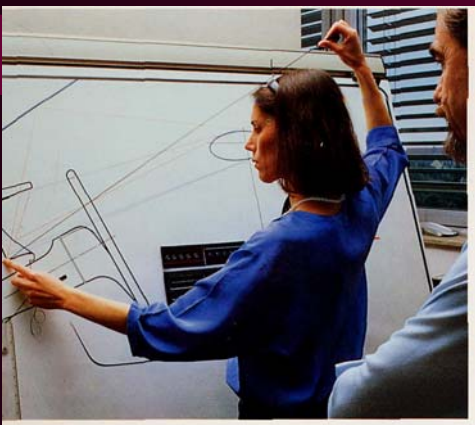
Interior Design Sketch

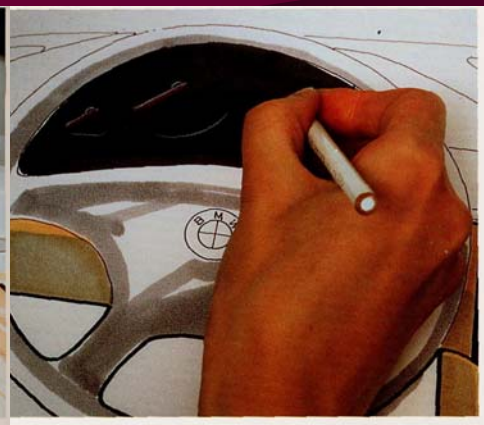






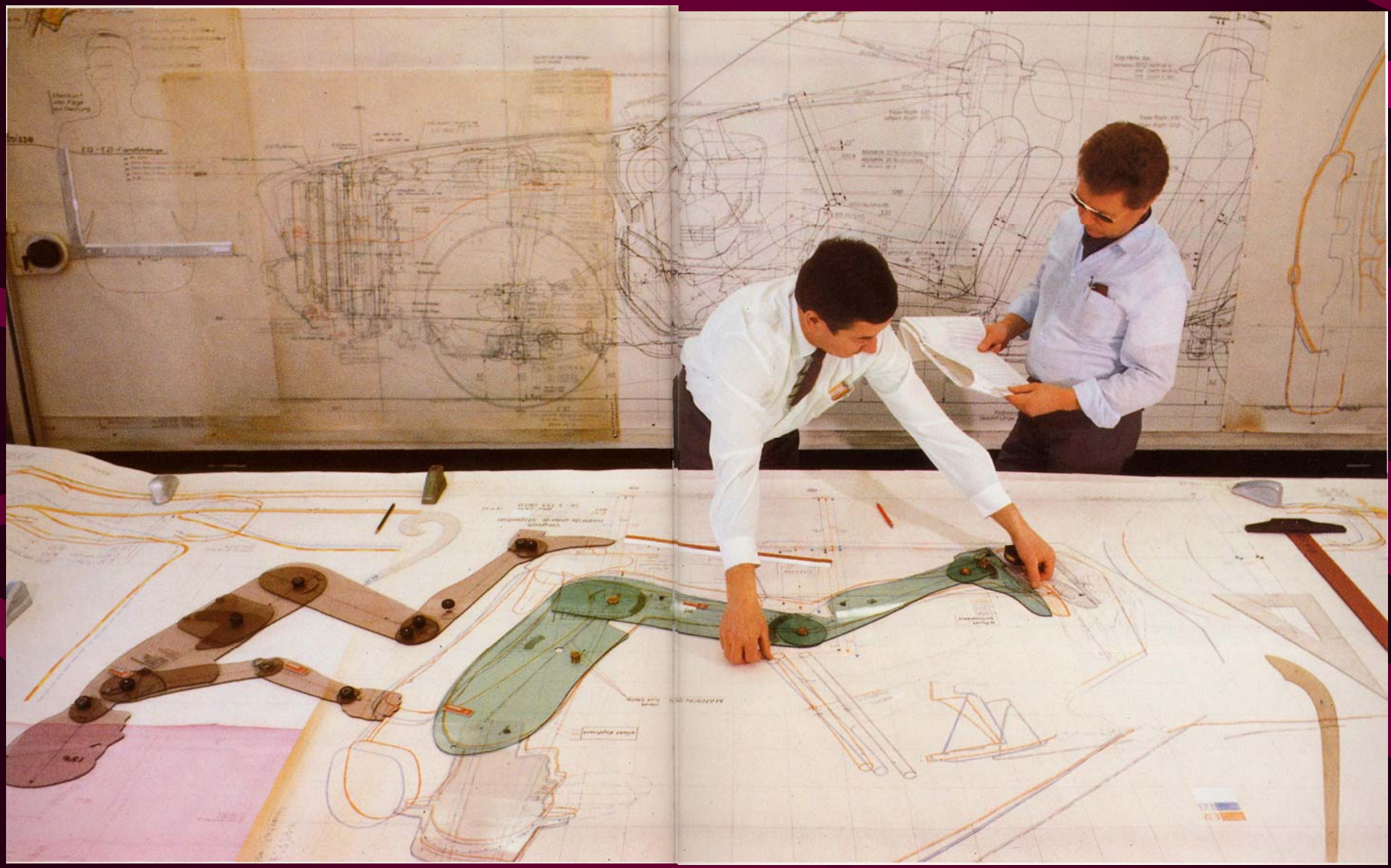
Interior Design and Modeling (3 dimensional)



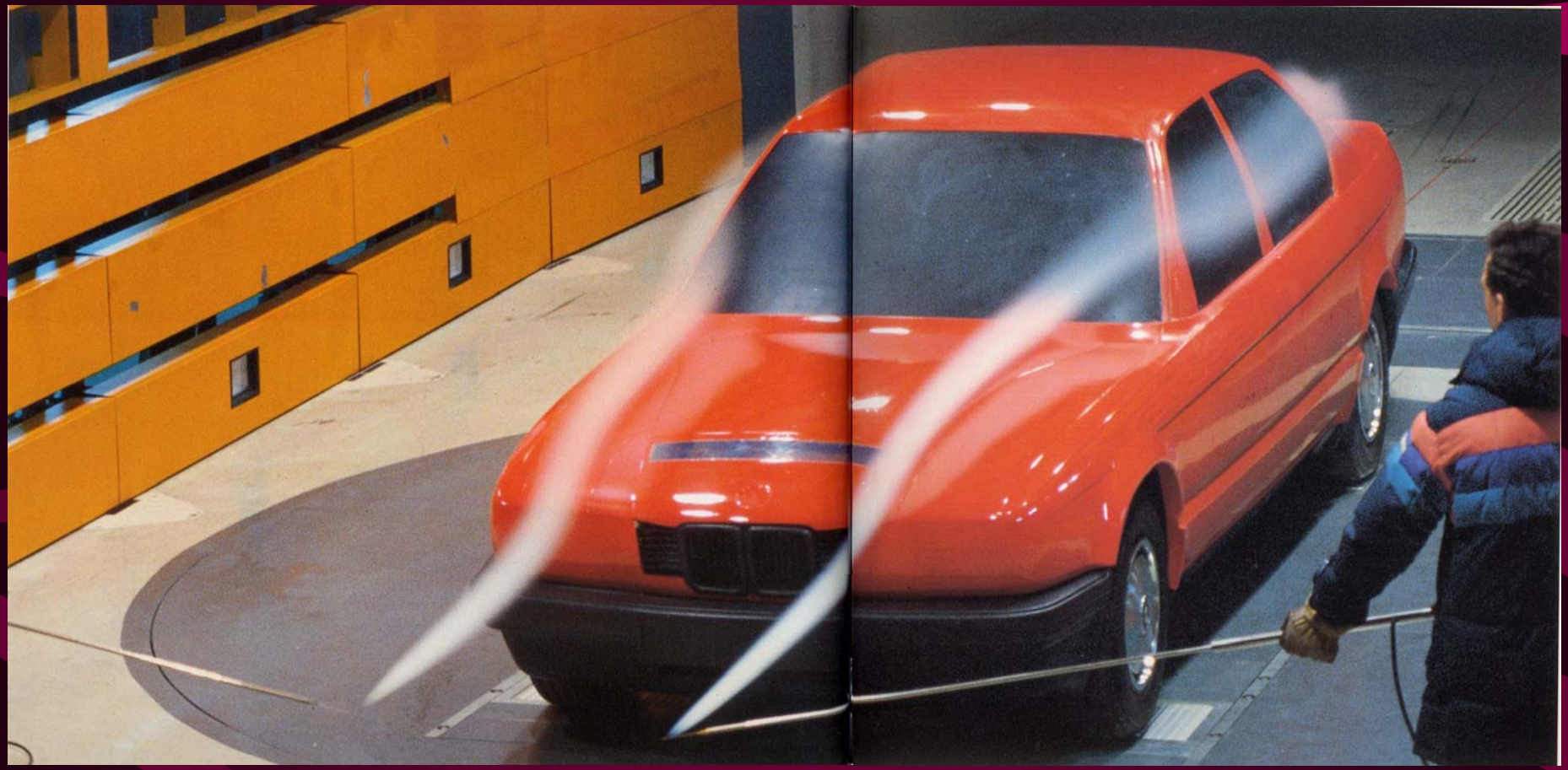


Interior Mockup (actual 3 dimensional model for sake of appearance evaluation)

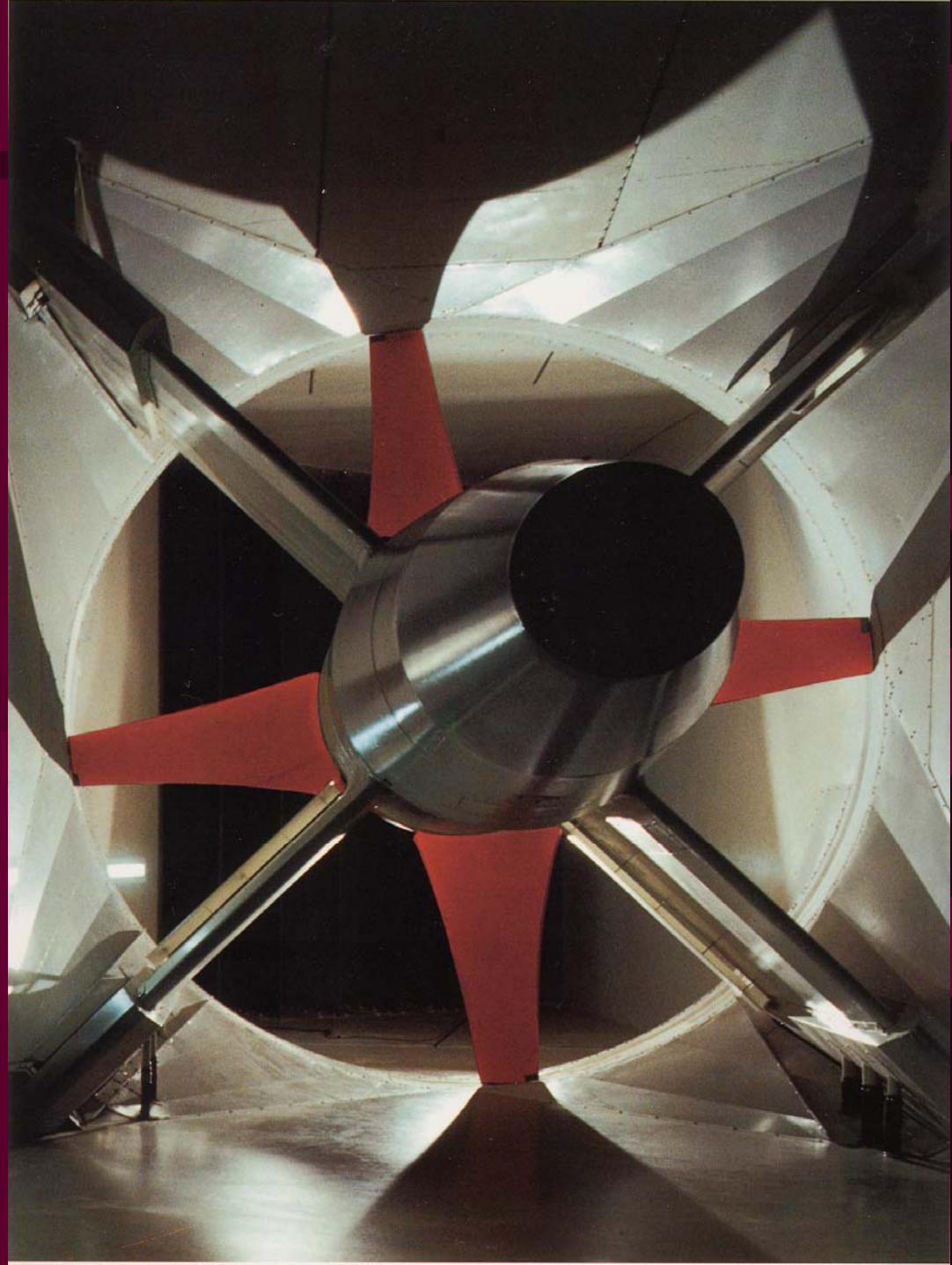
Layout Diagram (basic design for parts assignment)



Evaluation of Aerodynamics by Clay Model



Facility for Wind Tunnel Experiment



(3) Product Engineering

Cycle of **detail design, trial manufacturing, experiment**

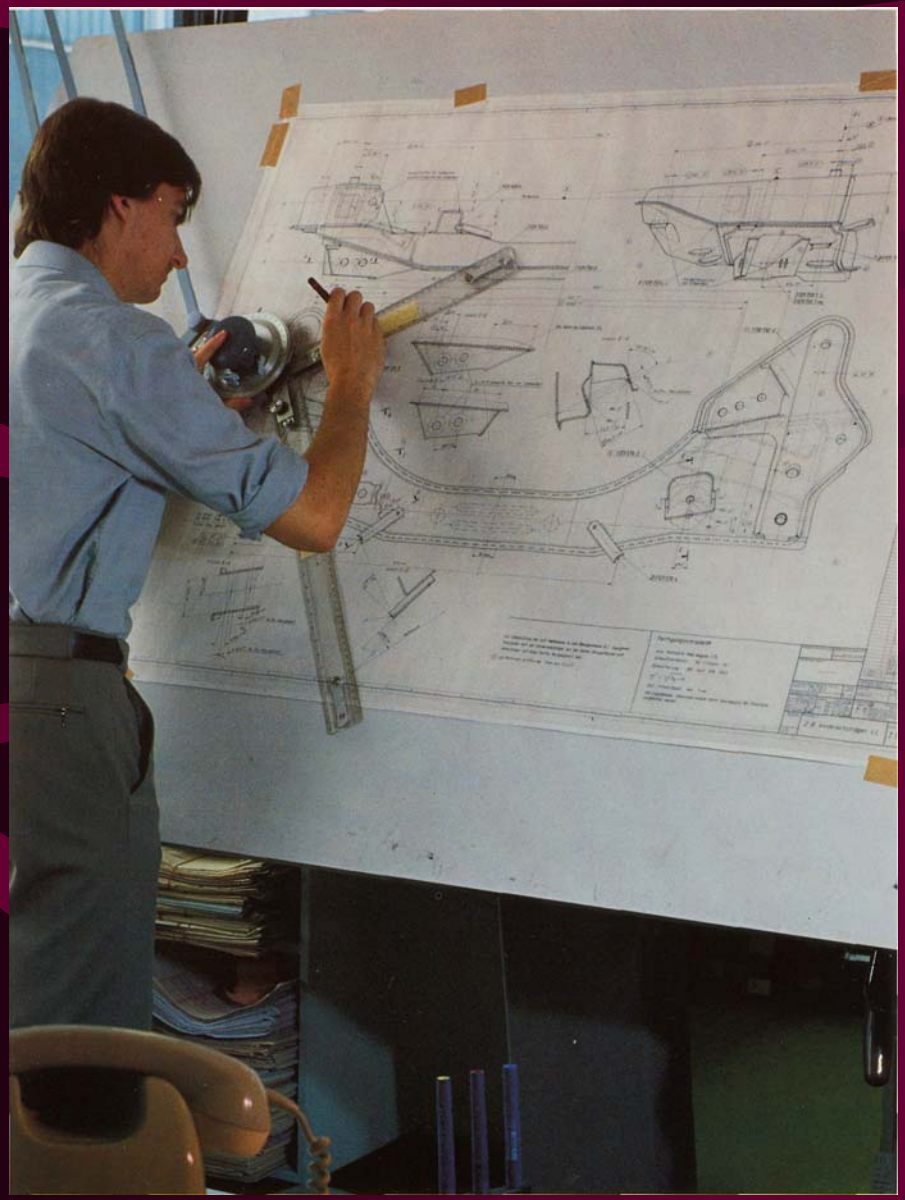
Expenditure of development to expand from this stage on

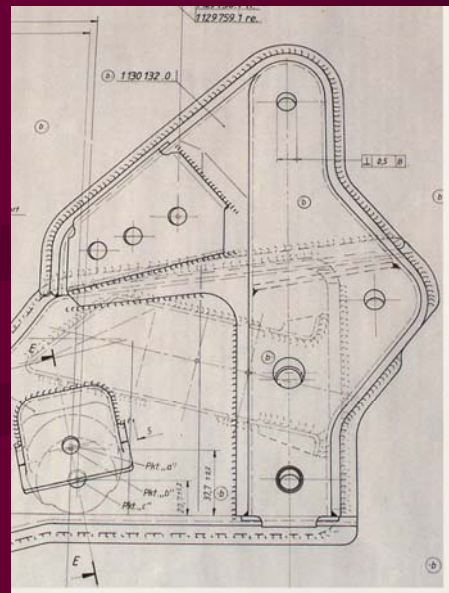
To repeat **a problem-solving cycle** of design/trial-manufacturing/experiment, until an objective set at the product-planning stage comes to be achieved.

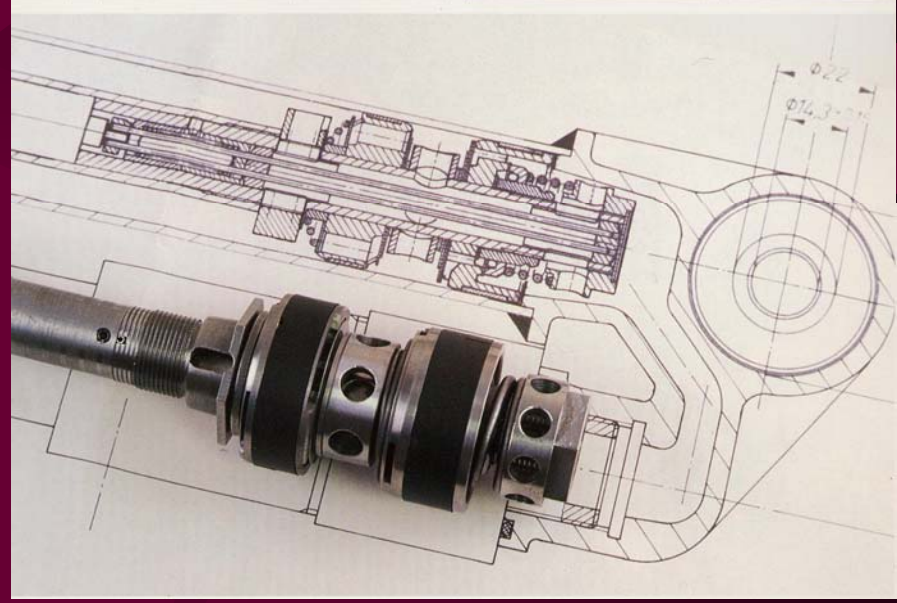
Detail design drawing of product --- file of computer-assisted design (**CAD**) now

Design of Engine and Developmental Trial Manufacturing

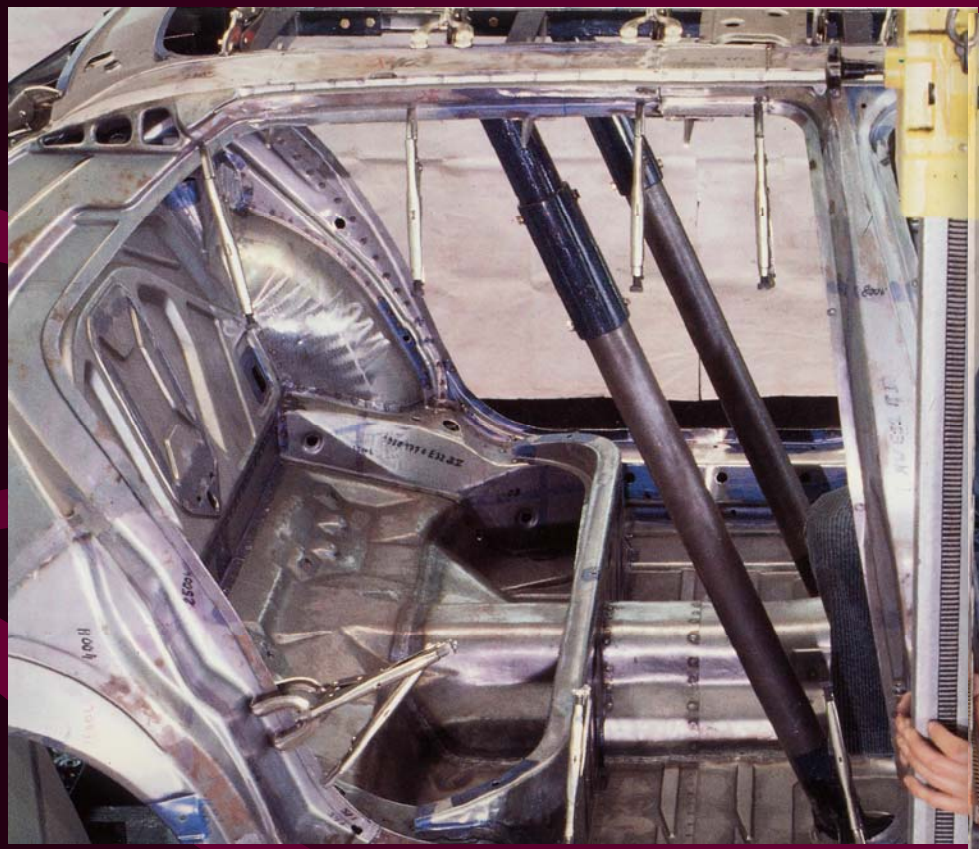
Detail Design and Developmental Trail Manufacturing of Parts (basically computerized now)





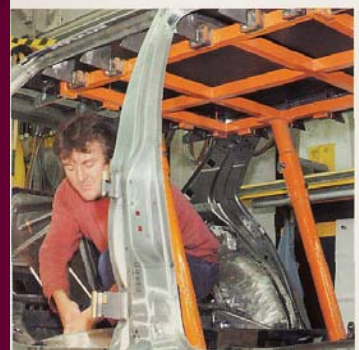


Manufacturing of Developmental Prototype Car (auto body)
･･･Universe of Super-Skilled Workers



Manufacturing of Developmental Prototype Car

handmade
(ranging Yen 50 million - 100 million)



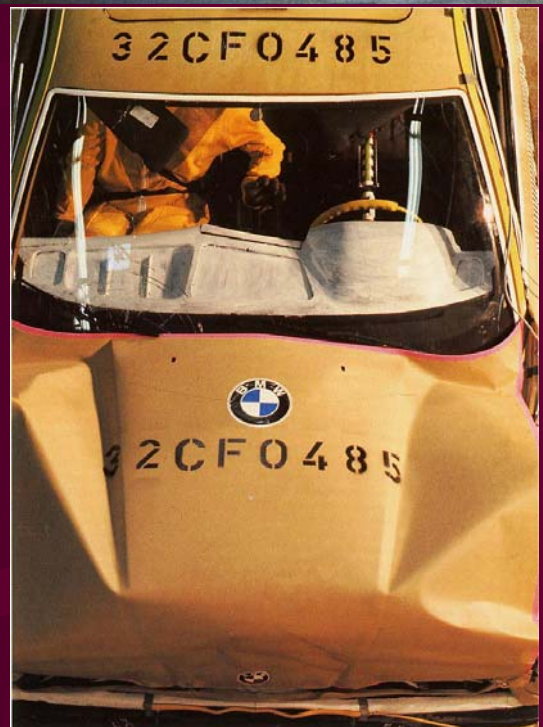
First Prototype Car (Yen 100 million)

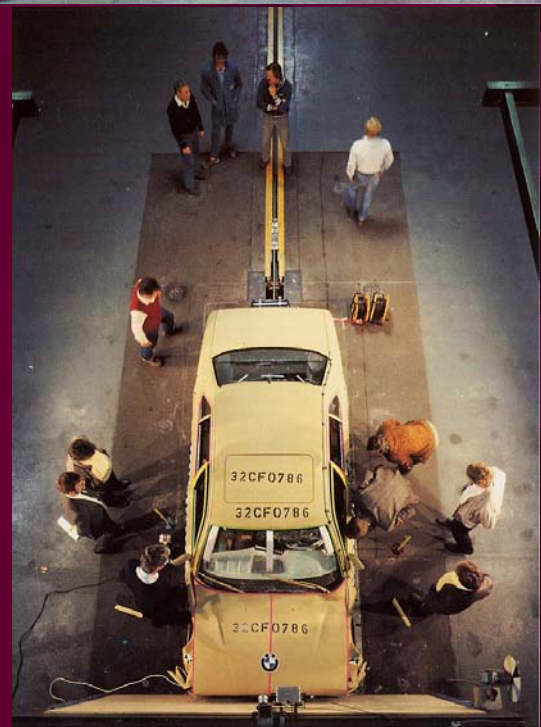
Experiment/Evaluation Using Developmental Prototype Car

Experiment/Evaluation Using Developmental Prototype Car

Experiment/Evaluation Using Developmental Prototype Car (noise test in anechoic room)

Experiment/Evaluation on Collision Safety Using Developmental Prototype Car





(4) Process Engineering

To create information asset of machinery facility, jig, tool, mold, layout, work manual, numerical control, etc. for sake of **mass production**

To be also named "**production preparation**"

To include "**pilot line**" (volume production experiment) and "**start up**" In broader term.

Up-stream/down-stream relationship where the result of a preceding activity (product design) constitutes the prerequisite condition to the succeeding stage (process design)

Both, in actuality, being **duplicating**/interactive in terms of time period

Cooperative activity among companies involving parts makers and facility/mold makers, etc.

Advanced Technology Development

To develop "**element technology**" (technology embodied in parts and material) in advance ("refrigerator")

In case of machine product consist of functional parts, much of "product technology" is buried in an individual constituent part as "element technology".

・・・"**Advanced development**" at the level of parts, separated from a development of an entire product

Example of large computer：
success and failure of a product to determine the feasibility of new element technology

General Model of Innovation

Conceptual model to regard a product innovation as a process of "**information processing**" "**problem solving**"

Three steps:

(1) "**Idea creation**" (problem finding)

(2) "**Problem solving**" (quest for alternative, evaluation)

(3) "**Implementation**" (in commercial production)

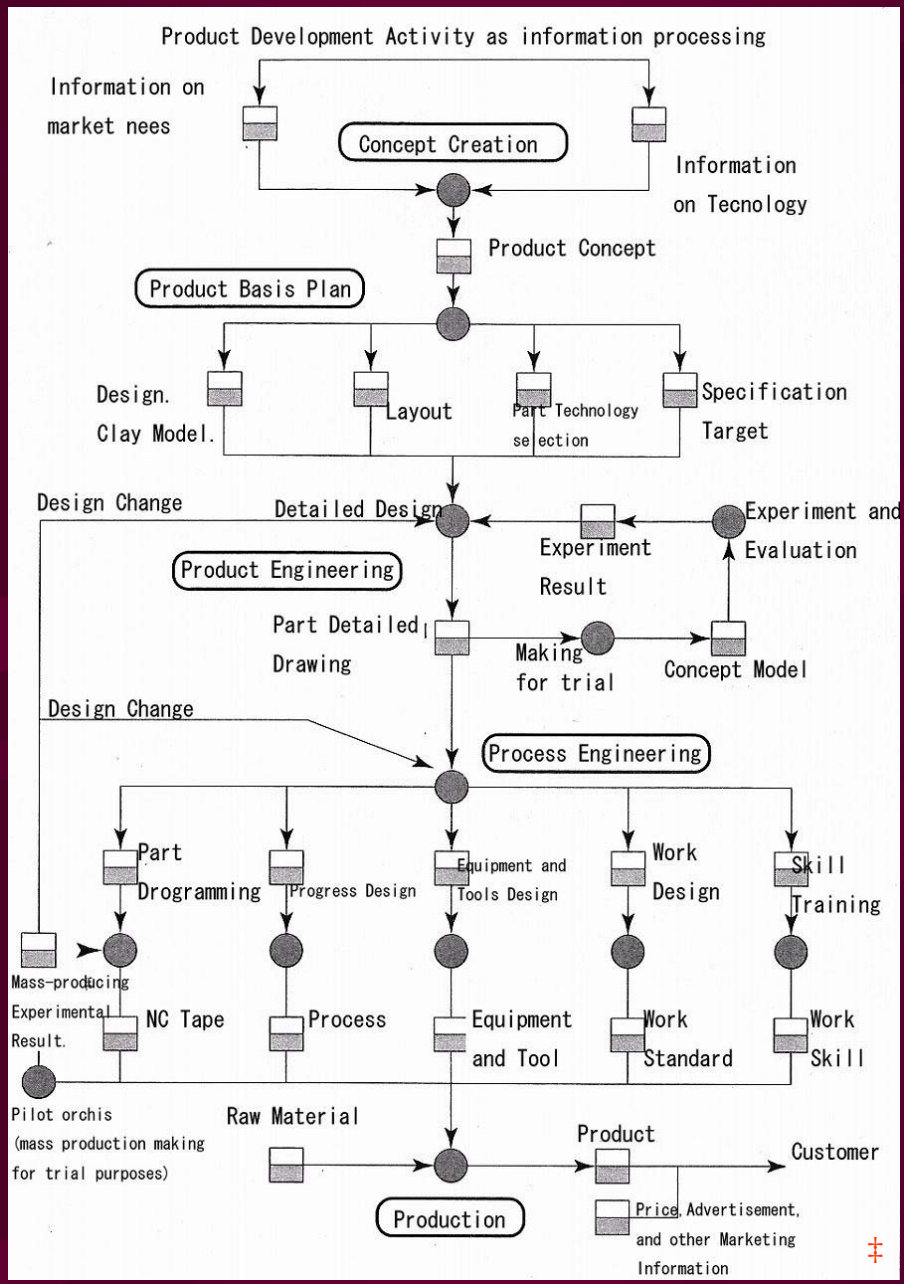
Development Process as System of Information Creation/Information Processing

Product development = "process of **information creation /information processing**"

Integration of knowledge on **market needs** and knowledge on **technological possibility**

To be translated to a group of information stock required for commercial production

"**Single item production of the stock of product design information**"



"Takahiro Fujimoto 'Introduction to Production Management' Nihon Keizai Shimbun, Inc. 2001 (Ⅱp174 figure.13.3)

Development Process as Bundle of Problem-Solving Cycle

Bundle of "**problem solving cycle**" (H. Simon)

Input = **objective** to achieve

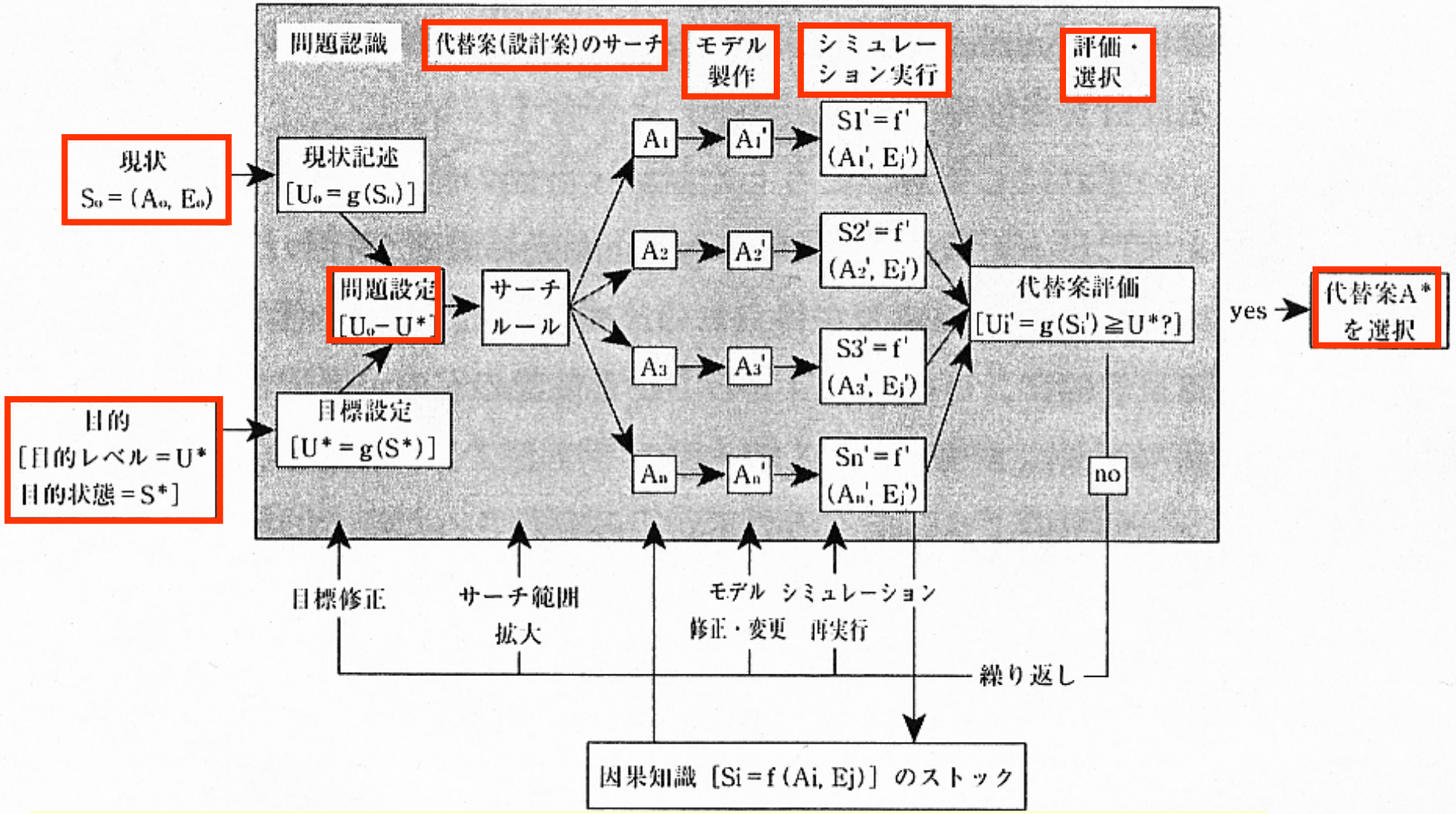
Output = **means** to achieve objective with (solution)

Case where knowledge on cause and effect is inadequate ・・・

to **search** an alternative,

to **simulate** the result of each idea

Standard (in H. Simon model) Cycle for Problem Solving



図中において、U＝効用、S＝状態、A＝人工物、E＝環境、f＝因果関係、g＝効用関係を表す

‡

Takahiro Fujimoto 'Management organization and New product development' Yuhikaku Publishing Co., Ltd. (p.228 figure.3)
Referenct: 'Corporate system of Japan (volume 2)' Yuhikaku

Example: "Product Engineering" of Automobile

Input = targeted performance/specification/style/layout

Detail design information as **an alternative** (drawing and computer file)

Trial manufacturing and **simulation model** based on detail design information (CAE)

Experiment/evaluation of trail model ・・・

Design verification to technically check the achievement of product specification

Confirmation of design validity to evaluate merchantability from the stand point of customer satisfaction

Design change, back in an up-stream, when the objective is not achieved

Product development project = "**multiple bundle of mutually combined cycle of problem-solving**"

Development Process as Simulation

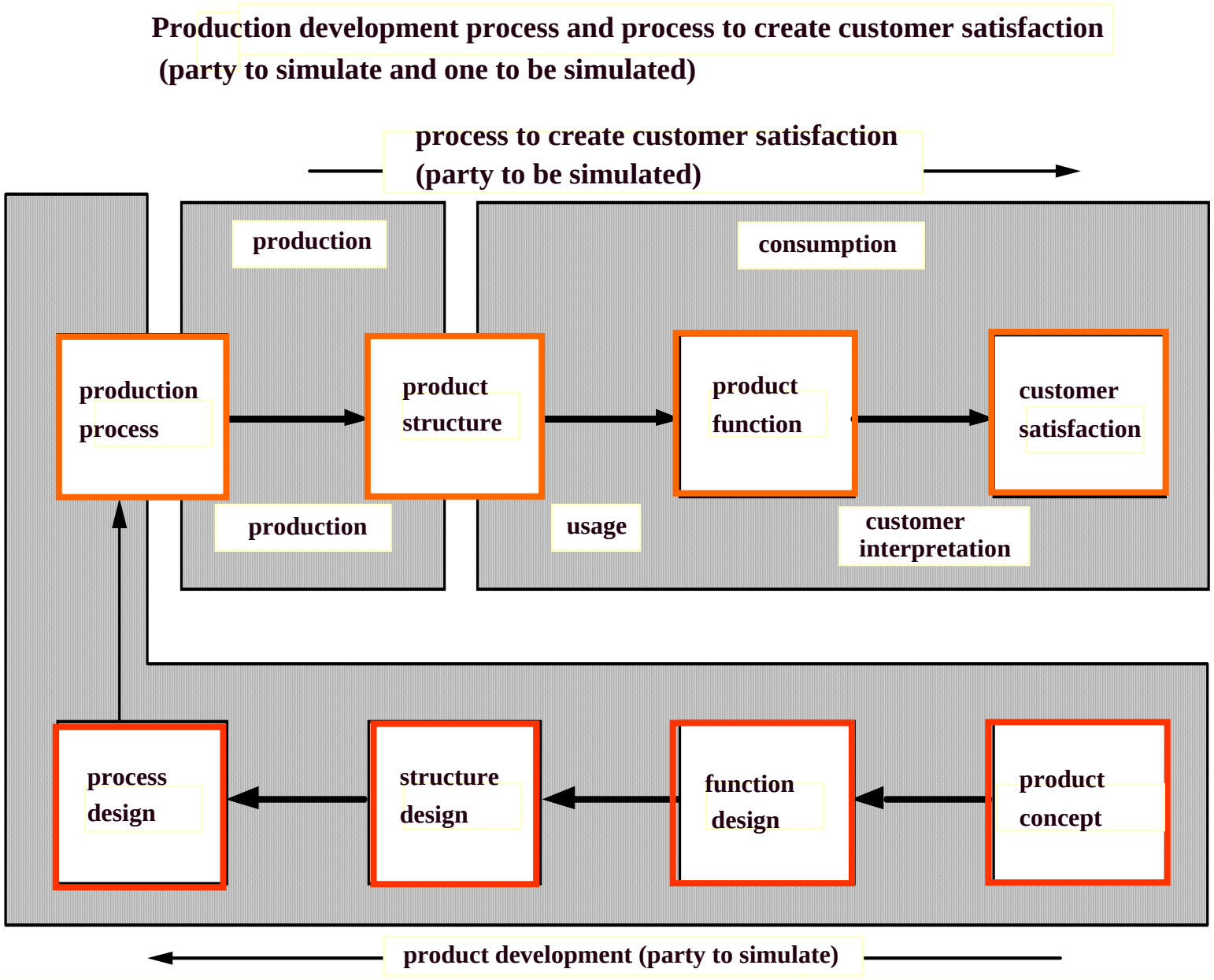
Process of product development is **a simulation of process for generating customer satisfaction** in future.

"Process for generating customer satisfaction" = cause-and-effect chain comprised of **production/sales/consumption**

Product development process =

to simulate in advance process for generating customer satisfaction that has not yet been realized in a form of **adversely tracing back**

Product development is to simulate production/consumption process by adversely tracing it back.



Takahiro Fujimoto 'Introduction to Production Management' Nihon Keizai Shimbun, Inc. 2001 (Ⅱp178 figure.13.6)

Inseparability of Development/Production/Sales Viewed from Information's Aspect

"Competitiveness" =power of influence, held by a bundle of information embodied in a product, onto a customer

Development and production are an inseparable **total system**

Development and production in partnership **transmit an information** via a product as medium **to the market place**

"**Product design information**" is the key to combine development and production

（1） **product development** ＝ **to create** a new product design information by combining market information and technology information

（2） **production** ＝ **to transcribe** product information arrayed in process onto material

（3） sales/marketing ＝ **to** actually **transmit** information embodied in a product, and to convey it to consumers

Thus, the point is a coordinated play among development, production, and marketing.

Development and Manufacturing: Similarities in Pattern

Production (JIT-TQ model)	Development (high speed/ high efficiency model)
pattern of process flow	
▪ frequent set-up change ▪ short throughput time ▪ decrease in in-work product inventory among processes ▪ "one-by-one production" (not batch transaction) of parts from upstream process to downstream process ▪ quick feedback of trouble/problem in downstream process ▪ prompt cycle of solving production problem ▪ activity in upstream process being induced by demand in downstream (pull system)	▪ frequent model change ▪ short lead-time for development ▪ decrease in informational stock among development steps ▪ frequent transmission of information from upstream of development to downstream (not batch transaction) ▪ early discovery of potential problem in developmental downstream, and its feedback ▪ prompt cycle of solving development problem ▪ activity in upstream being motivated by product's release date (request by downstream)
organizational capability	
▪ capability to simultaneously improve quality/productivity/delivery ▪ "capability to build quality in product" to produce salable product without inspection/rework ▪ flexibility to production volume/product mix/model change ▪ productivity increase by broad job assignment to worker (multi-skilled) ▪ worker's capability and mental set being inclined for continuous improvement and prompt problem solving ▪ inventory reduction to forcefully produce information flow for problem solving and improvement	▪ capability to simultaneously improve design quality/development productivity/development period ▪ capability to design easy-to-make product ▪ flexibility to product design, development schedule, and other objective change ▪ productivity increase by broad job assignment to worker ▪ engineer's capability and mental set being inclined for frequent reformation of product/process ▪ reduction in development period to forcefully produce information flow between up/down streams for problem solving

Beyond Dichotomy of Production and R&D

"Emphasis on efficiency in production, flexibility in R&D" ??

"Importance on a group discipline in production, an individual creativity in R&D" ??

"Suitability of a mechanical organization for production, an organic organization for R&D" ??

・・・No.
R&D and production function are, rather than being bipolar, the same spectrum.

Product development = single-item production of information stock

Production system of JIT-TQ Model = improvement (continuous process innovation) being built in

Plenty of similarities can be observed between these two (**s**).

	R&D		Manufacturing	
	basic study	**product development**	**new paradigm (continuous improvement)**	former paradigm (Taylor doctrine)
process/activity	unique	⟷		repetitive
structure of operation	extraordinary	⟷		ordinary
organization	organic	⟷		mechanical
management	gentle	⟷		hard
emphasized value	creative	⟷		efficient
time	long	⟷		short

Reference: Fujimoto/Clark "Product Development Performance" Diamond Co.

3. Organization of Product Development

Development Organization as Joint Problem-Solving Pattern

Contemporary new product development is a collaboration work by plural persons ・・・**joint problem solving**

Product development activity in contemporary companies is mainly "**routine activity**" of high repetitiveness

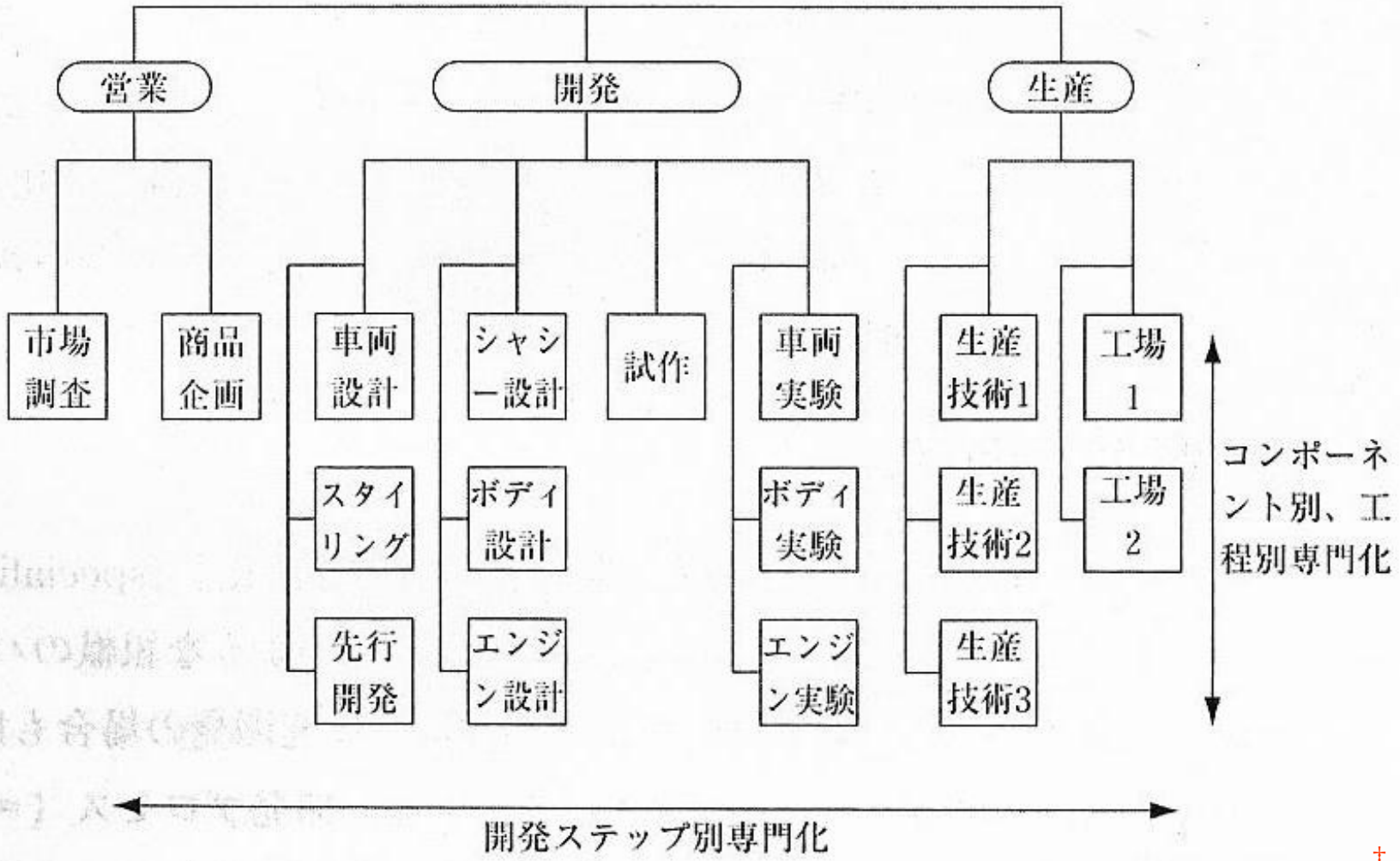
Product development organization contributes itself to a developmental performance through the application of the joint problem-solving routine

(1) **specialization and integration** of developmental organizations on **an individual project level**

(2) integration **among plural projects**

(3) formation and management of a research center group on **a company-wide level** in diversified companies

Dividing Departments in Development Organization: Typical Example of Automobile



Takahiro Fujimoto 'Product Development Organization and Quality of Design of Car' 1987
Reference: 'Histochemistry' Vol.22 No.1

Specialization and Integration

Basic axis of organization design ・・・

"**specialization by department**"

"**coordination among departments**"

(1) **Specialization**：

by developmental stage (by function)

by product group

design department being possibly separated by parts

(2) **Integration**： ・・・cross-departmental organization for inter-departmental adjustment

preadjustment based on **regulation/plan**, etc

vertical adjustment (**hierarchy**)

liaison for inter-departmental adjustment (**liaison**)

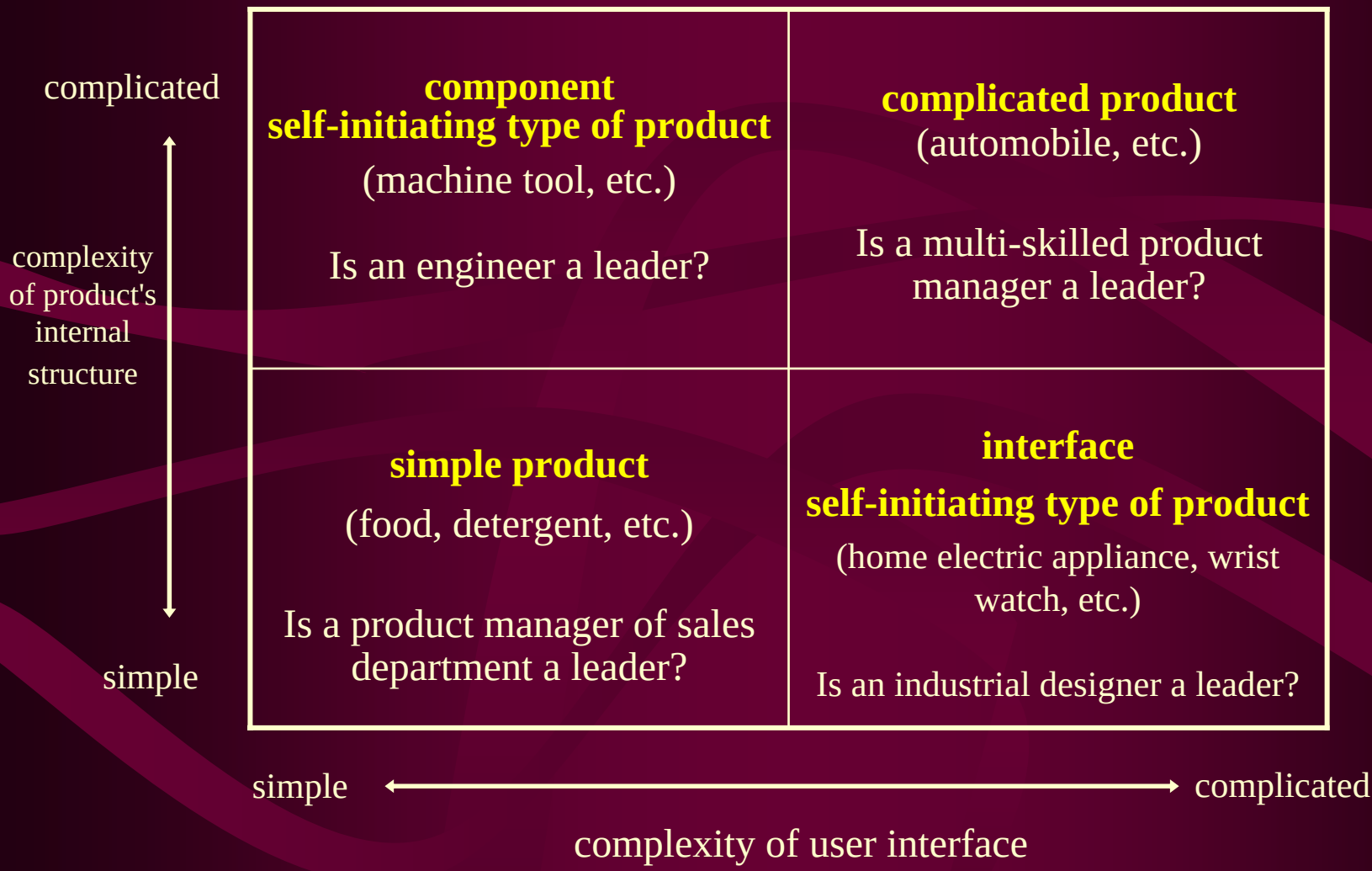
task force (temporary team for inter-departmental adjustment)

project team (organization for inter-departmental adjustment through project)

product manager (role of promoting/adjusting project)

matrix organization

Are a product type and a project-leader type linked?



Reference: Clark, Fujimoto, Product Development Performance, 1991

Characteristics of Japanese Product Development Organization

In 1980s, Japanese manufacturing companies, compared to Euro-American ones, tended to be

lower in the level of **by-department specialization**, and
more advanced in the level of **cross-departmental organization**.

Later, the Japanese-style product development organization characterized by such **wide job range** and a relatively **strong project manager** was dispersed to Euro-American companies, mainly in the automobile industry.

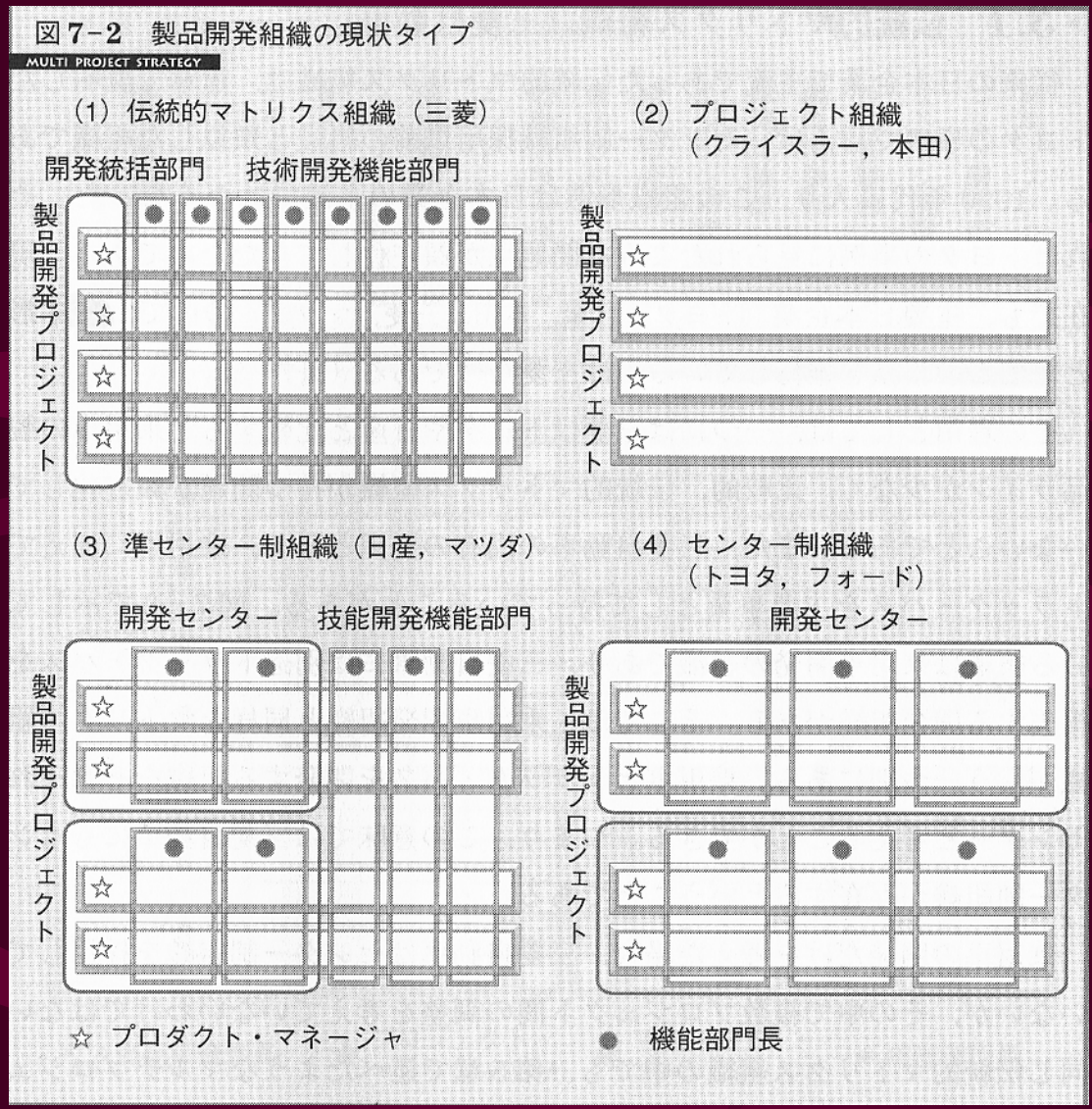
In the product category of "**lapping architecture**", the product development pattern having the **integrated organizational capability** of the Japanese style was the world standard.

Distinction of "**lapping architecture**" vs. "**modular architecture**"

An cooperative adjustment among departments is more important is more important in "lapping (integral) architecture".

Design of Multi-Project Organization (Nobeoka)

It is necessary to proficiently organize and operate a bundle of plural product-development projects ・・・"**multi-project organization**"



Company-Wide Research and Development Organization in Diversified Company

Centralized R&D department on company-wide basis (centralization type), or

Decentralized development organization for each business sector (decentralization type)

Centralized in headquarters ･･･concentration of company-wide R&D capability, promotion of R&D on the cross-business-sector basis avoidance of duplicating investment to R&D among departments

Decentralize by business sector ･･･flexible/prompt response to each sector's request, development structure capable to make small adjustments

The choice is delicate.

Permanent Organization for Development "Does your company have the following organizations?"

item \ number of companies	
(1) planning department	**67.08**
(2) development department in headquarters (mainly in searching new business)	**51.55**
(3) development department in headquarters (mainly in planning/management of technology research)	**62.73**
(4) sales department in charge of development	**18.01**
(5) department concentrated in specially fostering fresh-from-oven new business	**21.74**
(6) technology research center under direct supervision of headquarters	**42.24**
(7) development department of business division (mainly in searching new business)	**40.99**
(8) development department of business division (mainly in design)	**48.45**
(9) research center of business division	**22.36**
(10) special committee to technologically evaluate new product	**34.16**
(11) special committee to economically evaluate new product	**18.63**

[Related question] "Which one on the following is the domestic organization of your company?"

(12a) type of by-product business division	**67.93**
(12b) type of by-region business division	**7.55**
(12c) type of main product by function/minor product by business division	**3.77**
(12d) organization by function	**20.75**

Toyohiro Kawano 'Investigation of actual conditions of new product development (2001.11)'

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Specialization of Basic Research Organization and Development Organization

How to maintain the split of work between **a basic research center** and **an application/development center**?

How to smoothly **transfer** the accomplishment of a basic research center to an application/development center?

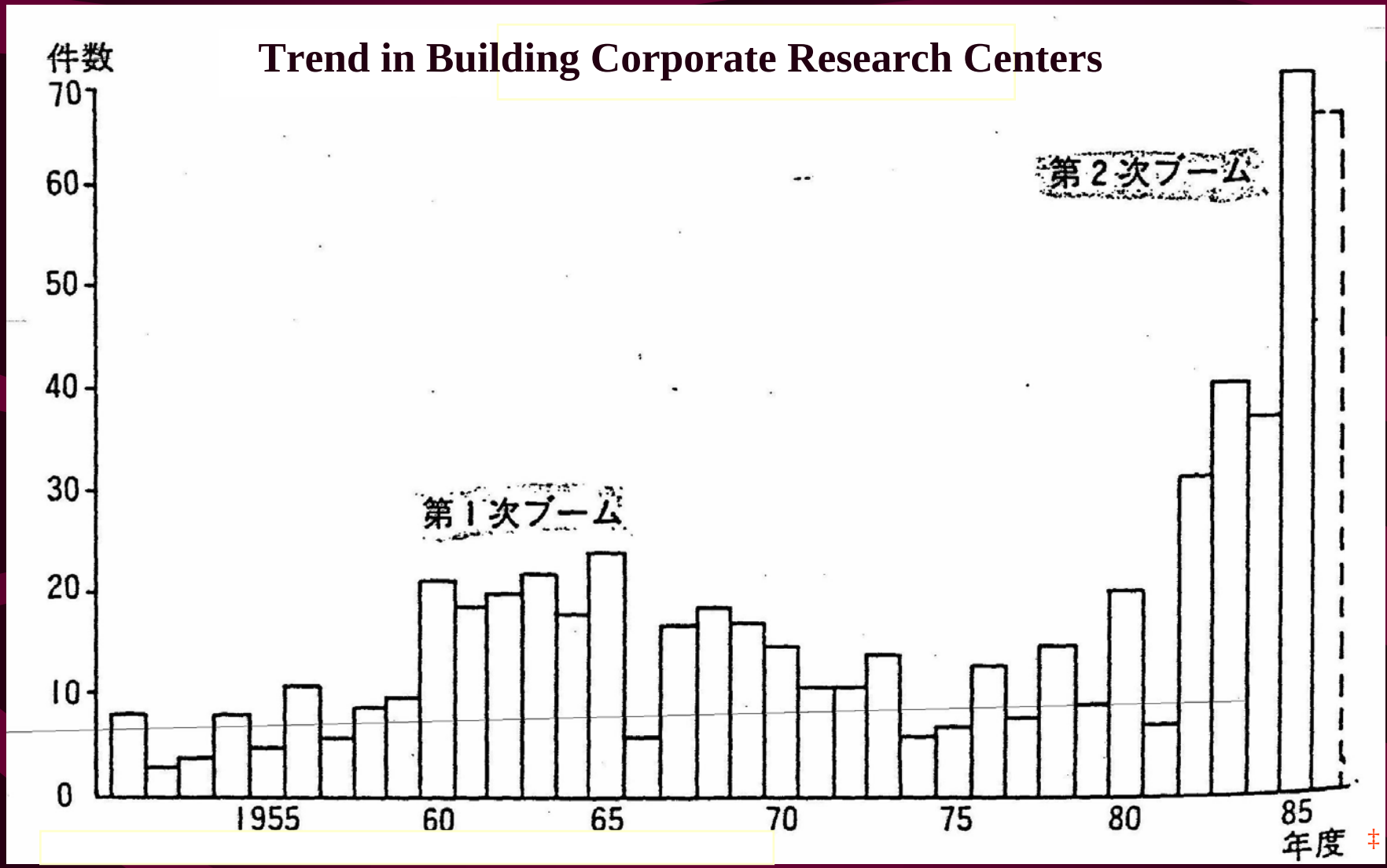
In Japanese manufacturing companies after the war ･･･
in 1960s, "boom in central research centers"
in 1980s, "boom in basic research centers"

Tendency for a basic research center to transform to a facility for an applied research and development

"Drift" phenomenon of a basic research center

Transfer from research to development ･ ･ ･a researcher himself moving to the down stream

Boom in Central Research Centers and Boom in Basic Research Centers



'Agency of Industrial Science and Technology investigation' NIPPON JITSUGYO PUBLISHING 1987..3
Referentce: Such an organization makes the best use of the engineer.

Case of Building Research Centers of Recent Date

	企業名	研究所名	設立年月
食品	雪印乳業	＊生物科学研究所	1983. 5
	エスビー食品	中央研究所	83. 8
	キリンビール	開発科学研究所	83. 9
	サッポロビール	中央研究所	84. 4
	明治乳業	＊ヘルスサイエンス研究所	84. 8
	森永製菓	総合研究所	84.10
	日本冷蔵	＊バイオテクノロジー研究部門	84.12
	森永乳業	＊新技術研究所	85. 7
	味の素	＊基礎研究所	
化学	三菱レイヨン	東京研究所	83.12
	日本触媒化学	ポリマー加工研究所	84. 3
	昭和電工	微粉研究センター	84. 3
	日本油脂	＊筑波研究所	84. 7
	日本化薬	＊生物化学研究所	84. 8
	東洋曹達	樹脂研究所	85. 4
	津村順天堂	薬理研究所	83.12
	第一製薬	中央研究所	84. 4
	大塚製薬	＊バイオ研究所（米国）	84.12
	台糖ファイザー	新薬研究所	85. 2
	山之内製薬	焼津製剤研究所	85. 3
紙	三菱製紙	中央研究所	84.12
	王子製紙	中央研究所	84.12
	山陽国策パルプ	総合研究所	85.10
窯業	旭硝子	電子商品開発センター	85. 5
	東海カーボン	富士研究所	86. 4
非鉄	住友電気工業	米国研究所	85. 1
		＊基礎技術研究所	
メカトロ	三菱重工業	＊基盤技術研究所	
	久保田鉄工	技術開発研究所	84. 7
	日揮	原子力研究所	84. 7
	ファナック	＊基礎技術研究所	84. 9
	ミノルタカメラ	中央研究所	84.10
	小松製作所	新研究所	85. 2
	栗田工業	厚木研究所	85. 4
	キヤノン	中央研究所	85. 4
	メイテック	メカトロ研修センター	85. 6
	アイシン精機	技術本館	85. 7
	日本電装	テクニカルセンター（米国）	86.春
	ノーリツ	＊基礎研究所	
電機・情報	日本電気	＊基礎研究所	82. 7
	シャープ	＊東京研究所	83.11
	東芝	超LSI研究棟	84. 3
	京セラ	東京中央研究所	84. 5
	日立製作所	＊基礎研究所	85. 2
	三洋電機	＊筑波研究所	85.10
	松下電器産業	＊半導体研究所	85.11
	コンピュータサービス	CSK総合研究所	83.12

注：表中の＊印は、基礎的研究を指向した研究所と思われるもの。

Kazuaki Maruge 'Basic Research, what is the problem now?'
Reference: 'Technology and Economics' Japan Techno-Economics Society

What is an optimum distance between basic research and development?

If too close ･･･

A long term research will be crashed by a logic in favor of "competition of tomorrow".

If too far ･･･

An achievement of research won't be reflected on development

4. Performance of Product Development

(1) **Total product strength**

design quality

manufacturing quality

product cost

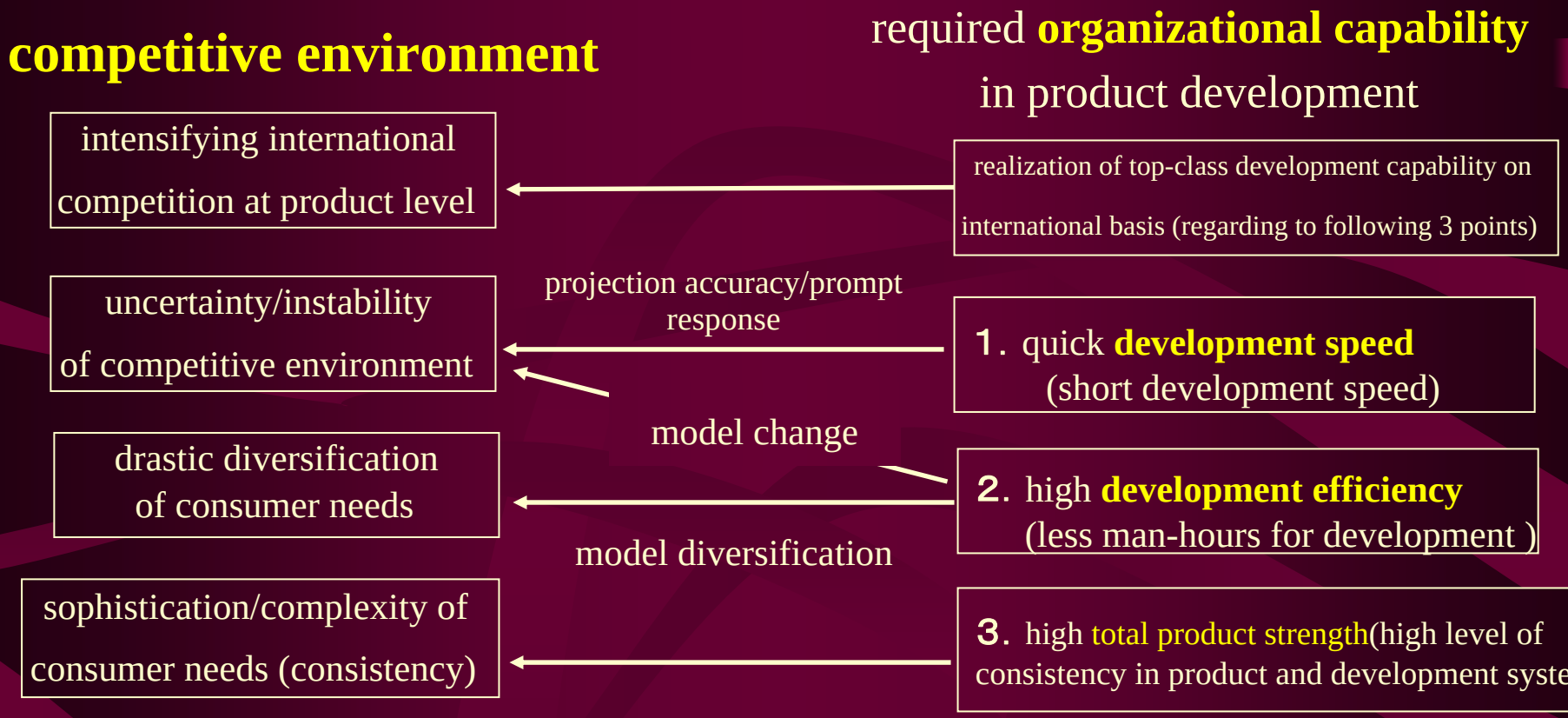
(2) **Development productivity/Development cost**

: volume of resource investment in development sector

(3) **Development period (lead-time)**

: from onset of development to either product release or onset of production

Competitive Environment and Required Organizational Capability in Product Development



"Hitting Average" and Performance of Product Development

There cannot be a 100% success in a new product development

There are always hits or misses in product development activities that are the creative process of design information

New product development
for automobiles ･･･"hit" being less than half
and for pharmaceuticals ･･･one in several thousands

Analogy of baseball

product strength ＝direct impact on a hitting average of a new product

development period and development productivity
＝basic stamina of product development

development period ･･･swing speed
development productivity ･･･to earn an at-bat frequency