

Application Oriented R&D: Aphorisms & Anecdotes

Some of what I think I learned about leading
and managing it in 55+ years of practice.

Robert A. Frosch

Nature, to be commanded,
must be obeyed.

- Francis Bacon, 1561 - 1626

Life is short, art long,
opportunity fleeting,
experiment treacherous,
judgment difficult.

- Hippocrates of Kos, ~400bc

My Experience:

- Scientist & Dir. of Hudson Labs. (Columbia),
doing research for ONR
- Dir. for Nuclear Test detection, Dep. Dir.
ARPA
- Assistant Secretary of the Navy for R&D
- Assistant Executive Director UNEP
- Assoc. Dir. for Applied Oceanography WHOI
- Administrator of NASA
- VP of GM in charge of Research Labs.

Some Aphorisms and Anecdotes

All applications oriented R&D
organizations are alike.

(Scale is important,
but
all are fractal.)

Bureaucracy, Rules, Policies,
and Standards are all necessary

but:

No one who is obeying ALL the
rules can possibly be doing any
work!

(Why the “work to rule” non-strike is so
devastating!)

(Why R&D organizations tend to be rather
relaxed and chaotic!)

The customer for R&D is
always wrong.

-Misstated problems:

Customers say what they think the answer is,
not:

What the question on their minds really is.

ie: “What I want is...,”

not:

“My problem is...”

- Besides:

How would they know the technical possibilities?

How would technologist really know what they want?

“We need a faster fighter aircraft!”

After dialogue, really ended up meaning:

We need a better, longer range, air to air
weapon.”

Buying R&D is not like buying shoes!

- Shoes exist, and can be seen, and tried on.
- R&D is about future possibilities that don't exist, can't be seen, and can't be tried on.
- 'Requirements' are guesses about possible futures.
- Specifications don't really specify:
 - They can only be an incomplete sample (tacit knowledge)

A Requirement

Navy helicopter requirement:

Take off from 14,000 feet on a
90°F day!!!???

(There is no such place!)

Tacit Knowledge

Why the Hughes TWTs suddenly started dying
too soon:

Must weld the filaments in with the tube upside
down!

Inventing and defining problems
is generally even harder than
solving them!

(“The one who says it cannot be
done should not get in the way
of the one who is doing it!”
- (Said to be a Gaucho proverb)

Application oriented R&D is a
contact sport, fueled by
dialogue, discussion, and
argument.

An **early** dialogue between customer for and supplier of R&D is necessary for success.

Arms length dealing doesn't work!

but:

Continuing attention and discipline IS required!

A **continuing** dialogue between customer and supplier is needed.

Discipline is required in this dialogue,

but:

Arms length dealing does not work!

(Everyone involved has a conflict of interest or a bias. That's ok as long as everyone knows this.)

("Trust but verify."
- Ronald Reagan)

Building a Large Aperture Seismic Array (LASA) under budget and time

Clear system definition of task
Continuous team management of the task
Adjustments in details as necessary
System approach

“The best fertilizer is the footprint of the owner.”

- Said to be a Sicilian proverb, probably dating back to an anecdote of Pliny the Elder (died 79AD at Pompeii)

It is easy to know what is
relevant; impossible to know
what is irrelevant.

Polymer door rib 'read through'

Comment by customer:

'It must have been an easy problem, you guys solved it in two weeks!'

Response from R&D:

'Easy after twenty years of thinking about such problems!'

Scheduling assembly plants

Luncheon conversation re intractable computational problem:

Engineer:

'We're stuck...'

Mathematician:

'It sounds familiar; I think there may be a theorem.'

ACuZinc

AlCuZn alloys for “one day die”
(and, by the way, the customer specified the
wrong problem, but we couldn’t convince him;
he was my boss, and already knew how to
build cars!)

Never put into practice (at least then), but the
alloy knowledge later made it possible to solve
an important problem very rapidly,
and made new products possible.

Application tasks require
knowledge matrices

Knowledge Matrices

- A more efficient, lower emissions auto engine involves:
 - combustion chemistry
 - electric spark/plasma physics
 - fluid flow
 - heat transfer
 - mechanical systems
 - materials
 - etc., etc., etc.....
- And then the next level down of detail.....
 - Etc.,etc.,etc.....

Application oriented R&D needs
central organization of some
kind

Besides:

The organization may need (eg) mathematicians all the time, but any division may need one only infrequently,

and:

The division may not even know when it needs one!

Good application oriented R&D organizations do much more than R&D:

Some Tasks of Industrial R&D Labs

Product Development
Process Development
Problem Solving
Eye on the S&T World
S & T Memory and Perspective
Education and Training

Two management systems:

MBWA: Management by Walking Around
- David Packard

-MBAQ: Management by Asking Questions
- Bob Frosch

A question:

About a ship being (re)designed to hold a very heavy object on a long string:

What happens if the string breaks?

It can't break.

But, suppose it does...

.....

Some Additional Anecdotes

- SOSUS array length and depth
- Shuttle tiles and 'felting'
- Shuttle tail & control redundancy
- Assembly scheduling
- Theory of manufacturing
- Thin shell die casting
- "read through"
- Iron casting cupolas
- SWATH ship/facility Kaimalina
- Hybrid cars
- Intelligent cars

Measurement of application
oriented R&D organizations:

Only over time

Only whole organizational pieces:

NOT by project by project success

What should the success rate of
projects be?

100%, 90%, 50%, 10%, 0%?

NASA Center Director:
Everything my lab did last year
was successful!

Response:
Are you going to try
something difficult and
risky this year?

The success rate should be such
that the organization, or piece of
the organization, 'pays it's way' in
\$, or other contributions to success.

[In a sampled year at GM Research
Labs ~12 projects out of ~120 (~10%)
put into company use gave the total
Lab an IRR of 70+%!]

Further note:

For a complicated product (eg: vehicles) its easier to track process and production improvements than product improvements.

(eg: The value of an improvement in combustion efficiency gets lost in the rest of the changes to the design.)

Production cost, time, or labor and machinery changes are relatively easy to track.)

A successful R&D organization
is not sufficient to ensure
successful operations,
or a successful company!