Business Administration

Lecture No. 21
Development period and Its Reduction

1. Concept and Purpose of Development Period
2. Constituent of Development Period and Critical Path
3. Method to Reduce Development Period

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1. Concept and Purpose of Development Period

What is a development period (lead-time) ?

Lead-time of development project

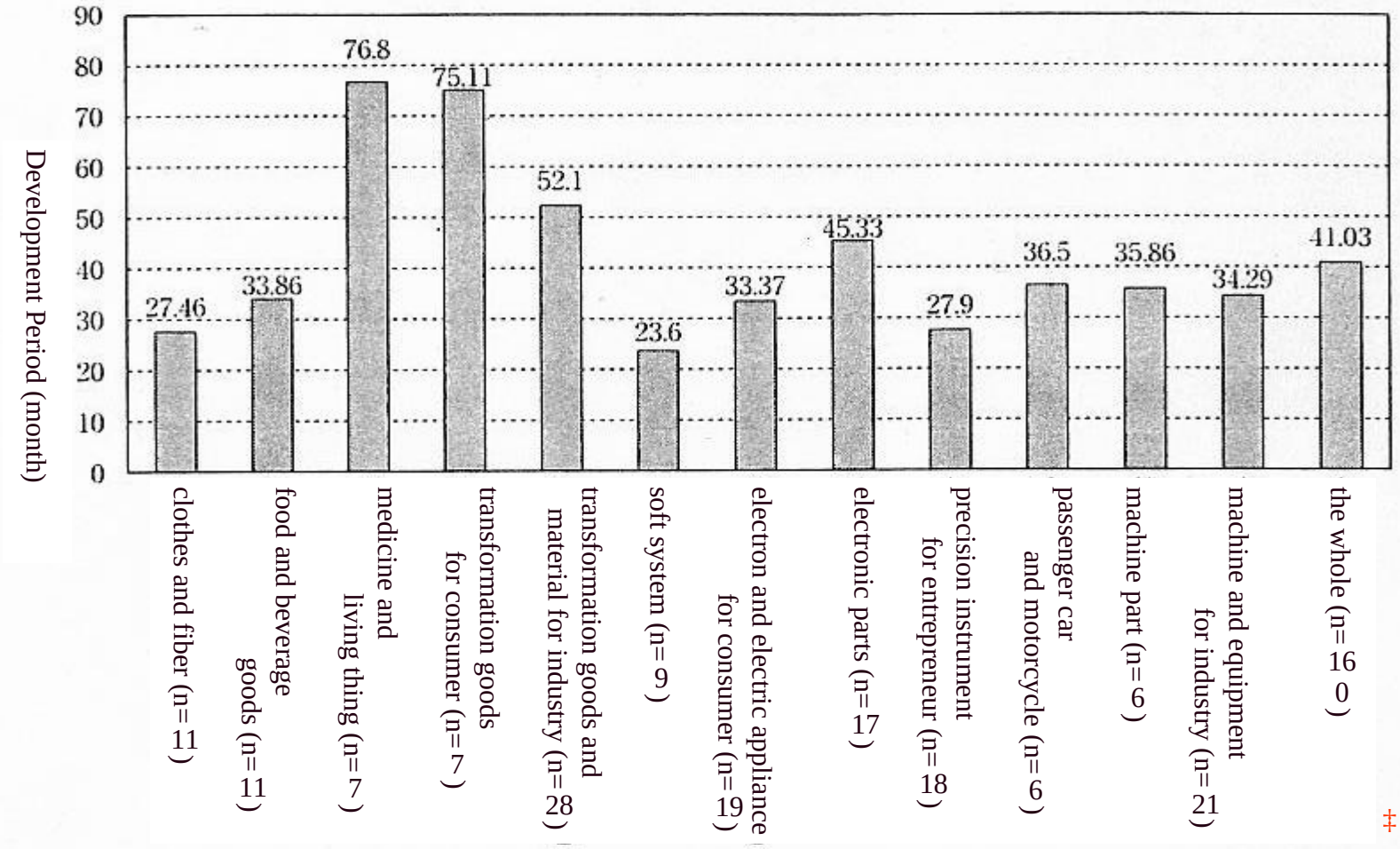
To clarify definition
(definition of starting point and ending point)

Choose a definition according to the purpose of measurement

from start of planning? from approval of plan?
from start of designing?
up to start of production? up to release for sale?

Period From Advanced Development Start to Sales of Main Technology (average by industry/product category)

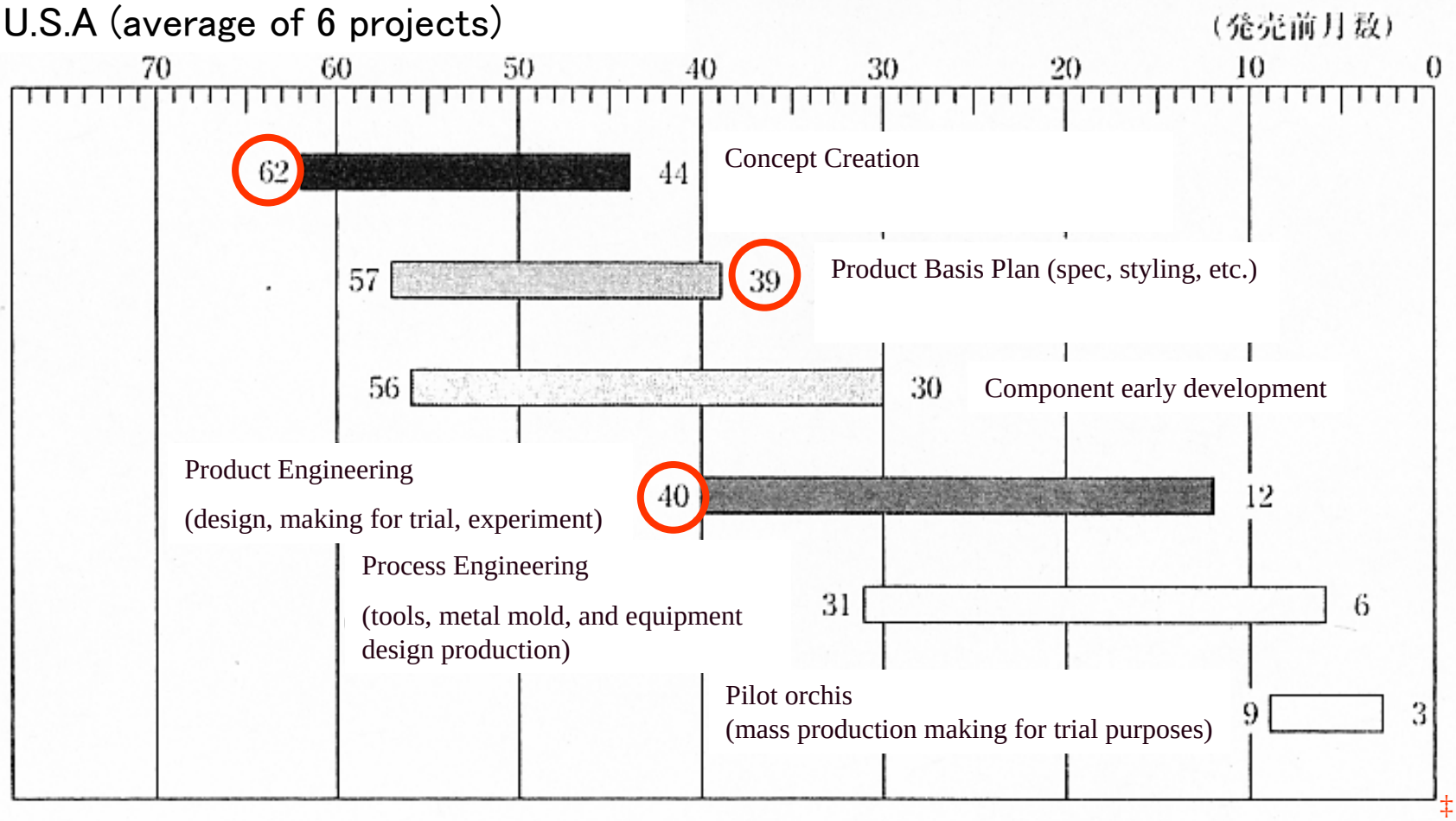
Period from early start of the development of the main technology to sale (industry and average according to product field)



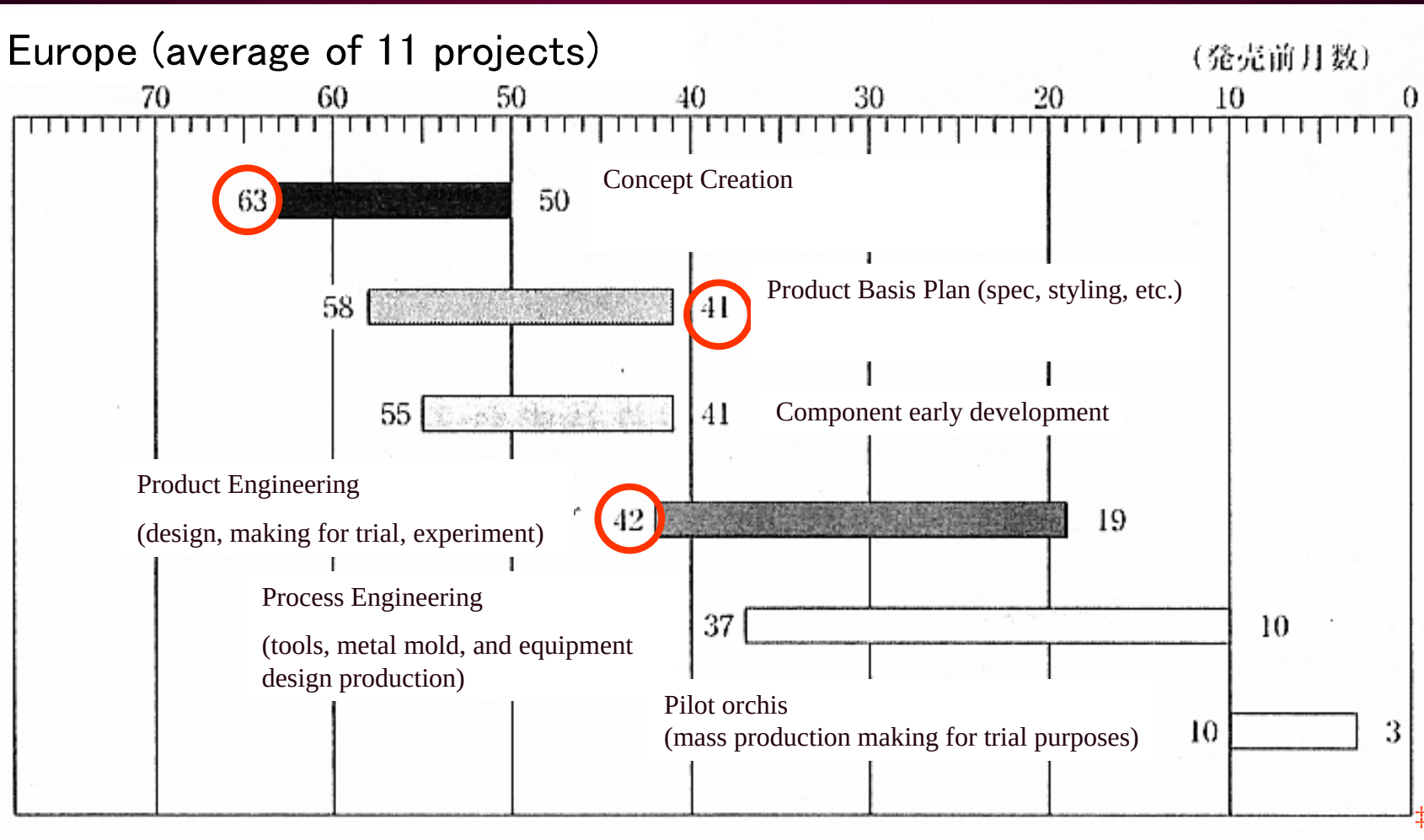
Takahiro Fujimoto, Masanori Yasumoto 'What is the Succeeding Product Development' Yuhikaku Publishing Co., Ltd.

International Comparison of Development Period (before adjustment of project contents)

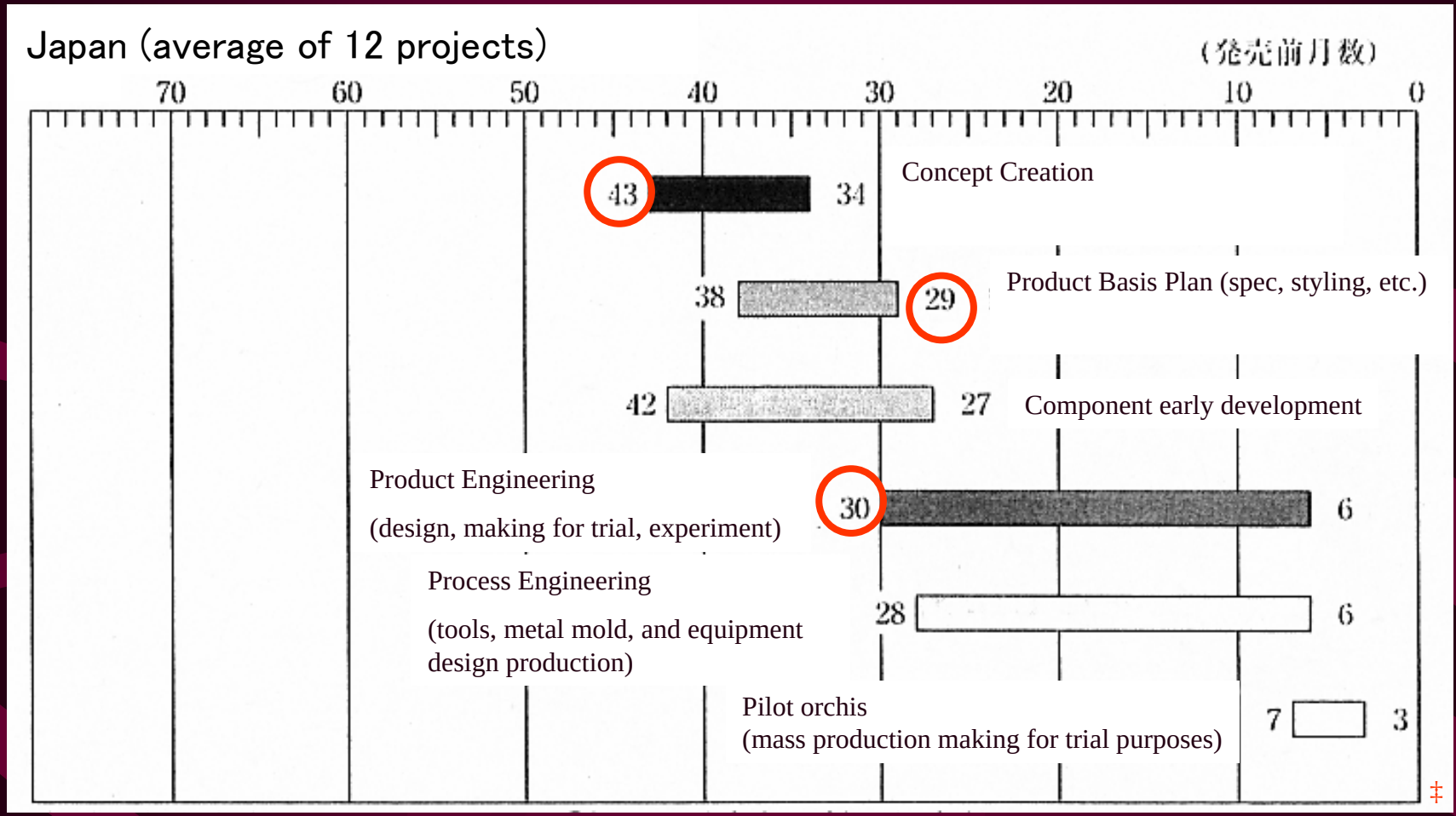
Cross country comparison at development period (Before adjusting the project content)



Takahiro Fujimoto, Clark K.B. 'Product Development Power' DIAMOND,Inc. 1991

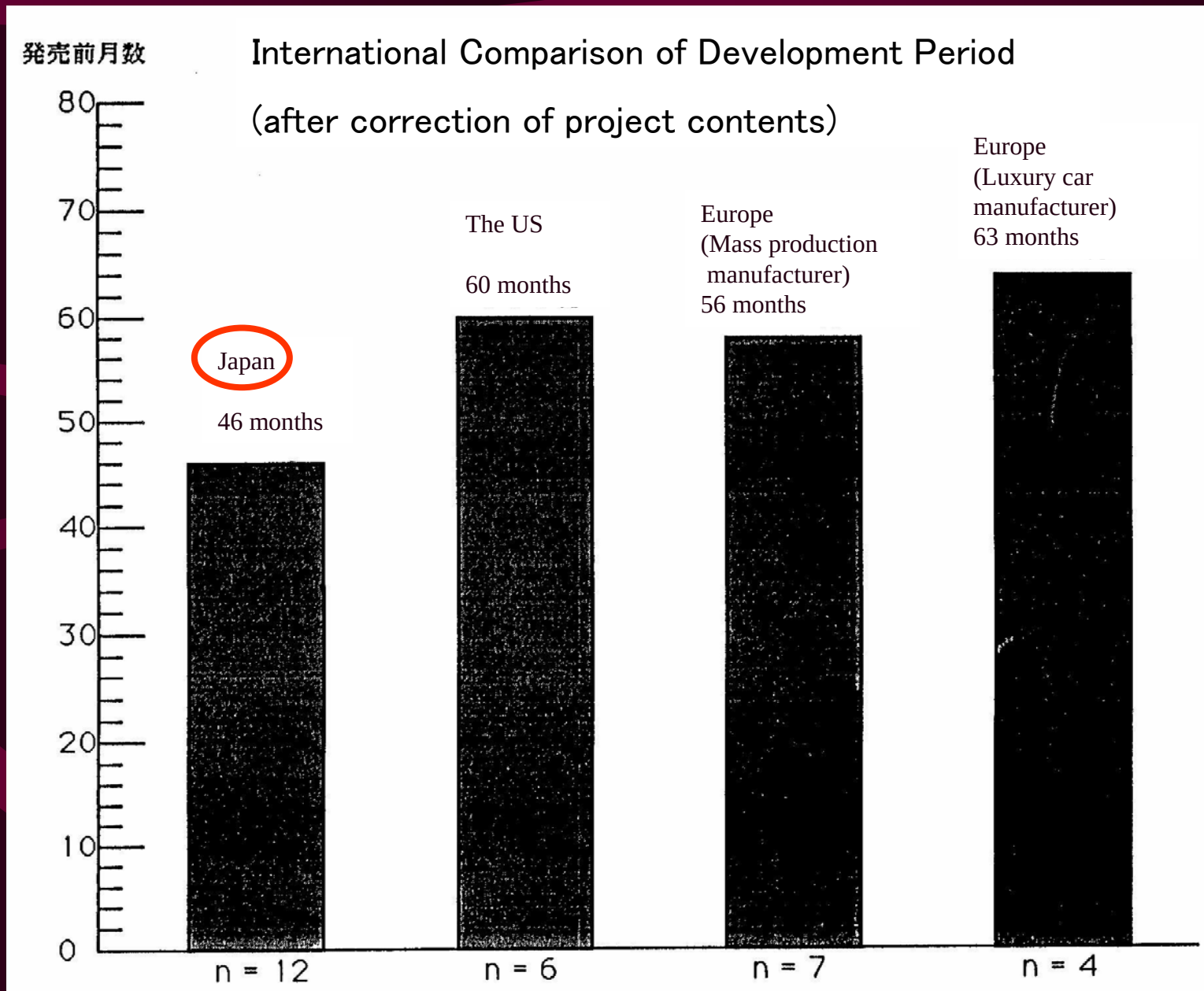


Takahiro Fujimoto, Clark K.B. 'Product Development Power' DIAMOND,Inc. 1991

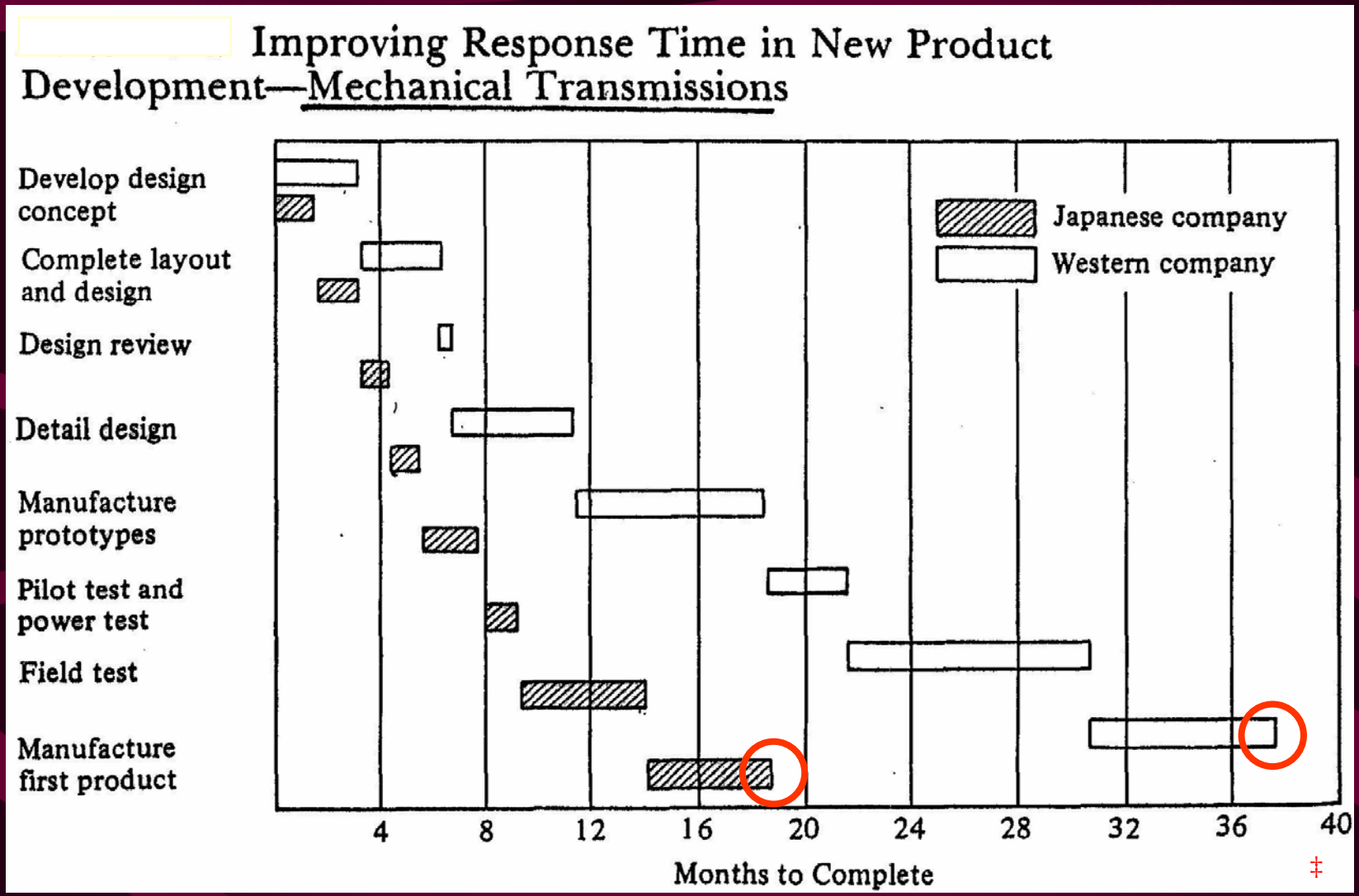


Takahiro Fujimoto, Clark K.B. 'Product Development Power' DIAMOND,Inc. 1991

Development Period of Automobile
(from start of planning/ after correction)



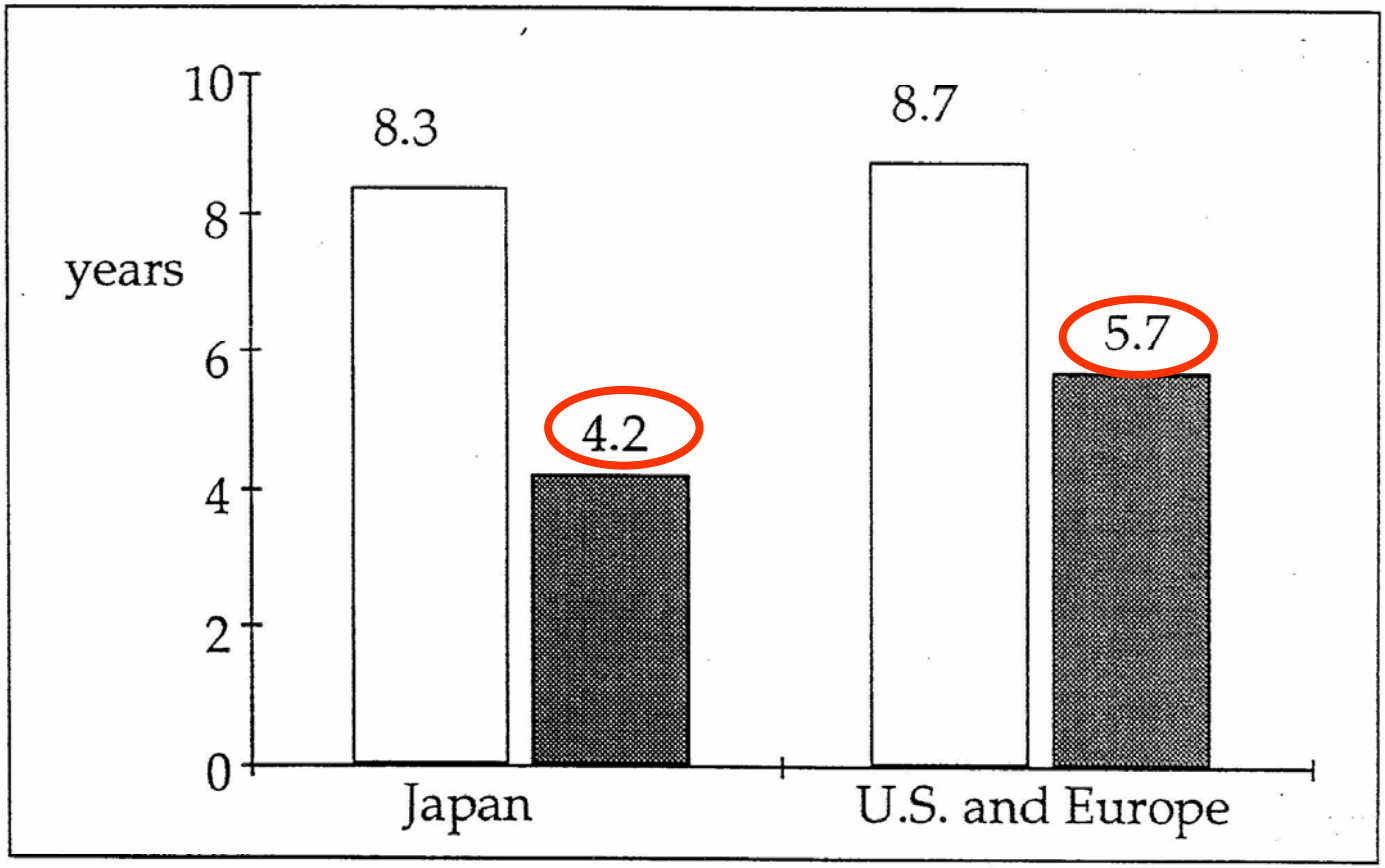
Development Period of Transmission for Auto



George Stalk Jr., Thomas M. Hout 'Competing Against Time : How Time-based Competition is Reshaping Global Markets' Free Press 1990.3

Engineering Lead-Time of Supercomputer Module

Empirical Results: Lead Time



scientific exploration to market

development to market

Entire sample; not adjusted for content.

Purpose of Shortening Development Period

Shortening delivery （in case of customized product）

Profits of antecessor ： new product launch to take the initiative

Quick counterattack ： quick retrieval to a rival's offensive

Accurate market projection ：
to improve the accuracy of success in product planning

Period shortening → reduction in development man-hours
→reduction in development cost（for more at-bat frequency）

Secondary effect of the capability building to shorten lead-time
（DFM, etc.）

2. Constituent of Development Period and Critical Path

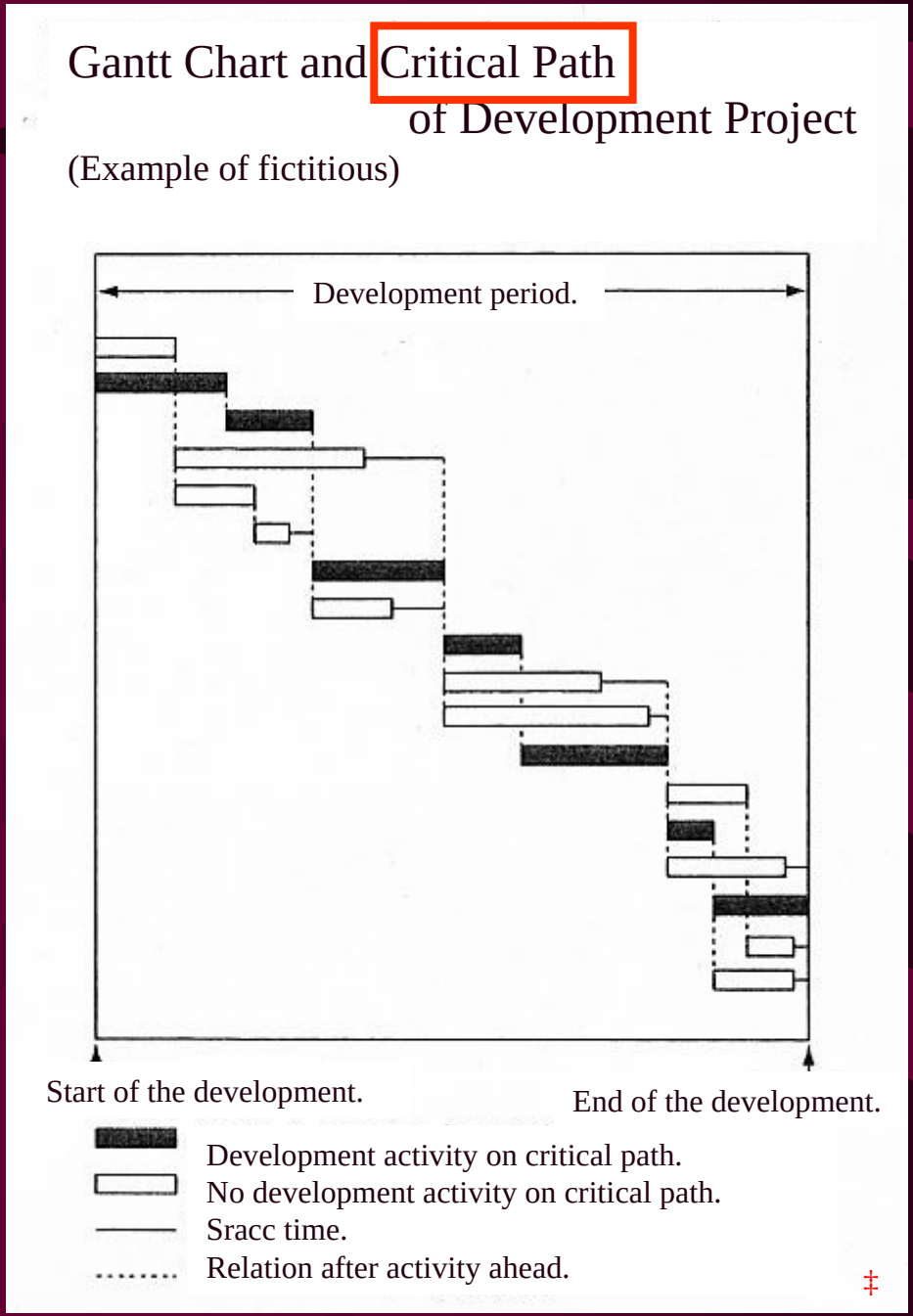
Development project = a bundle of activities for developing a specific product

Development lead-time ≠ Σ lead-time of development activities

Development lead-time = Σ lead-time of activities on critical path

Way of searching critical path ・・・ CPM／PERT

Gantt chart of Development Project and Critical Path (hypothetical example)



Takahiro Fujimoto 'Introduction to Production Management' Nihon Keizai Shimbun, Inc. 2001 (Ⅱ p198 figure.14.5)

Systematic Method for Finding Critical Path
・・・CPM and PERT

CPM (Critical Path Method)

Developed in 1957 by Kelly (Remington-Rand Inc.) and Walker(DuPont)for the schedule management of a science plant repair.

PERT (Program Evaluation and Review Technique)

Developed in 1958 by the U.S. Navy special project office for the management of Polaris missile project.

Procedures (CPM)

1 Specify the activity which constitutes a project.

2 Decide sequence of activity and describe by network.

3 Estimate the time required of each activity:

for CPM, an expected value

for PERT, the three values being an optimistic value,
a pessimistic value, and one most likely to be

4 Find the critical path.

to calculate following four times in each activity

ES (Early Start Time) : accumulate the activity time from the start

EF (Early Finish Time) : add to ES the time required of the activity

LF (Late Finish Time) : calculate back from an end point of the project

LS (Late Start Time) : deduct from LF the time required of the activity

Fine the activity in which slack time (LF−ES or LS−ES) is zero.

This is the critical path.

5 Take measures to shorten the critical path.

3. Way of Shortening Development Period

To realize, in essence,

"quick and early problem discovery/problem solving"

Multilayer/systematic approach

Compressing (with all strength, without changing the structure of process)

Repetitive reduction (repetitive reduction of design change etc.)

Switching of mode (to switch to the virtual mode of short cycle)

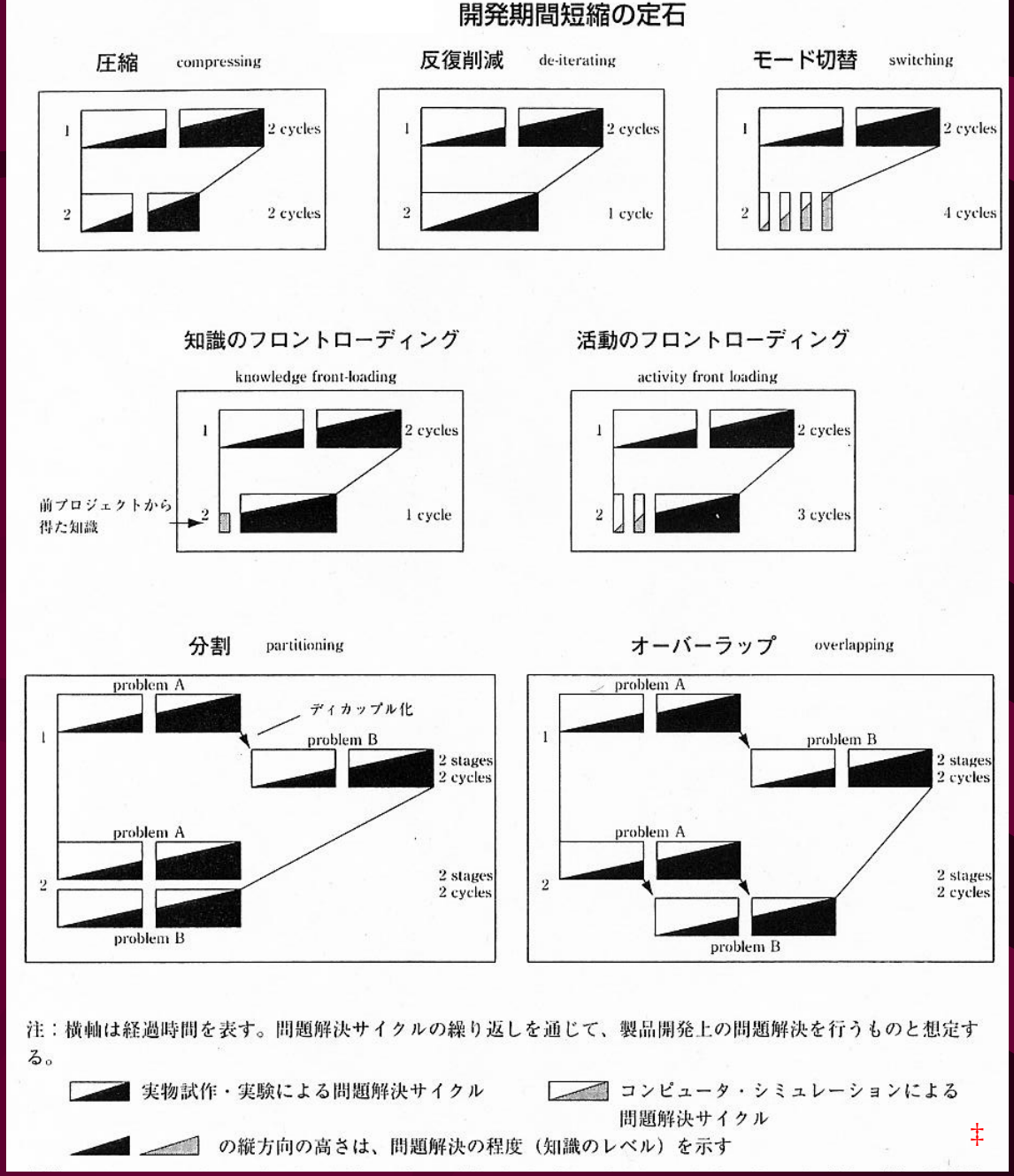
Front-loading of knowledge (to transfer of the solution information of a former project)

Front-loading of activity (by moving up virtual simulation)

Partitioning/advancing of task
(to dissolve the interdependence of task, and then to advance)

Overlapping
(to overlap while maintaining the information connection between up-stream and down-stream)

Standard Tactics for Shortening Development Period



'Fujimoto,T.Shortening Lead Time through Early Problem Solving －A New Round of Capability-Building Competition in the Auto Industry' Nihon Keizai Shimbun, Inc.

Reference: Takahiro Fujimoto 'Introduction to Production Mmanagement' Nihon Keizai Shimbun, Inc. 2001 (Ⅱ p202)

Concrete Method of Period Shortening

(1) Speedup of each activity on critical path

① additional injection of staffs

② speeding up of
"manufacturing activities embedded in development"

③ use of CAD-CAM-CAE

(2) Synchronization of activities on critical path

① task partitioning

② overlapping-type problem solving

（1－1）

Additional Injection of Staffs（batteries of manpower）

If development activity is

divisible and independent・・・

→period shortening can be carried out
in partitioning and parallel of work.

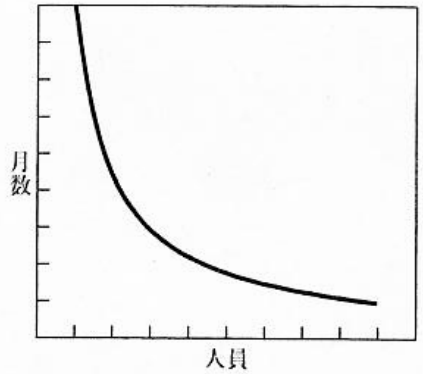
However, in practice・・・

Mythical Man-Month（Brooks）

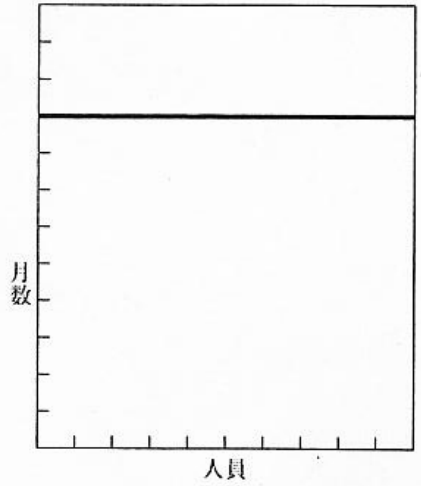
Number of Injected Staffs, and Development Period

投入人員数と開発期間

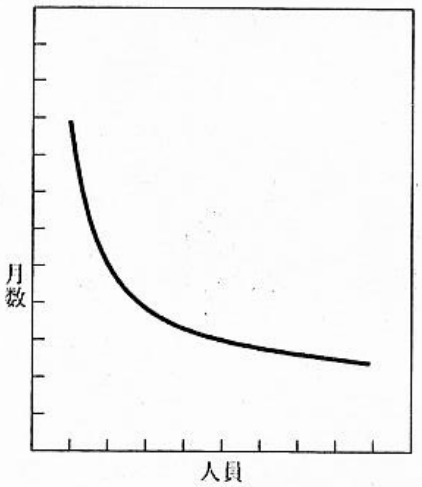
1. The development can subdivide. And, it happens of between work having assumed that there is no necessity the adjustment.



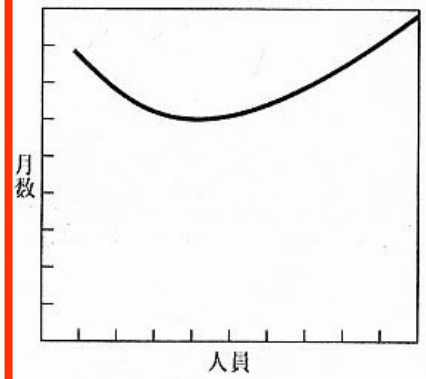
2. It is a case that cannot differentiate again as for the development.



3. When the load of the adjustment and the communications between work hangs.



4. Case where development period is rather extended for adjustment and the communications between work.



'Brooks,Jr,F.The Mythical Man-month, Addison Wesley' Nihon Keizai Shimbun, Inc.
Reference: Takahiro Fujimoto 'Introduction to Production Mmanagement' Nihon Keizai Shimbun, Inc. 2001 (Ⅱp206)

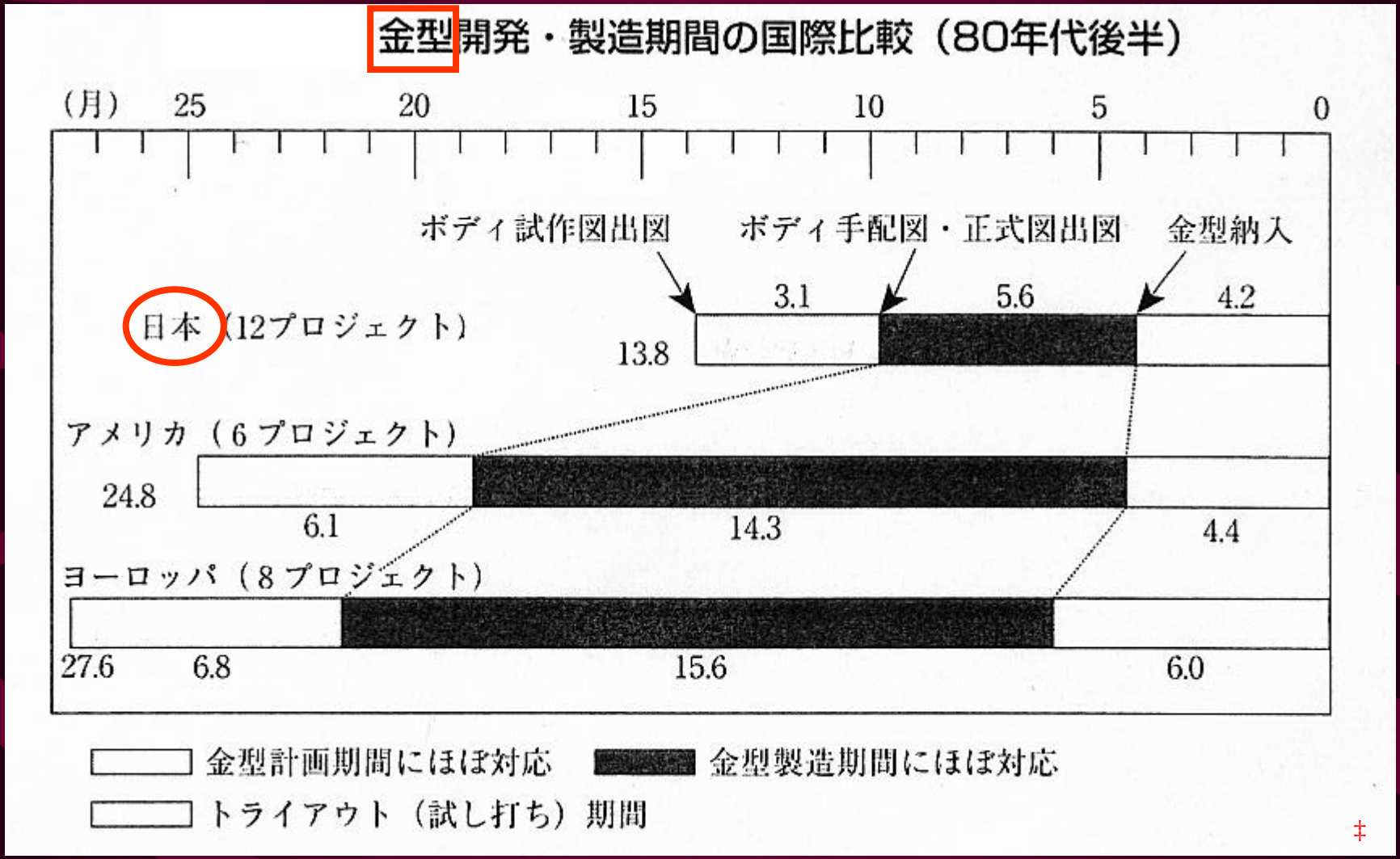
(1－2)
Speeding Up of “Manufacturing Activities Embedded in Development”

Speeding up of trial production

Shortening of metal mold development period

Speeding up of mass-production launch , etc.

International Comparison of Metal Mold Development / Manufacturing Period (second half of the 80s)



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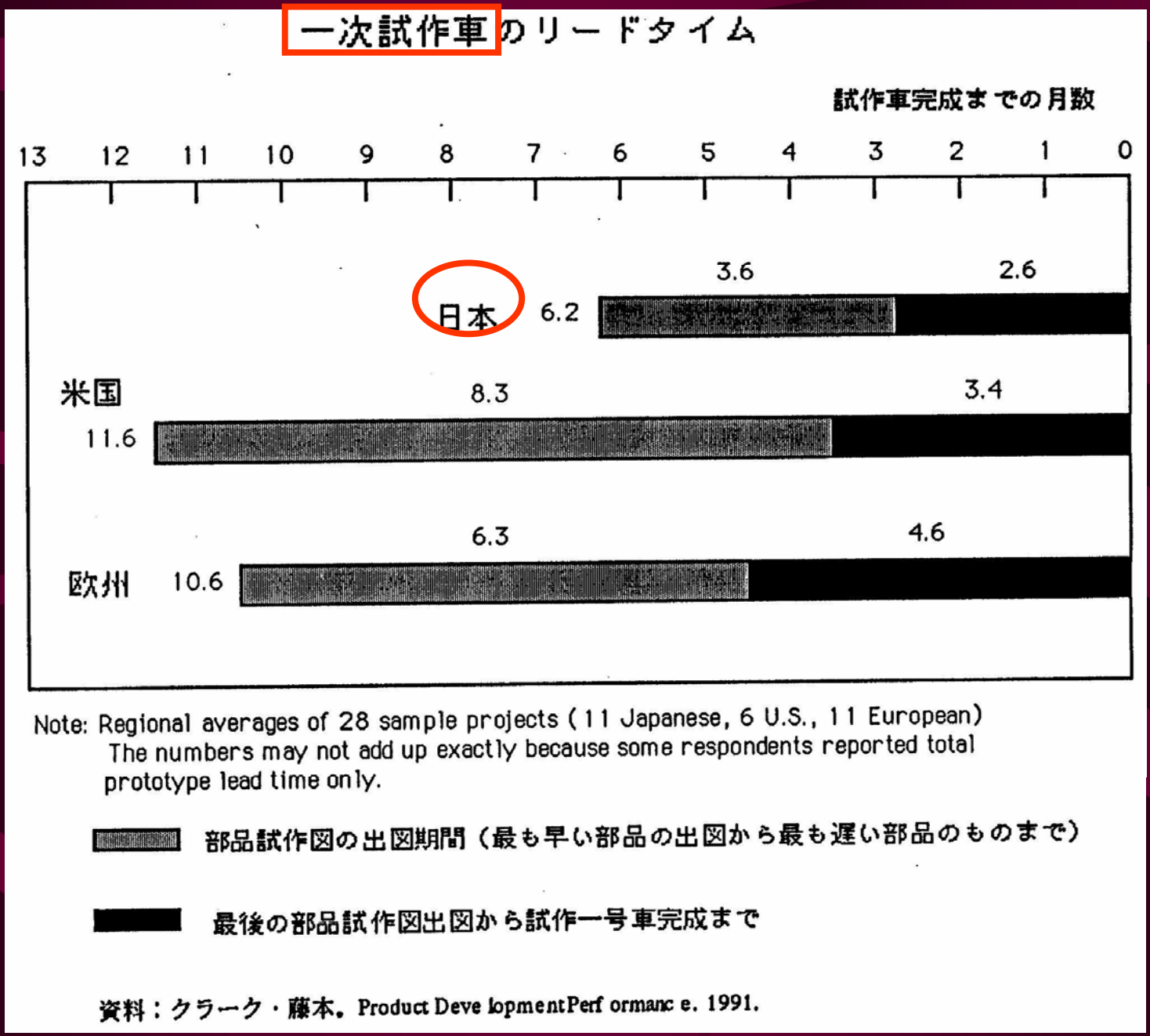
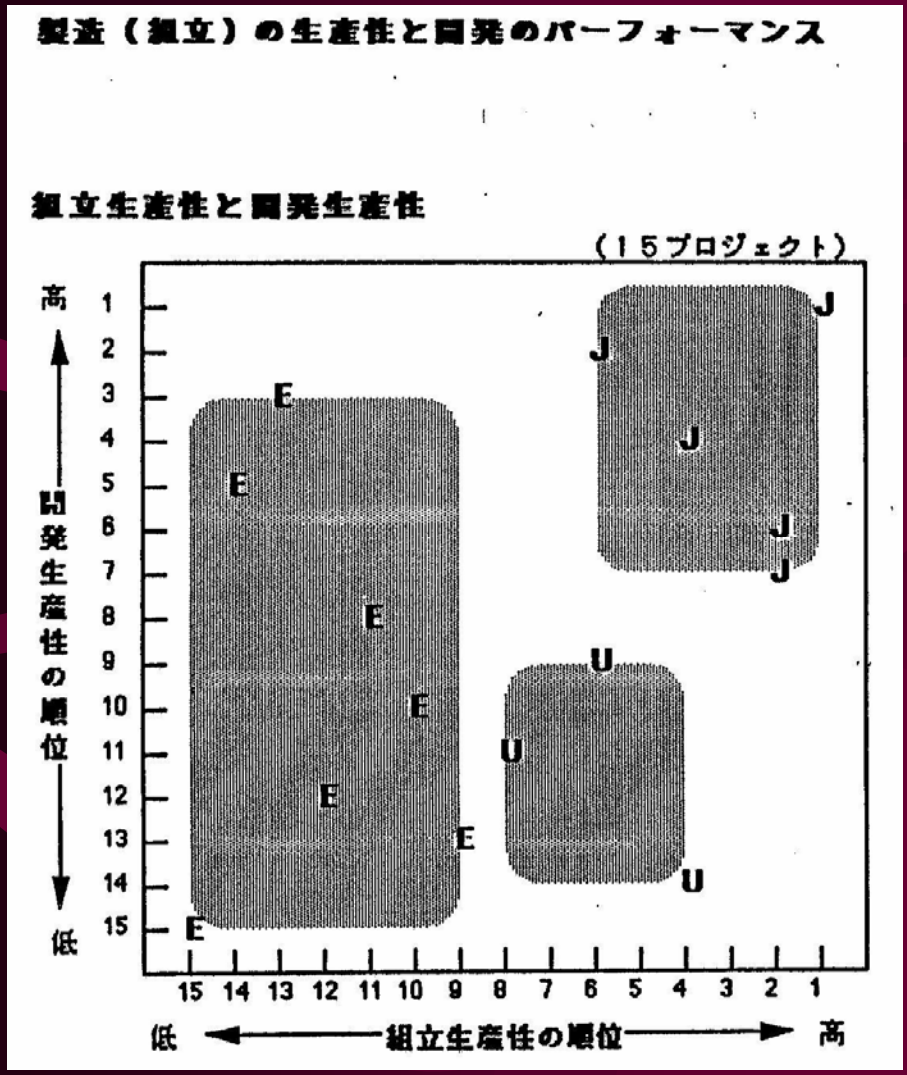
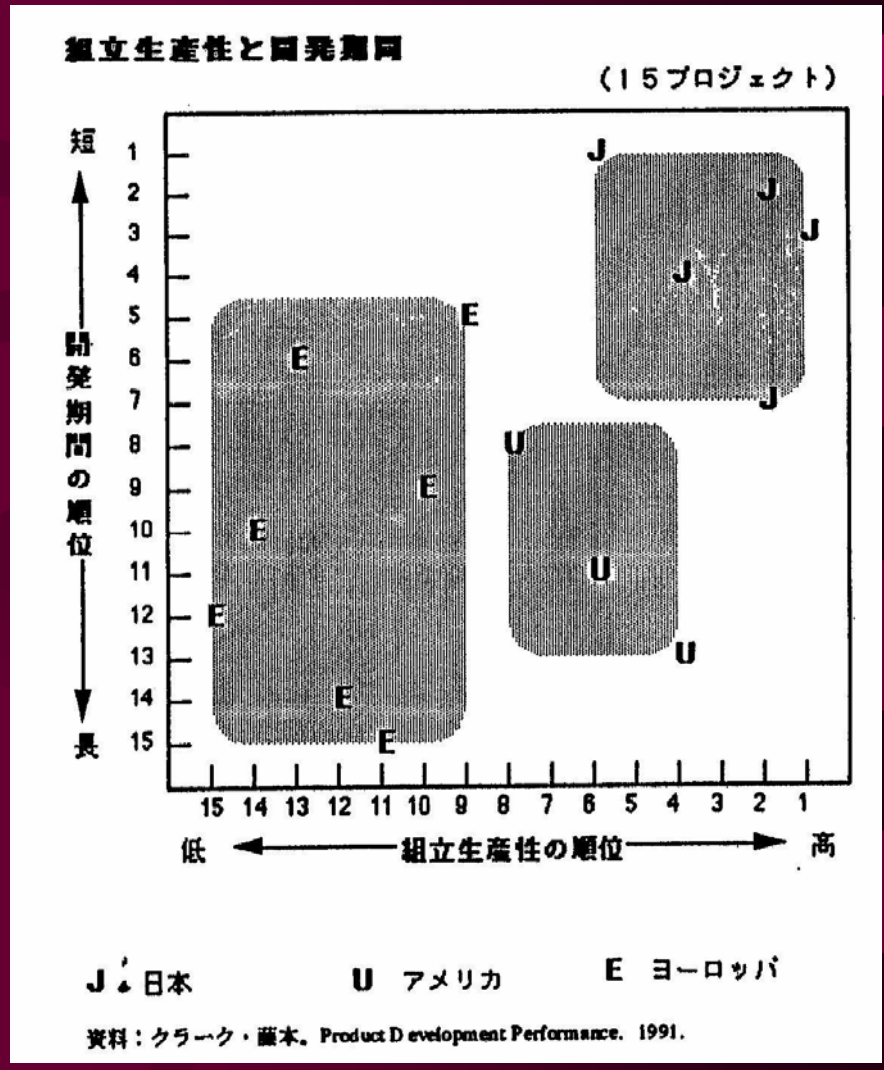
Lead Time of 1st Stage Experimental Car



Competitive Power of Development and Competitive Power of Production: likely to be linked





（1－3）Use of CAD-CAM-CAE

CAD （product design with computer support）

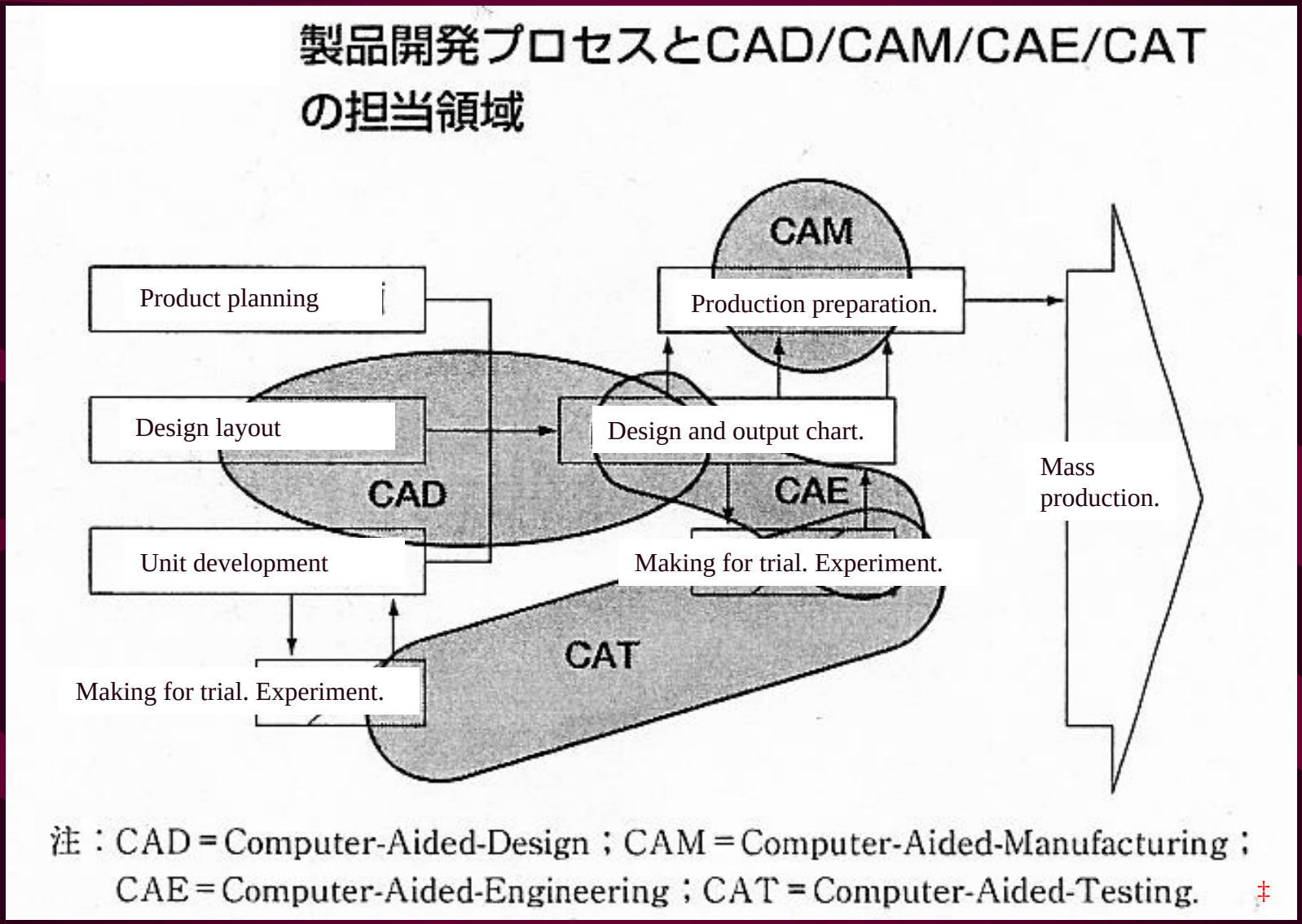
CAM （metal mold manufacturing with computer support）

CAE （test evaluation with computer support）

Expected result

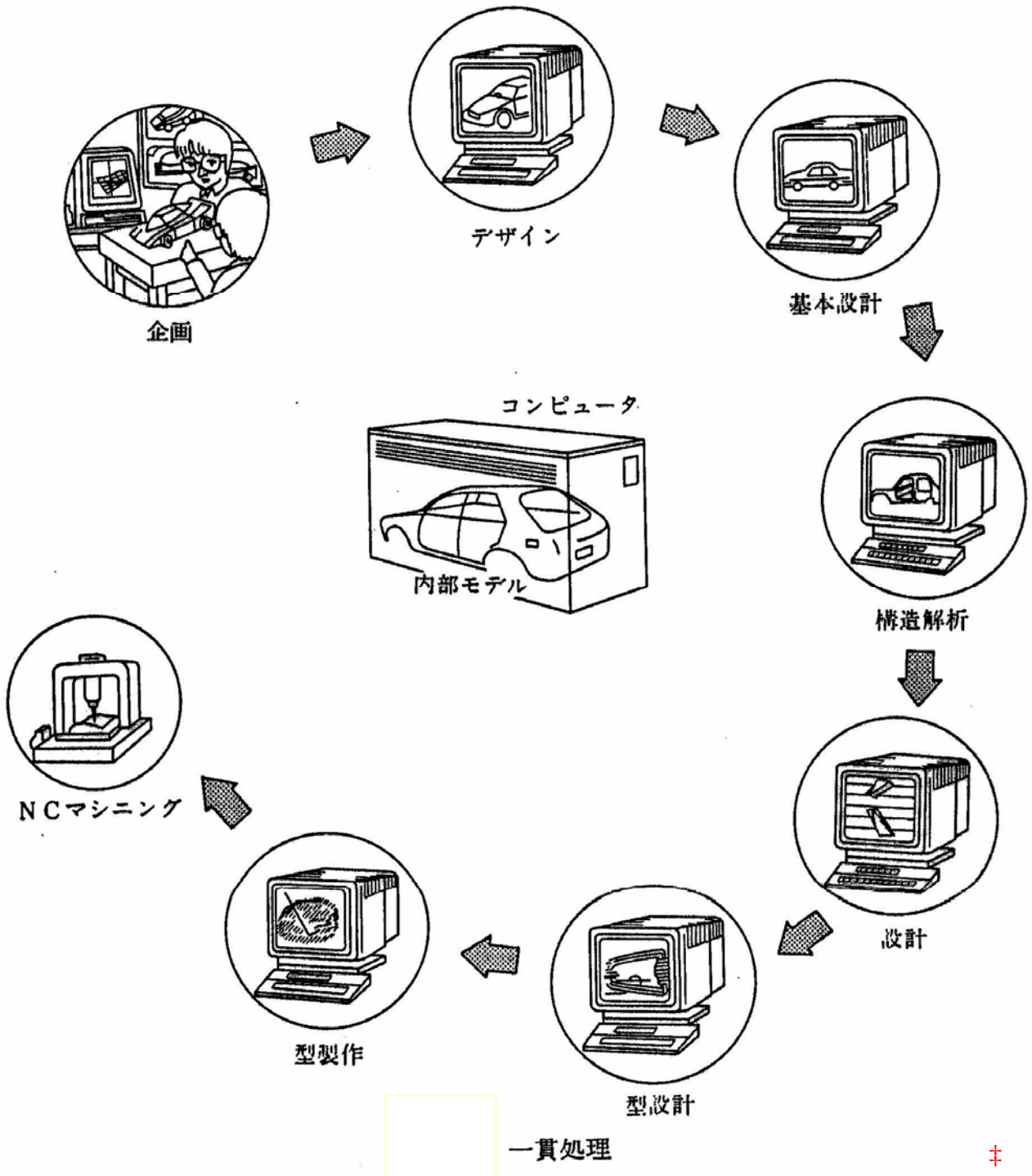
Speeding up of design activities
Omission of part of development activities
Speeding up of simulation (checking before trial production to become possible)
→front-loading (to “advance” problem solving)
examples: parts interference, collision experiment

Product Development Process and Domain of CAD/CAM/CAE/CAT



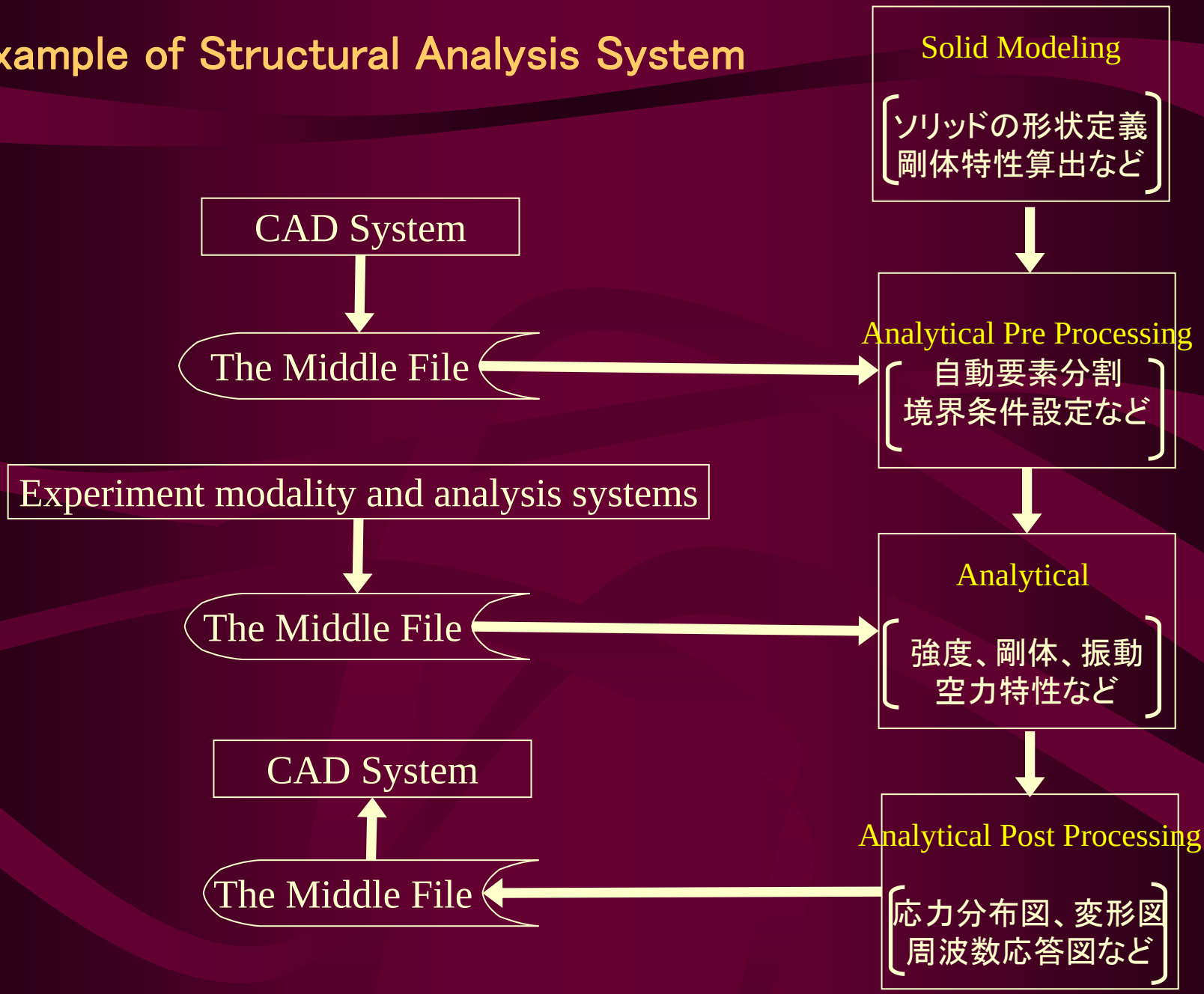
Shohachiro Takahashi 'CAD/CAM of Matsuda' Kogyo Chosakai Publishing. Co., LTD. 1985

Unification of Data (Product Model)



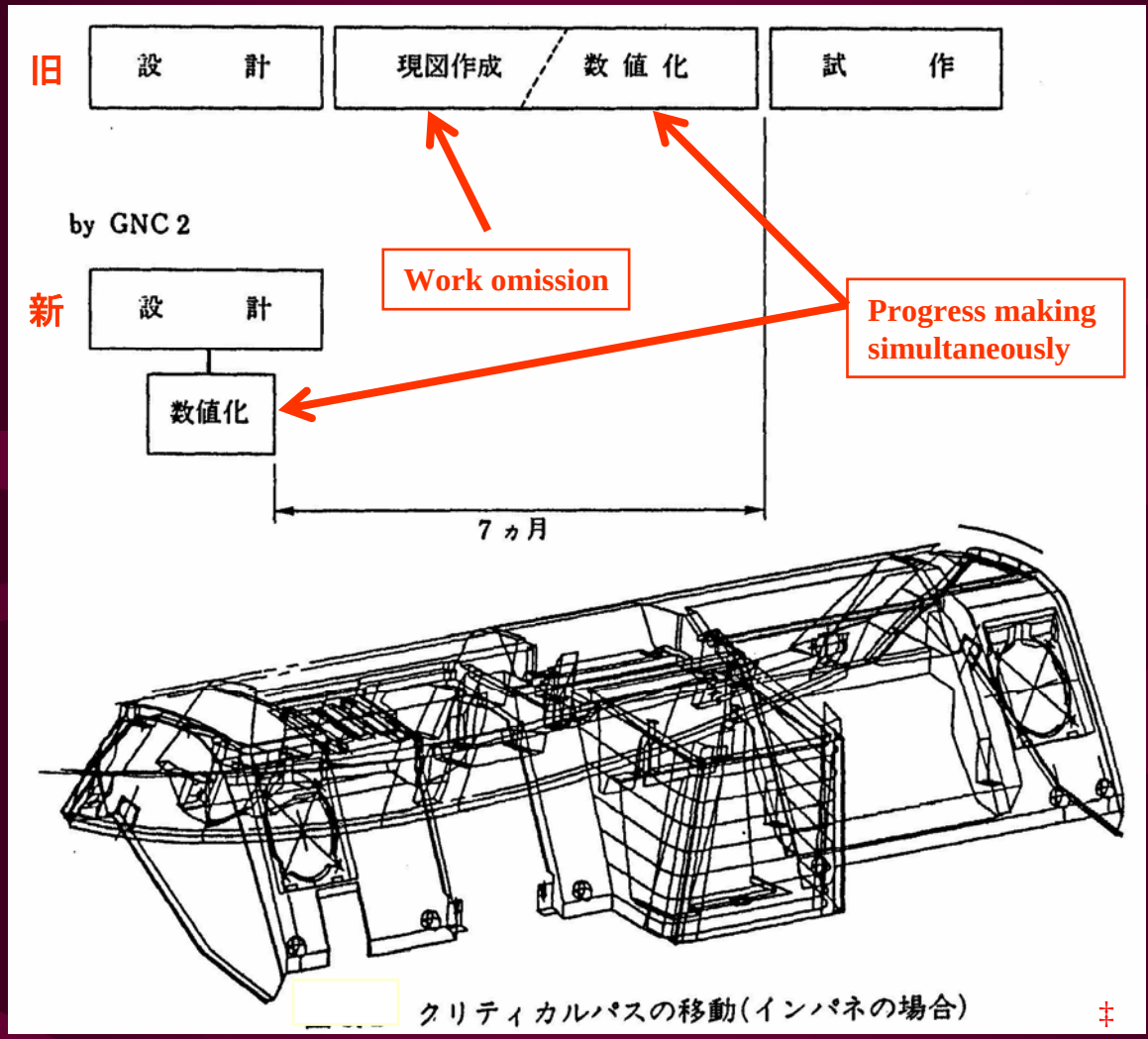
Shohachiro Takahashi
CAD/CAM of Matsuda'
Kogyo Chosakai Publishing. Co., LTD.
1985

Example of Structural Analysis System



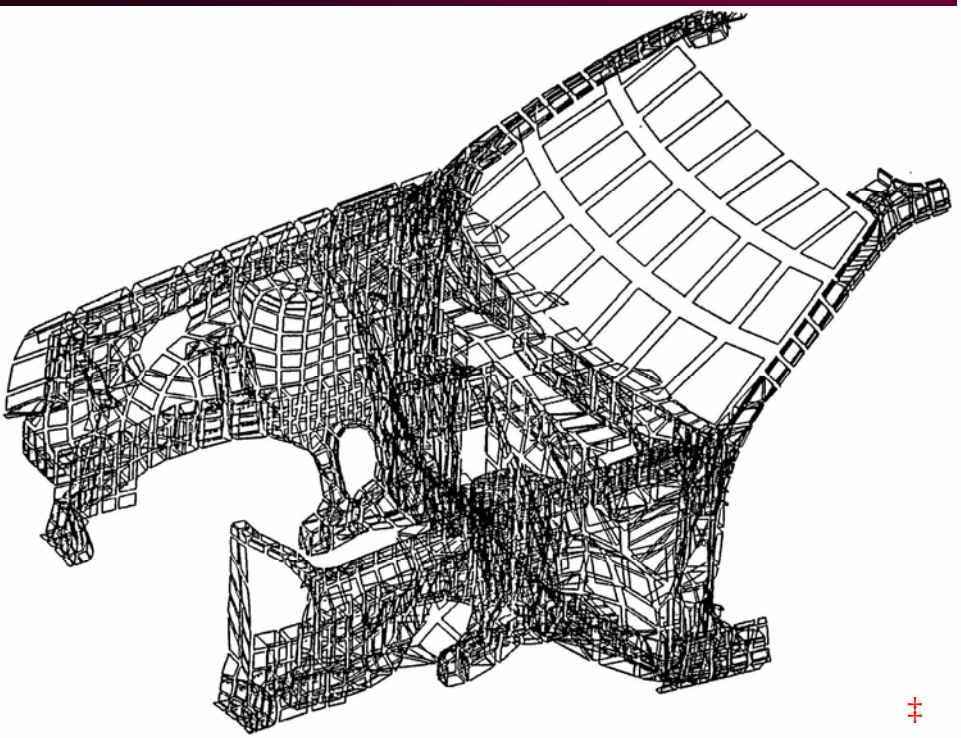
Noboru Miura, Mizuho Fukuda 'Car Design and Analytical Simulation' BAIFUKAN CO., LTD 1990 ‡

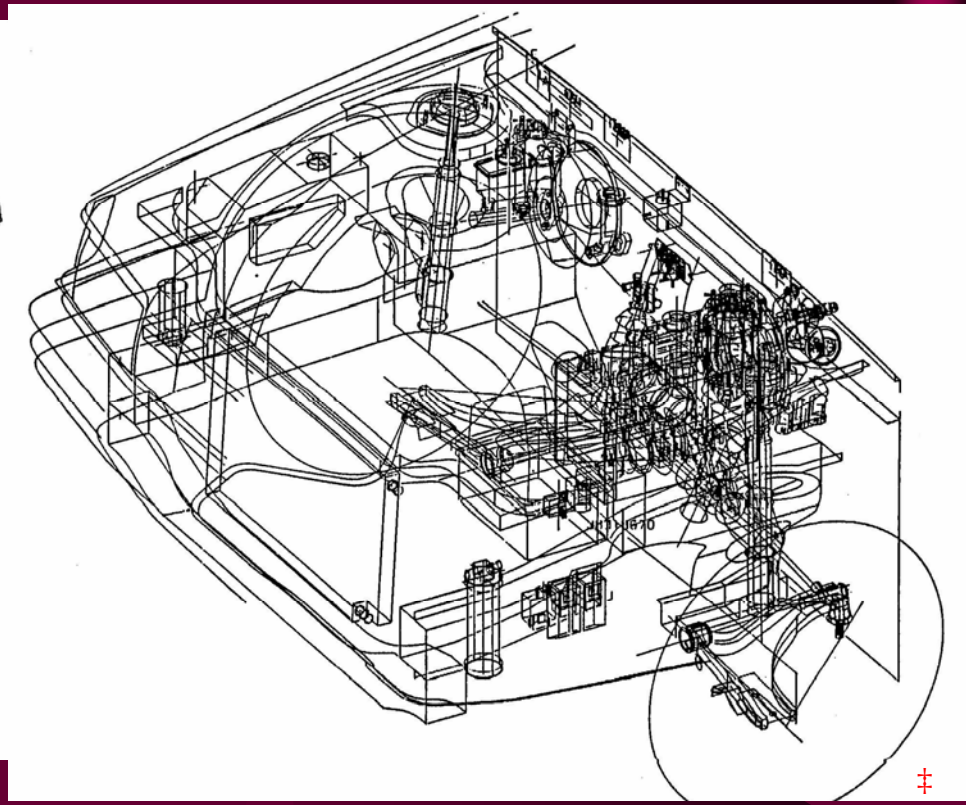
Shortening of Development Period by CAD Introduction



Shohachiro Takahashi 'CAD/CAM of Matsuda' Kogyo Chosakai Publishing. Co., LTD. 1985

CAD Model for Structural Analysis



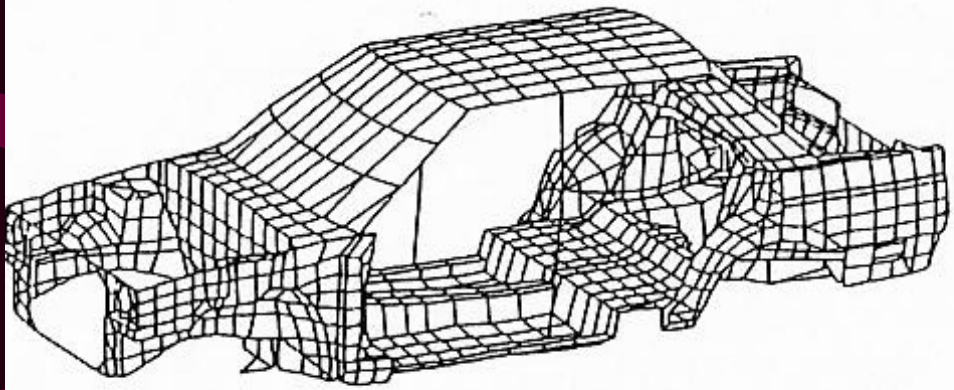


Shohachiro Takahashi 'CAD/CAM of Matsuda' Kogyo Chosakai Publishing. Co., LTD. 1985

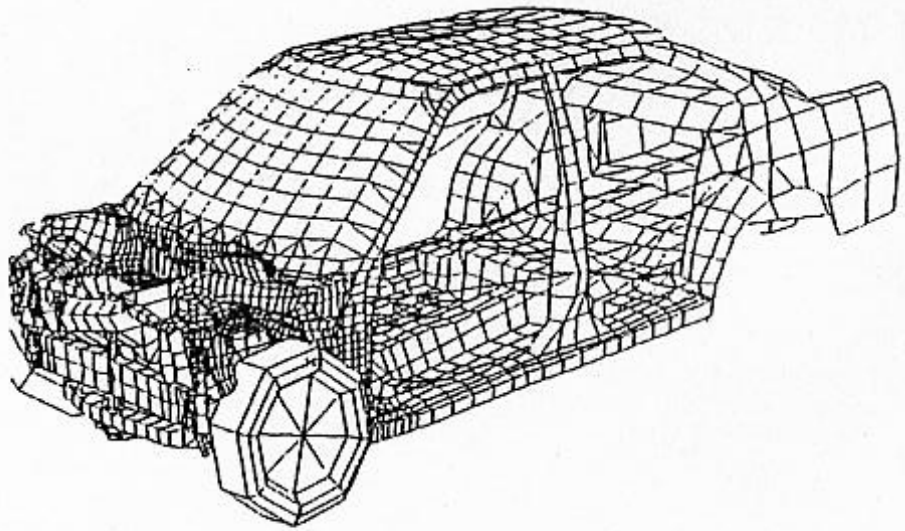
Collision Safety Simulation by CAE (finite element method)

CAEによるシミュレーション（自動車の衝突安全性分析）

a. 車体モデル（有限要素法）



b. 衝突（変形モード）解析



‡

Noboru Miura, Mizuho Fukuda 'Car Design and Analytical Simulation' BAIFUKAN CO., LTD 1990

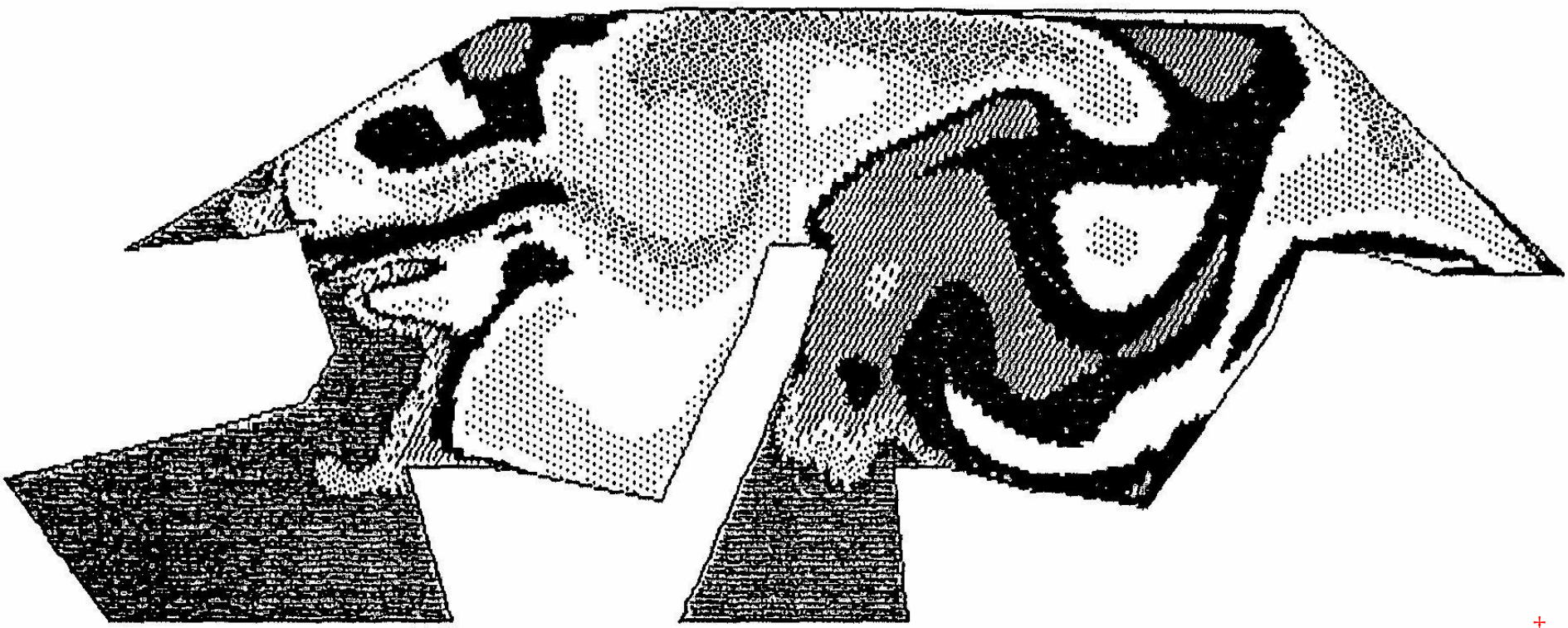
Simulation Result of Indoor Temperature Distribution by Car Air-Conditioner

自動車客室内の温度分布

ステップ＝2000　メッシュ＝85×64　初期温度＝50°C
無次元時刻＝20.0　レイノルズ数＝4.3464E5　入口温度＝10°C
実時刻＝2.86　アルキメデス数＝0.02683　平均温度＝28°C

温度スケール

10 15 20 25 30 35 40 45 °C



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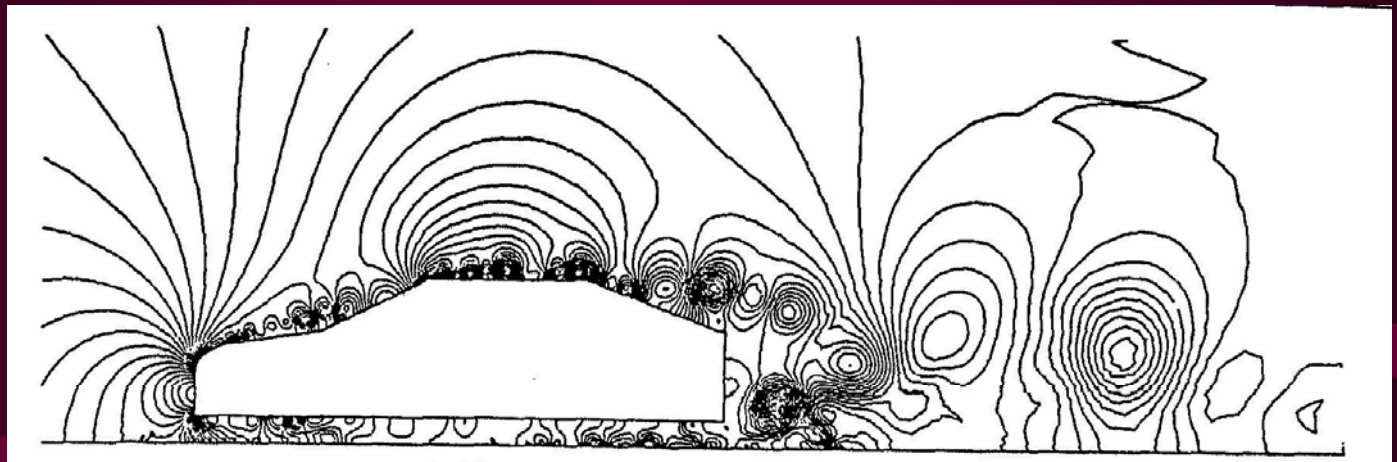
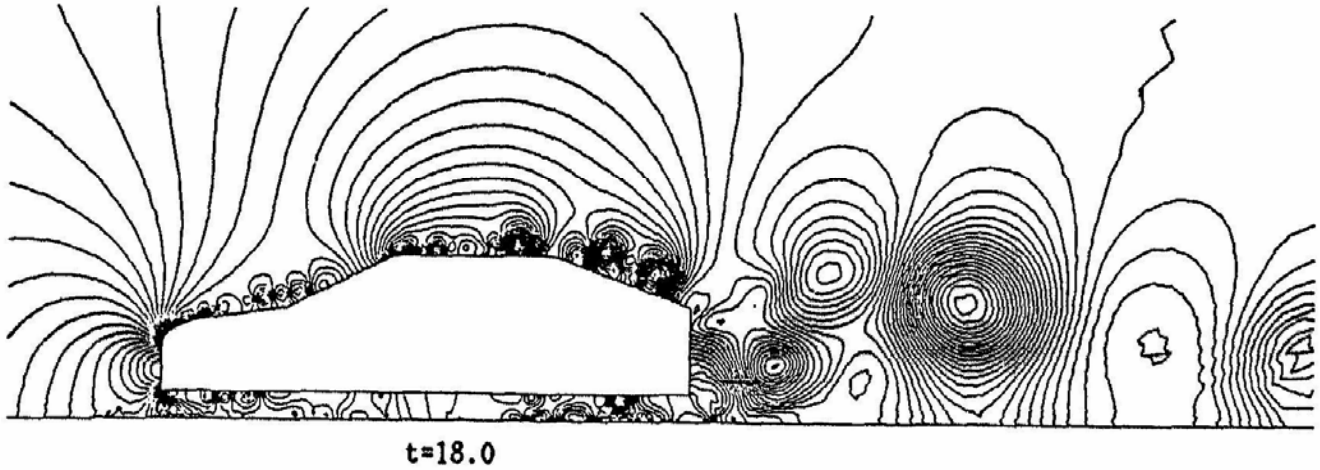
Simulation of Air Flow Around Auto Body

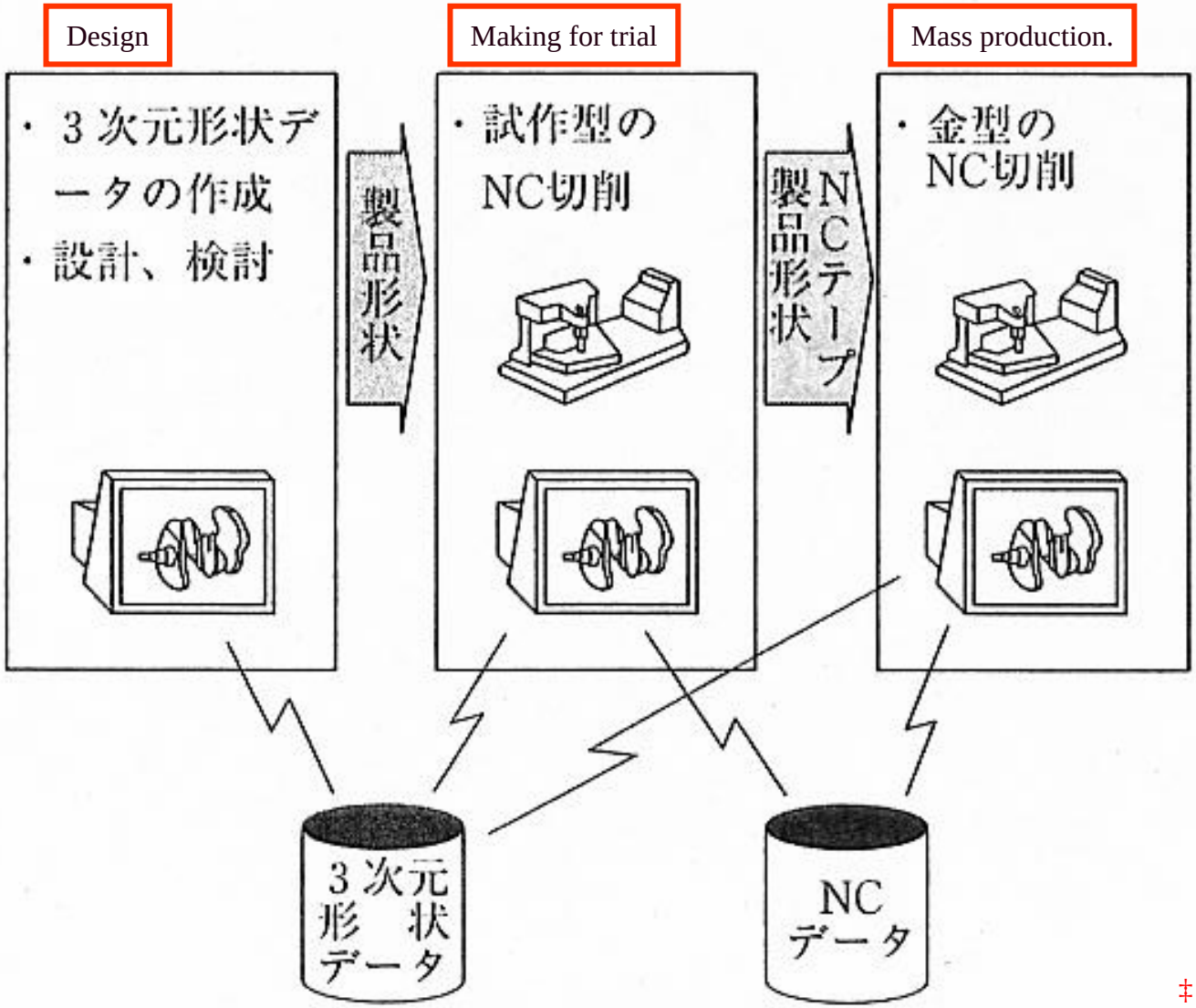




各瞬間での車体周囲の流線

Noboru Miura, Mizuho Fukuda 'Car Design and Analytical Simulation' BAIFUKAN CO., LTD 1990

Linkage of CAD and CAM
(cutting process of metal mold by NC)



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Shohachiro Takahashi 'CAD/CAM of Matsuda' Kogyo Chosakai Publishing. Co., LTD. 1985

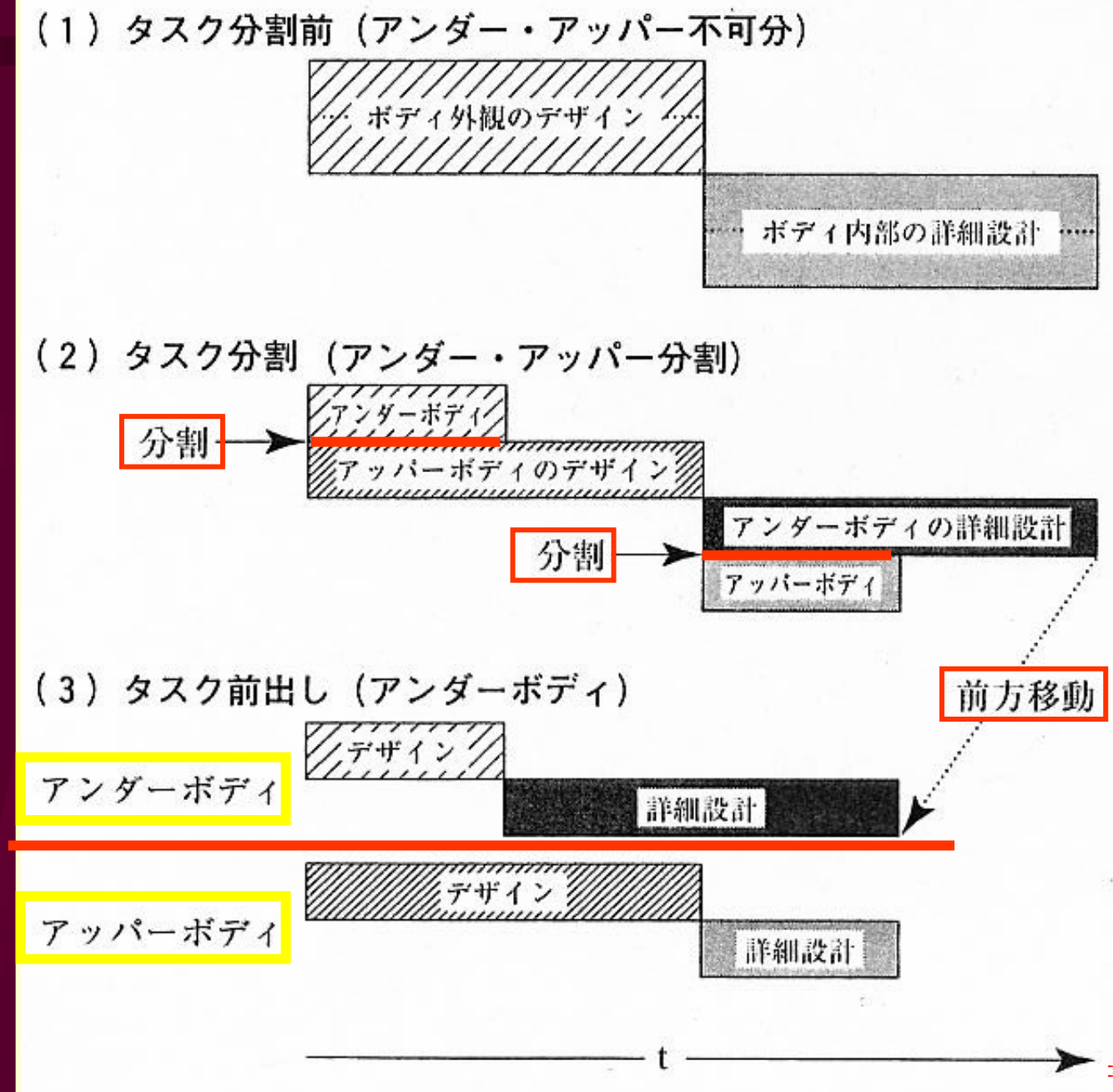
（2－1） Task Partitioning

To cut off an interdependence of tasks between the up-stream and the down-stream.

Example: division of upper-body design and under-body design of a car

→advancement of detail design work
of an under-body (down-stream work)

Example of Task Partitioning



Takahiro Fujimoto
'Introduction to Production Management'
Nihon Keizai Shimbun, Inc. 2001
(Ⅱp214 figure.14.14)

（2－2） Overlap Type of Problem Solving

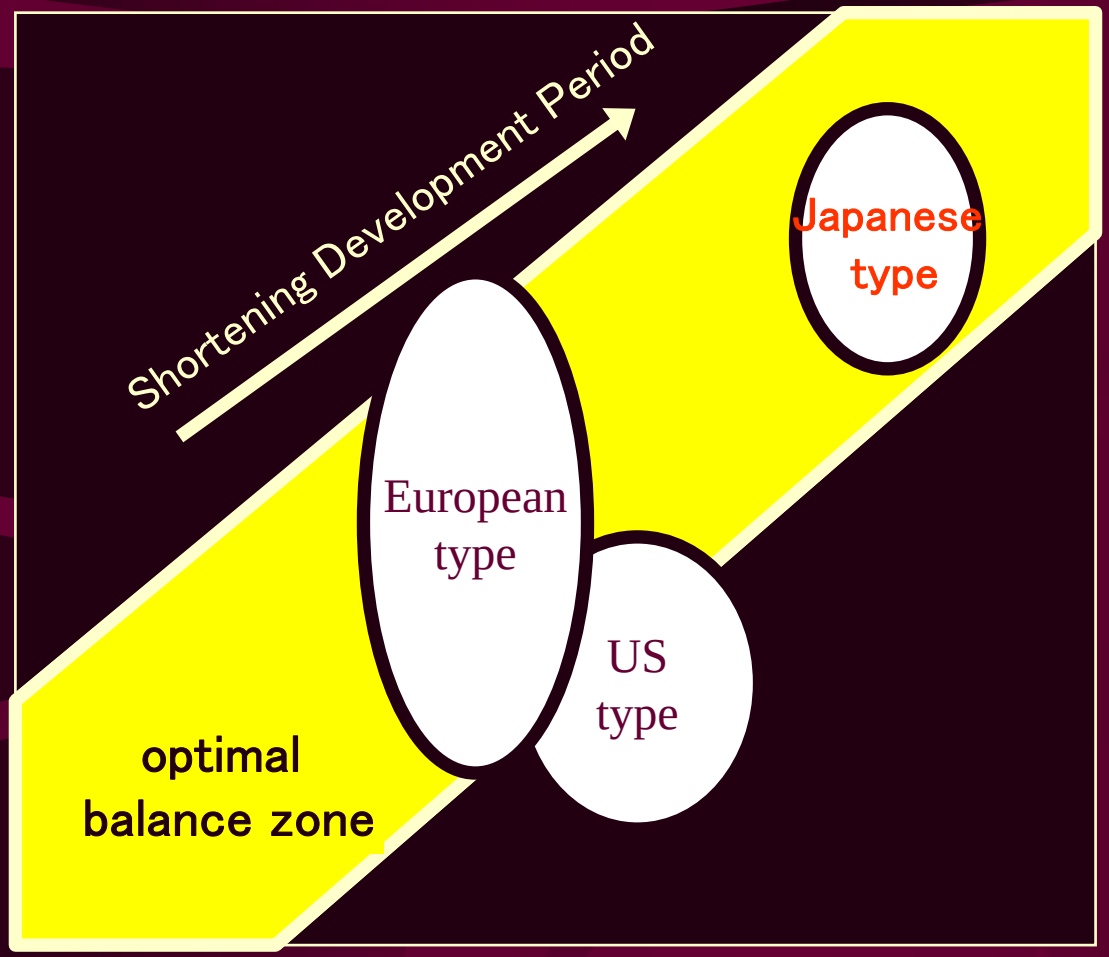
To overlap a problem-solving cycle of up-stream and down-stream

Close communication

Organizational capability: capability of integrated problem solving

Organizational climate:
conquest of “perfectionism” and ”opportunism”

Balance Between Stage-Overlap Degree and Communication Density



High (interactive, frequent)

communication density between stages

Low (batch processing, one-sided)

Low (in column)

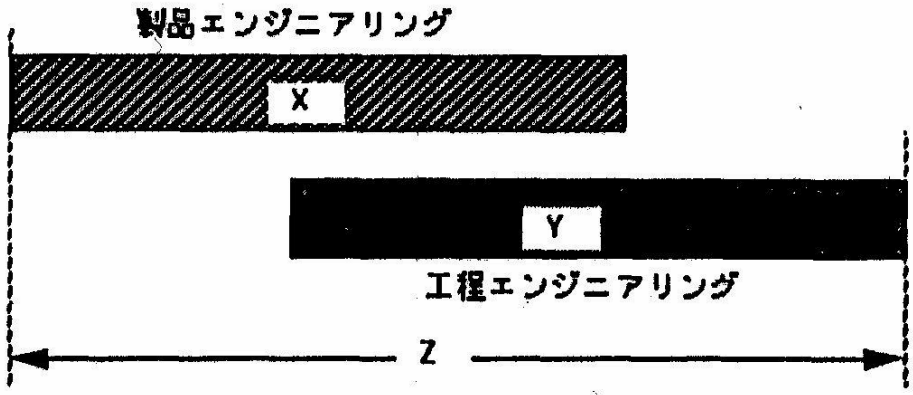
High (in column)

stage-overlap degree

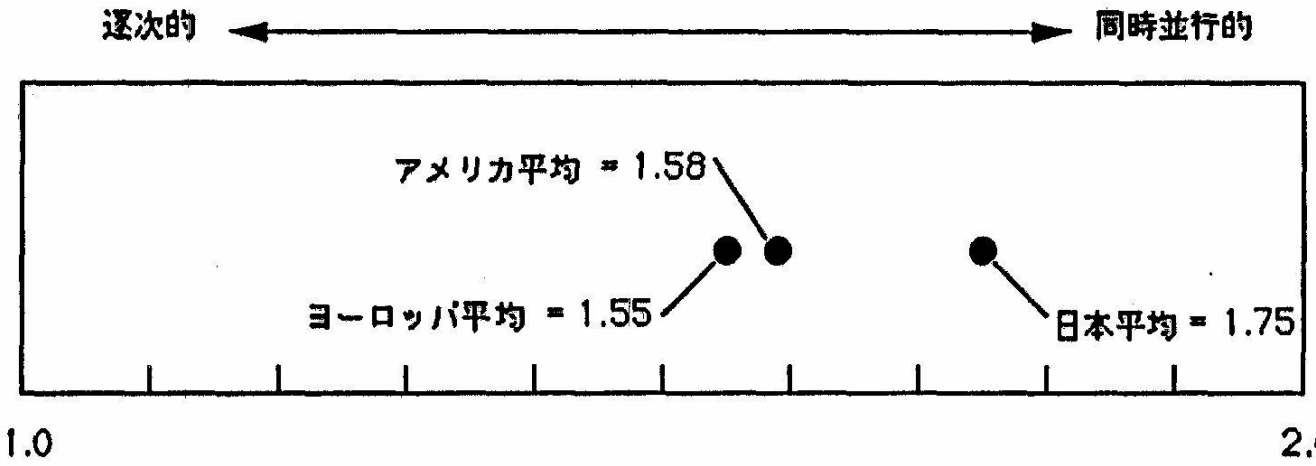
Comparison of Period Overlap Degree Among Japan, US, and Europe

1.オーバーラップ率の定義

オーバーラップ率 = (X + Y) / Z

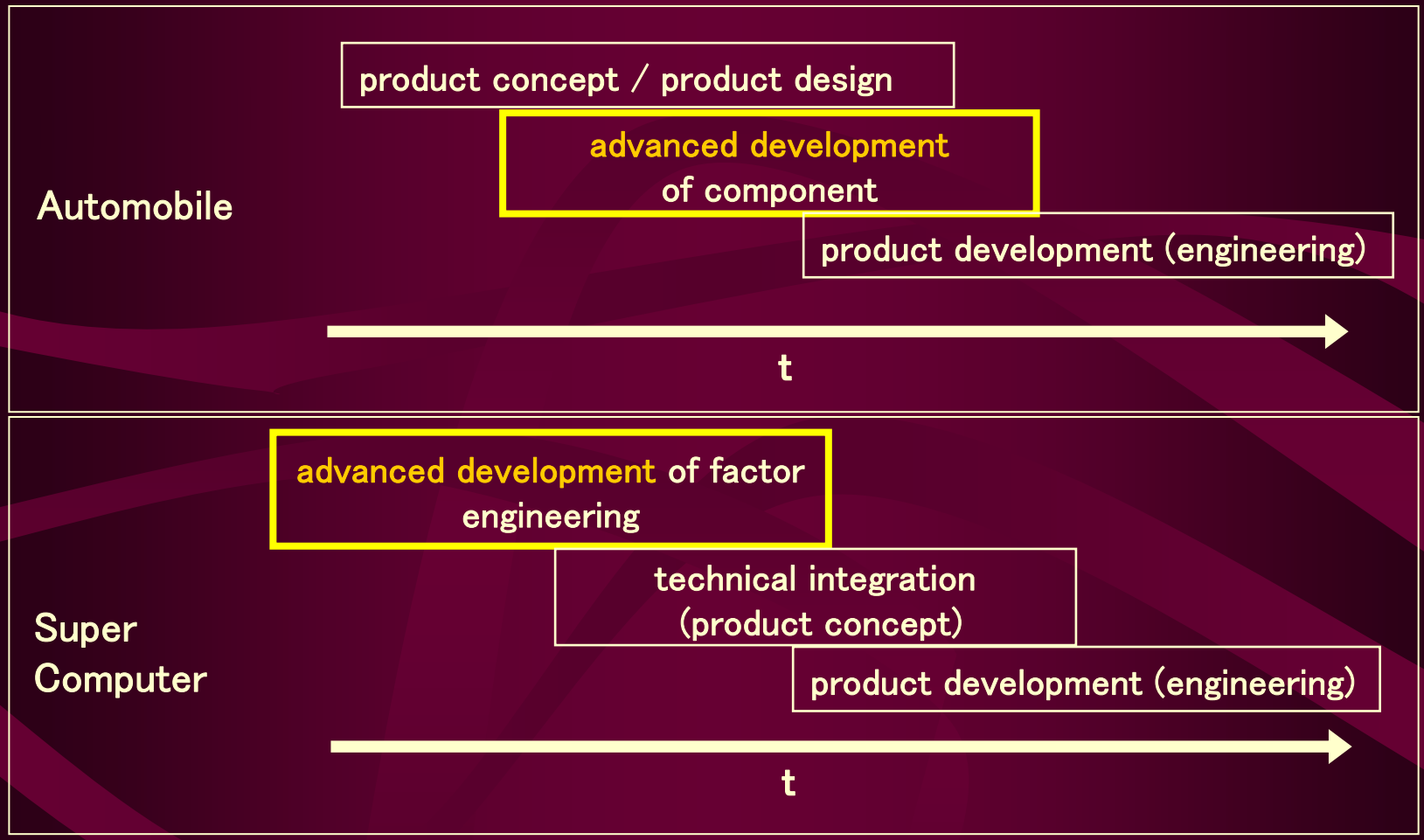


2.地域平均オーバーラップ率の比較



Takahiro Fujimoto 'Introduction to Production Management' Nihon Keizai Shimbun, Inc. 2001 (Ⅱp194 figure.14.3)

Pattern of Advanced Development (conceptual diagram)



Note: In case of a car, an engine is often developed separately.

Front-Loading

To shorten a whole problem-solving time (development period) by loading the timing of problem solving in the front

since problem solving at a later timing tends to require time and money

Front-loading of knowledge :

to transfer solution information from a former project

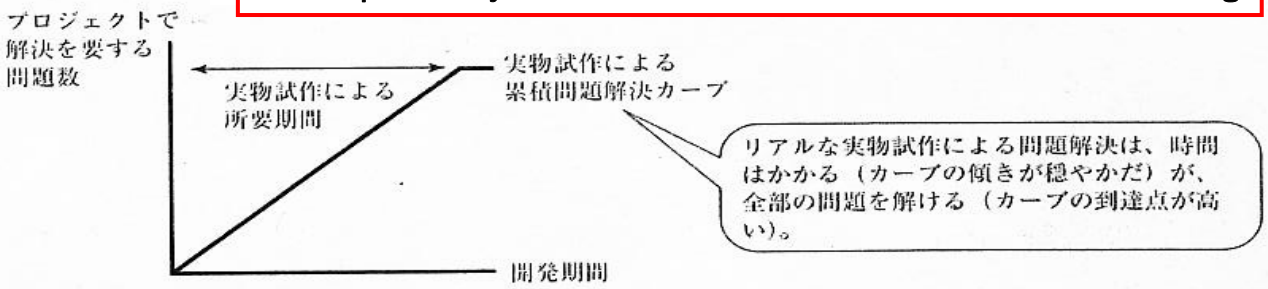
Front-loading of problem-solving activities :

to reduce an actual experimental manufacturing or a design change by pilot (consuming time and money) by way of utilizing 3-dimentional CAD and CAE

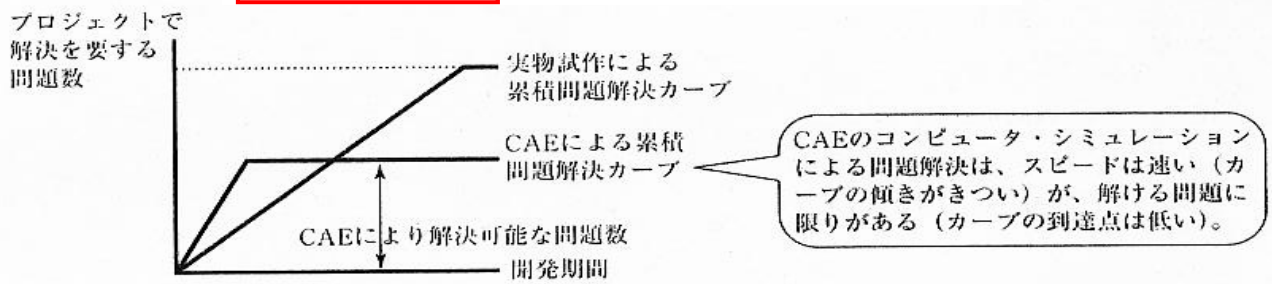
Period Shortening Effect of Front-loading and Accumulated Problem-Solving Curve

Effect of period shortening of front-loading and accumulation problem solving curve

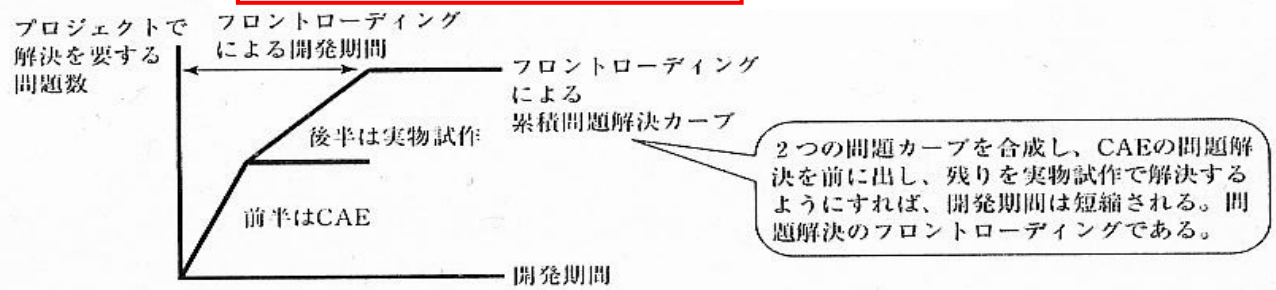
1. development by traditional format of actual trial manufacturing



2. entry of CAE



3. front-loading by utilizing CAE



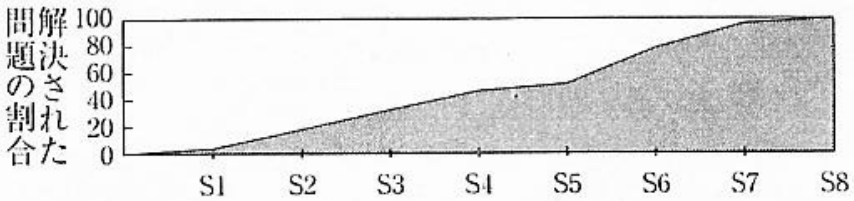
Takahiro Fujimoto
'Introduction to Production Management'
Nihon Keizai Shimbun, Inc. 2001
(Ⅱp219 figure.14.16)

Shift of Accumulated Problem-Solving Curve in Product Development

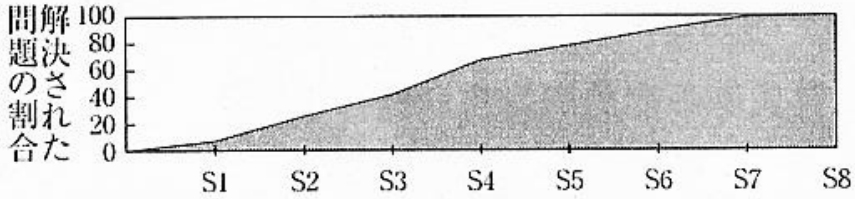
Transition of accumulation problem solving curve in product development

(Presumption: TOYOTA Motor)

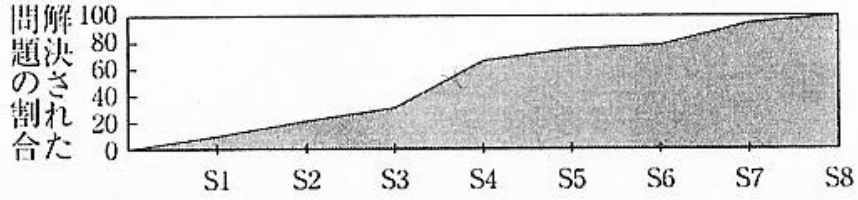
(a) 伝統的な開発プロセス（1970年代まで）



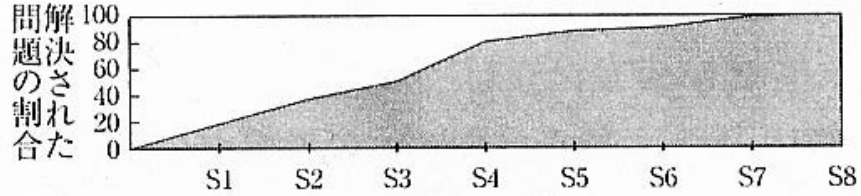
(b) 部分的で非公式なオーバーラップ方式（1980年代）



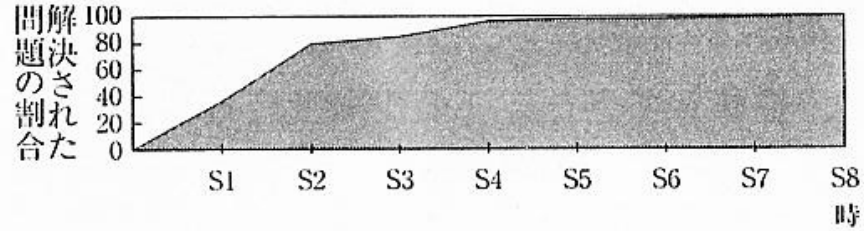
(c) フロントローディング推進の第1期：
生産技術と試作工場の連携本格化（1990年代初め）



(d) フロントローディング推進の第2期：
3次元CADによる部品干渉チェック（1990年代半ば）



(e) フロントローディング推進の第3期：
CAEによる製品機能チェック（1990年代終盤）

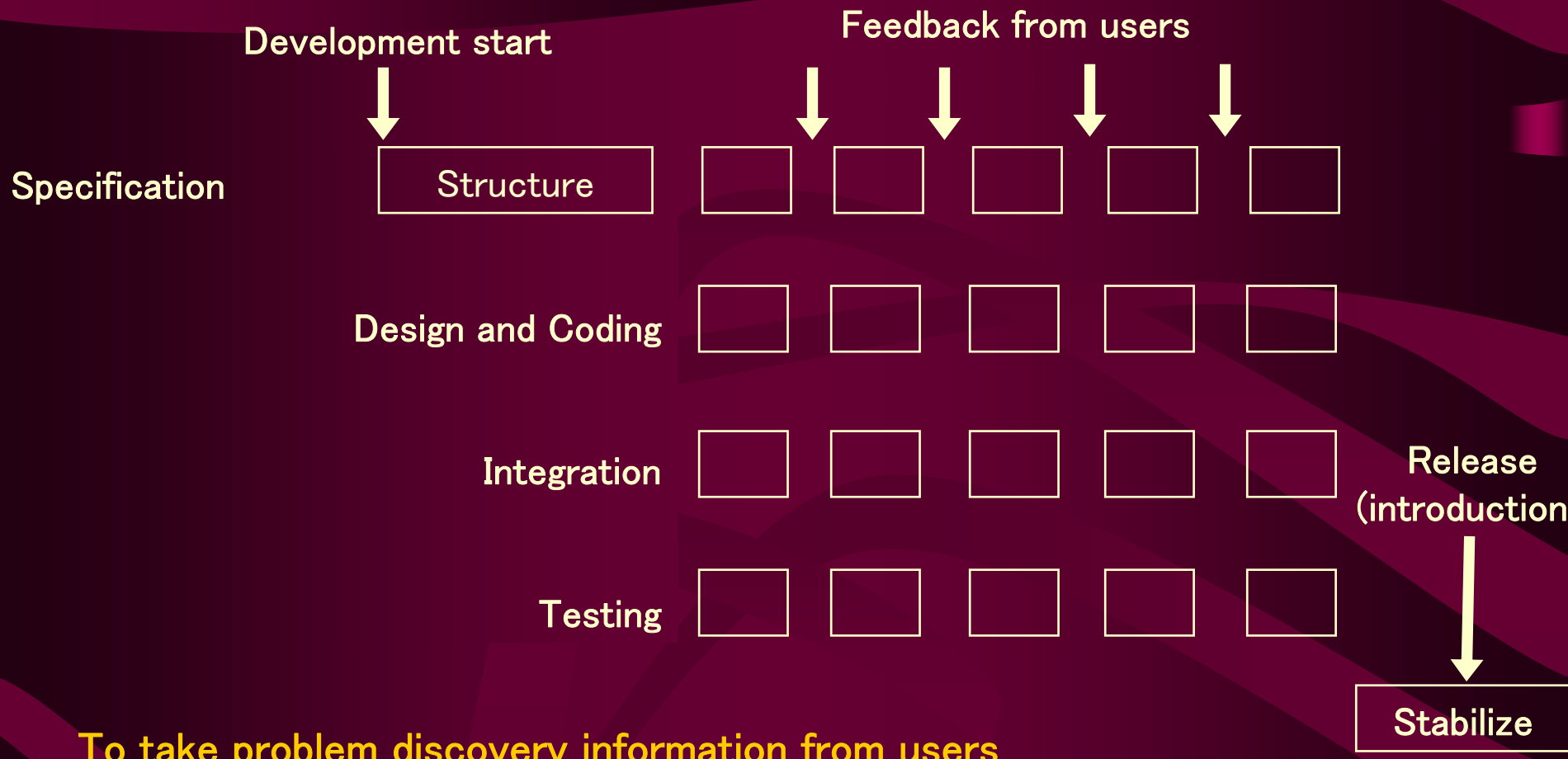


注：トヨタ自動車の外部公表資料（1995年）をもとに筆者らが推定。図中のS1は基本設計図（構造図）完了、S2は1次試作図完了、S3は1次試作車完了、S4は2次試作図完了、S5は2次試作車完了、S6は1次量産試作車完了、S7は2次量産試作車完了、S8は商業生産開始と推定される。

Thomke and Fujimoto, 'Effect of 'Front-Loading' Problem Solving on Product Development Performance, Journal of Product Innovation Management' Nihon Keizai Shimbun, Inc. 2000

Reference: Takahiro Fujimoto 'Introduction to Production Mmanagement' Nihon Keizai Shimbun, Inc. 2001 (Ⅱp223)

Reference: Flexible Development Method in Software Product



To take problem discovery information from users into development process (front-loading)

'MacCormack,A. and Iansiti.M. "Living on Internet Time
: Product Development at Netscape, Yahoo!, NetDynamics and Microsoft," Case 9-697-052, Harvard Business School'
Reference: Takahiro Fujimoto 'Introduction to Production Mmanagement' Nihon Keizai Shimbun, Inc. 2001 (Ⅱp195)

Organization Capability for Period Shortening

Shortening of development period = to shift
"accumulated problem-solving curve" up to front

This is exactly an enhancement in organizational capability (systematic problem-solving capability).

Information technology (three-dimensional CAD and CAE) is only "the requisite condition" to win a competition on shortening development period.

It is an organizational capability held by each company (organizational problem-solving capability) that can connect information technology to shortening of development period.

Example: competition on shortening development period in the auto industry (1980s-'90s)

IT-LT paradox --- Japanese companies which had started late on IT have taken a lead in shortening the lead-time (LT).