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SCHOOL ON PHYSIC IN INDUSTRY

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# " THE SOCIOLOGY OF PHYSICS "

presented by

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These are preliminary lecture notes, intended for internal distribution to participants only.

# OUTLINE of TALK

- "Sociology" of Physics
- Personal Experiences
- Industry's Demands from Physics
- R&D Economics
- APS Industrial Task Force Observations
- Industry's Interest in Goverment Policy
- Summary of Major Points



# "SOCIOLOGY" of PHYSICS

- Collective Human Activity
  - Economics & Economic Systems
  - Political Science & Cultural Norms
  - Government Policy re Education, Industry
  - Group Interactions
- Individual Experience
- "Peer Group"
  - Colleagues
  - Physics Societies
  - Other Technical Societies
  - International
- Institutions
  - Universities & Colleges
  - Government Institutes
  - Industries

# PERSONAL EXPERIENCES

Active in Research: 9 years

- Condensed Matter Theory (6 years)
  (thermionic & thermoelectric energy conversion, radiation damage of polymers, electron-nuclear double resonance in dilute ruby)
- Computer Science, Pattern Recognition & early Artificial Intelligence (3 years)

Industrial Research Management & Planning: 19 years

- Manufacturing Applications of Computers (2 years)
- Corporate Staff (3 years)
- Physics Lab Manager (3 years)
- Corporate R&D Planning (3 years)
- Advanced Product Development (5 years)
- Research Planning (3 years)



# INDUSTRIAL PHYSICS requires:

- Talented Practitioners
- Topics that are Intellectually Challenging but are "Timely" (Tractable)
- Topics that have Utility in the Industry

## RESEARCH AS AN ECONOMIC ACTIVITY

- "I shall define research as a specialized activity that requires special skills and facilities that are employed to discover and develop special forms of *new information*, a part of which acquires the properties of economic information. By this definition, such research is an economic *activity* because it requires scarce resources and because it produces something of value."

  * Theodore W. Schultz *Investment in Human Capital,* NY, The Free Press, 1971, p. 203.

- "It is not, after all, scientific knowledge which is ultimately valued in the economic sphere but, rather, knowledge in a form which is directly applicable to productive activity."

  † Nathan Rosenberg, *Perspectives on Technology,* Cambridge, Cambridge University Press, 1976.



## RESEARCH PRODUCTIVITY & RESEARCH YIELD

- RESEARCH RETURN = (Corporate Profits / R&D Investment)

$$= \left\{\frac{\text{(Corporate Profits)}}{\text{(Technical Progress)}}\right\} \times \left\{\frac{\text{(Technical Progress)}}{\text{(R\&D Investment)}}\right\}$$

= "Research Yield" X "Research Productivity"

RESEARCH PRODUCTIVITY = (Technical Progress/R&D Investment)

- *the generation of scientific knowledge*
- responsibility of Research management

RESEARCH YIELD = (Corporate Profits / Technical Progress)

- *transfer in the form of a working technology*
- responsibility shared by Research management and the management of receiving organizations

Not <u>seldom</u> yields a satisfactory return

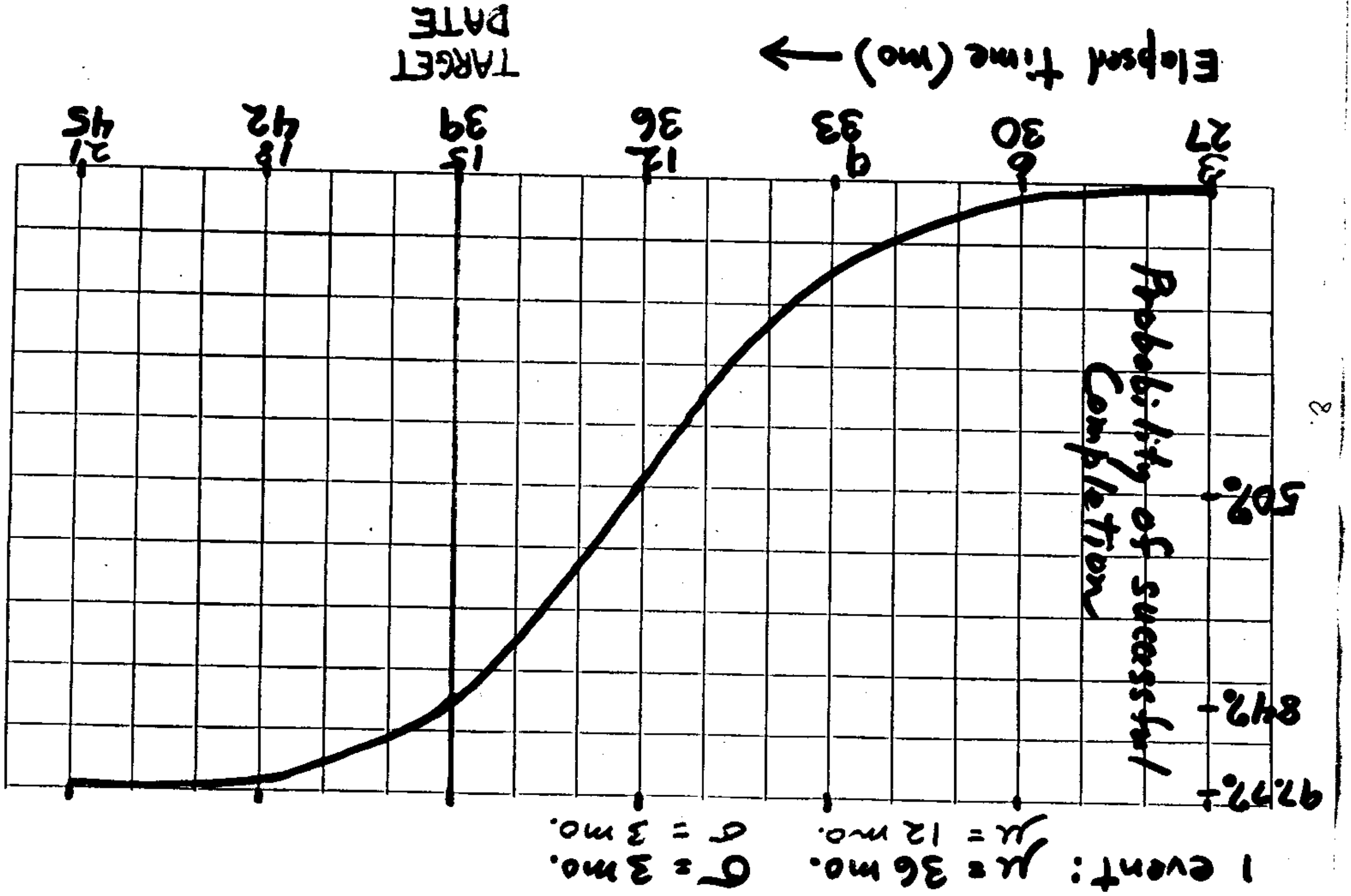
| | |
|---|---|
| Technical Failures | .40 |
| Planning Failures | .30 |
| Market Failures | .12 |
| **SUCCESSES** | **.18** |

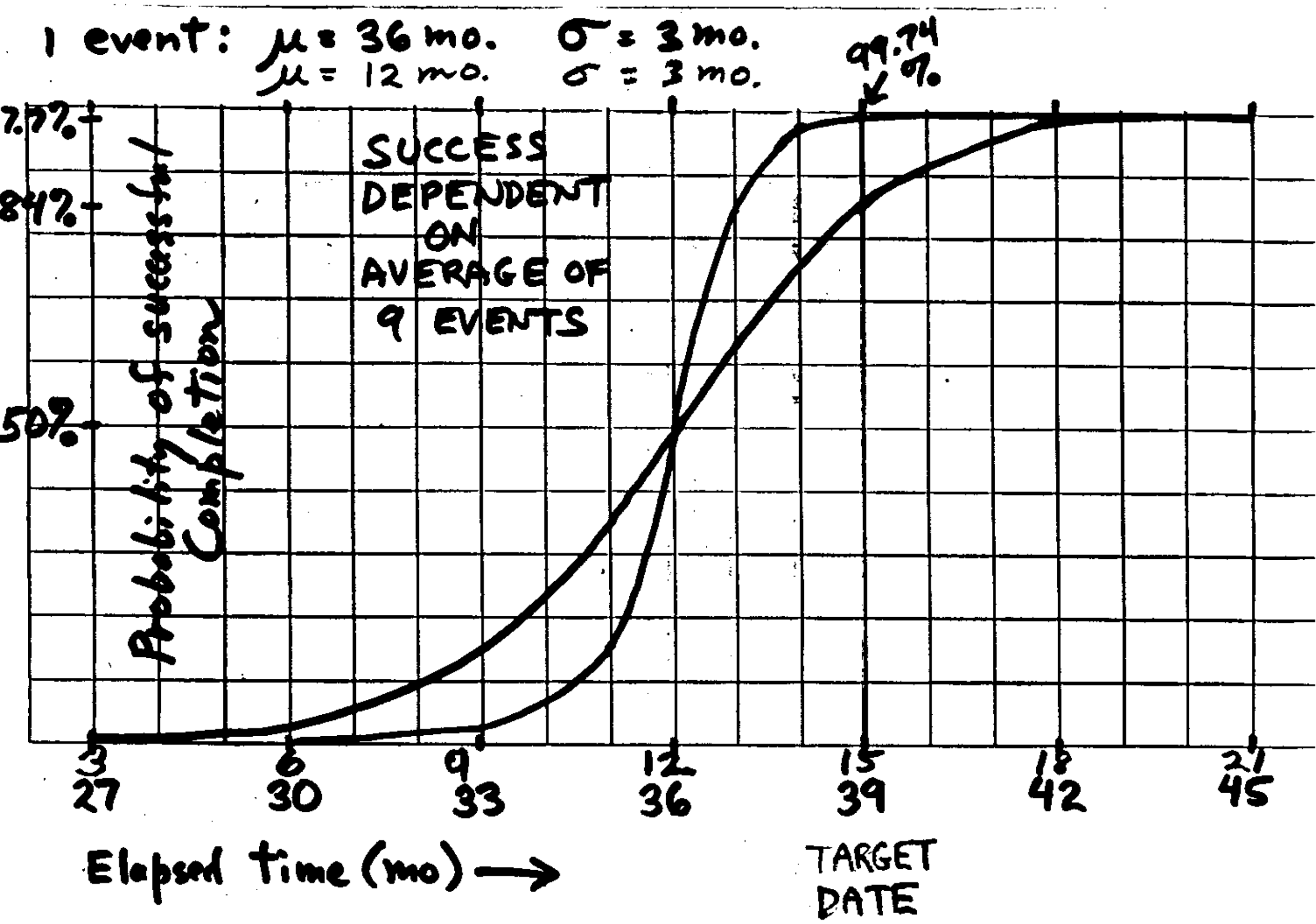
- Engineering Programs are always late
- Engineering Programs are always over budget.

$\Delta_1$ = expense of late task
$\Delta_2$ = " of maintaining the other tasks.
$\Delta_3$ = " of trying to accelerate

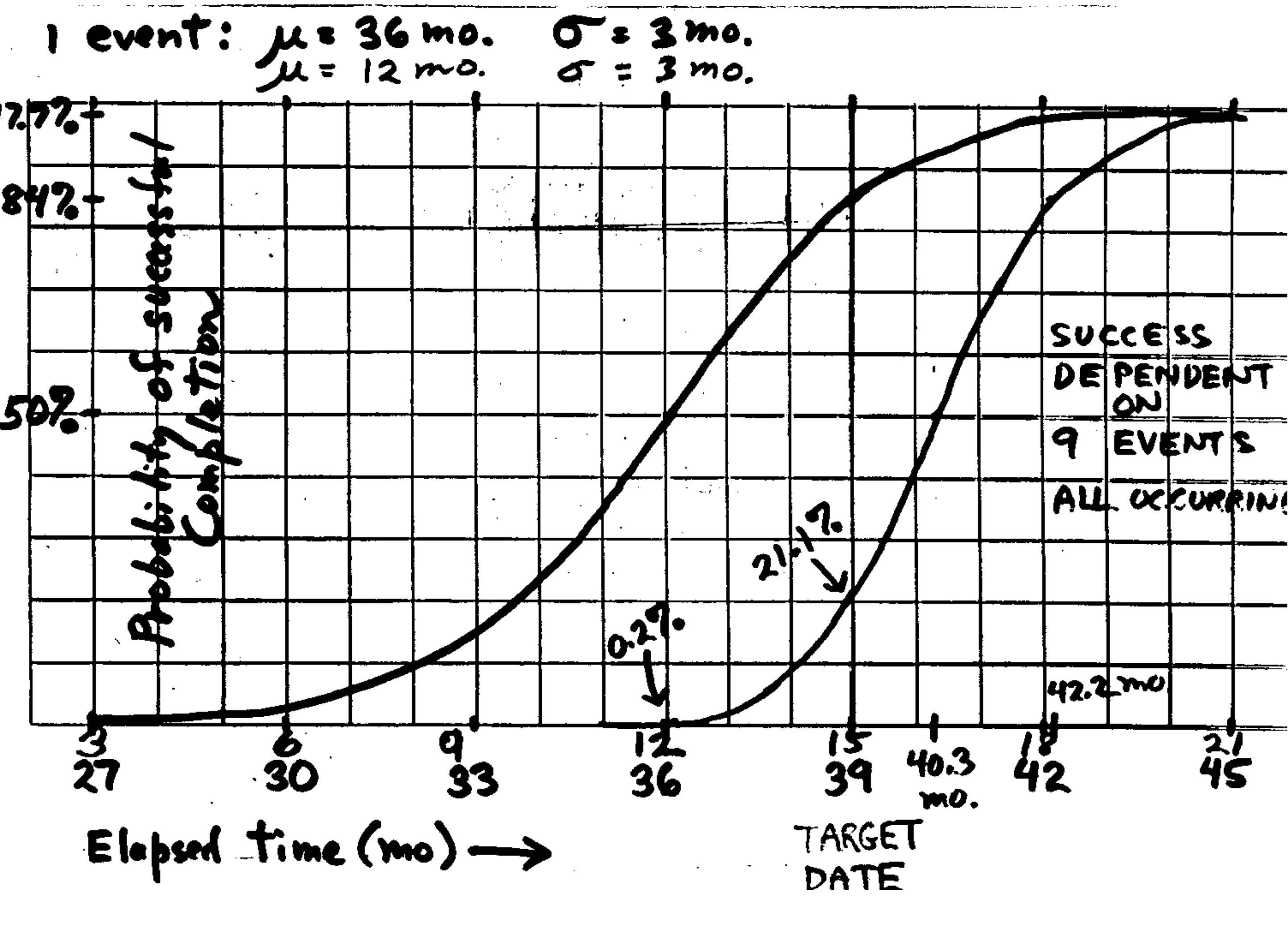







1 event: μ = 36 mo. σ = 3 mo.
μ = 12 mo. σ = 3 mo.
99.74 %
97.7%
84%
50%
Probability of successful Completion
SUCCESS DEPENDENT ON AVERAGE OF 9 EVENTS
3 27
6 30
9 33
12 36
15 39
18 42
21 45
Elapsed time (mo) →
TARGET DATE




1 event: μ = 36 mo. σ = 3 mo.
μ = 12 mo. σ = 3 mo.
97.7%
84%
50%
Probability of successful Completion
SUCCESS DEPENDENT ON 9 EVENTS ALL OCCURRING
21.1%
0.2%
42.2 mo
3 27
6 30
9 33
12 36
15 39
40.3 mo.
18 42
21 45
Elapsed time (mo) →
TARGET DATE

| | EXPENSE | RETURN |
|---|---|---|
| Technical Failures | | |
| $.40 \times (\frac{1}{3} \times .3) \approx .04$ | .04 | 0 |
| Planning Failures | | |
| $.30 \times (1 \times .3) \approx .09$ | .09 | 0 |
| Market Failures | | |
| $.12 \times (1 \times 1) \approx .12$ | .12 | $.12 \times (\frac{1}{2}T) \approx .06T$ |
| SUCCESSES | | |
| $.18 \times (1 \times 1) \approx .18$ | .18 | $.18 \times (3T) \approx .54T$ |
| | .43 | $\approx .60T$ |

where T = T-bill rate of return



## APS INDUSTRIAL TASK FORCE

The number of new physics PhD's in America accepting positions in industry has increased. It is perceived that these physicists tend to drop their membership in APS a few years after leaving graduate school.

The charge to the task force was to determine why the APS is not effectively meeting the needs of the industrial segment of the physics community, and to formulate new programs to encourage these physicists to continue as members of the American Physical Society.



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February 1986

The preliminary indication is that the problem of diminished professional allegiance appears neither in large graduate-degree-granting physics departments nor in major industrial laboratories (GE, BL, IBM, Xerox, etc.). The problem appears in small colleges, in University departments other than Physics Departments, in smaller companies, in laboratories dominated by other disciplines, and in industries having no research tradition whatsoever.



## PROBLEM STATEMENT

*The environment of the APS does not meet the dynamic needs of professional physicists (those who advance and diffuse the knowledge of physics). In particular, it does not respond to a changing demand for "downstream movement" of physics into technology and engineering.*

## TOPICAL GROUPS OF THE APS

APS has "Topical Groups" for fields not conveniently encompassed by a Division of the Society. Topical Groups plan and hold meetings either at separate Topical Conferences or at Regular Meetings of the Society.

A Topical Group may be established by Council upon petition by 20 members of the Society The membership must number at least 150 within two years, or the Group will be dissolved.

Now established are seven Topical Groups:

(1) Few-Body Systems and Multiparticle Dynamics

(2) Instrument and Measurement Science

(3) Laser Science

(4) Materials Physics

(5) Particle Beam Physics

(6) Shock Compression of Condensed Matter

(7) Computers in Physics



## FRACTIONATION: A FACT OF EXISTENCE

Physics has been, and will continue to be, a science that spawns applied disciplines. The practitioners of these disciplines "come home" to physics when the fundamentals of their field are shaken up by new discoveries. But the majority of their effort is conducted independent of the APS. Examples would include:

- nuclear reactors
- physical optics after the laser

The "cross-fertilization" of knowledge among fields of physics is done very well through APS means, but the "downstream movement" of physical knowledge into technology is not.

## PHYSICS AND PHYSICISTS

The American Physical Society's constitution states that the object of the society is "the advancement and diffusion of the knowledge of physics". By concentrating on the *science* of physics, and not on the *practice* of physics, the APS puts itself in a different category from engineering societies, which concentrate equally on professional practice and professional practitioners.

The APS physics community's tradition has been "basic" research, motivated by

(1) the desire to understand natural law (*not* by the possibility of applying that learning to societal goals), and

(2) conducted by individuals (*not* teams) in

(3) academic (*not* industrial) environments.



## COMPARISON OF APS TO OTHER SOCIETIES

A large array of organizations, many of them oriented to technology and engineering, compete to serve the needs of applied and industrial physicists. These other engineering and scientific societies hold meetings offering "vertical communication".

APS offers "lateral communication" to and from research physicists from other specialties, and does so in meetings that industrial physicists believe to be uniformly well-run and of very high quality.

## COMPARISON OF APS TO OTHER SOCIETIES

Applied physicists have a major clientele in engineering circles, and transfer their results by speaking primarily to their customers rather than to other physicists.

APS is viewed as old, established, and prestigious. However, the APS is also old, established and stodgy. The APS gets "prestige"; the IEEE gets "loyalty".



## POLICY ISSUES

- National Cooperative Research Act (US)
- Semiconductor Chip Protection Act 1984 (US)
- Software proposal from MITI (Japan)
- Freedom of Info Reform Act 1985 (S.774)
- Regulatory Policy (e.g. Telecommunications)
- Intellectual Property Laws
- Government Funding for Major Facilities
- New Instrumentation for Universities
- Anti-Trust Law and Collaborative Research
- Government Support or Protection of Industry
- Foreign/American Proportions in Students/Faculties/New Industrial Employees
- Applied Physics Education

## MAJOR POINTS

Industrial Physics requires:

- *Talented Practitioners*
- *Choice of Tractable Research Topics*
- *Choice of Topics that have Industrial Utility*

Physicists in Industry can lead to:

- *Economic Growth related to R&D Applications*

Physicists in Industry need to know a little:

- *"R&D Economics"*

Physicists in Industry require:

- *Vertical Communication*
- *Lateral Communication*



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