

Le management de projet à l'épreuve d'une situation extrême : le cas Manhattan.

Sylvain Lenfle

Colloque « Management des situations extrêmes »

Centre Culturel International de Cerisy

16 juin 2016

Plan de l'intervention

1. Les origines du projet
2. Le management de l'exploration dans l'inconnu
3. L'organisation du projet
4. L'héritage expansif de Manhattan

I. Origines et objectifs du projet Manhattan



Origins of the project

- The project builds on 20 years on research in nuclear physics (Rutherford, 1919; Chadwick, 1932; Cockcroft & Walton, 1932; F. & I. Joliot-Curie, 1934; Hahn & Strassman, 1938; Meitner & Frisch, 1938; Fermi, 1934 & 1938)
=> but « *there were many gaps and many inaccuracies. The techniques were difficult and the quantities of materials available were often submicroscopic. Although the fundamental principles were clear, the theory was full of unverified assumptions, and calculations were hard to make. (...) The subject was in all too many respects an art, rather than a science* » (Smyth report, 1945, p. 365).
- The strategic role of Atomic power is brought to the front by the famous Einstein letter to Roosevelt (August, 2, 1939)
- Three military considerations involved in the project (Groves, 1962)
 - Fear that Nazi Germany could build the bomb first
 - No known defense against nuclear bombing
 - Shorten the war and « *save tens of thousands of american casualties* »

A revolution...

« The most energetic chemical reactions – burning hydrogen with oxygen, for example – release about 5 electron volts per atom. Meitner calculated, and Frisch soon demonstrated by experiment, that a neutron moving at energies of only a few electron volts, bombarding an atom of uranium and bursting it, *would release about 170 million electron volt per atom*. The newly discovered reaction was ferociously exothermic, output exceeding input by at least five orders of magnitude. Here was a new source of energy like nothing seen before in all the long history of the world ».

R. Rhodes, in Serber, *The Los Alamos Primer*, 1992, p. xiii.

... if ...

-
- The Manhattan project has had to face two main design problems
 - The production of fissionable materials
 - The design of the bomb itself

=> In each case several paths were identified
 - Time was of the essence (nov 1942 : decision of the project steering comitee to skip the pilot phase and to go directly from research to full-scale production)
 - An unquestionably « extreme » situation : evolving, uncertain, dangerous (Lièvre, 2014).

Fissionable materials : U235 & Pu239.

- Two materials were identified to sustain a chain reaction :
 - U235 (present in 1/140 of natural uranium)
 - Plutonium (Pu239 discovered in 1941 by G. Seaborg)
- In both case the production of fissionable material raised huge scientific and technical problems :
 - Separating U235 from natural uranium involves extremely complex processes, based on the slight differences in mass between U235 & U238 (< 1% !!)
=> 7 methods are identified in 1941, 3 will be used.
 - Same problem for plutonium, produced in a nuclear reactor and furthermore involving complex chemical separation processes =>13 methods under study at the beginning of plant construction !!
- This were breakthrough innovations : new to the world, requiring extrem tolerances, radioactive, dangerous...

Example :

The MET Lab. Research program on Plutonium in 1943

(Abstract from Smyth, 1945)

Many of the topics listed are not specific research problems such as might be solved by a small team of scientists working for a few months but are whole fields of investigation that might be studied with profit for years. It was necessary to pick the specific problems that were likely to give the most immediately useful results but at the same time it was desirable to try to uncover general principles. For example, the effect of radiation on the properties of materials ("radiation stability") was almost entirely unknown.

"Product Production Studies.—These include all aspects of the research, development and semi-works studies necessary for the design, construction, and operation of chain-reacting piles to produce plutonium or other materials.

Pile characteristics.—Theoretical studies and experiments on lattice structures to predict behavior in high level piles, such as temperature and barometric effects, neutron characteristics, pile poisoning, etc.

Control of reacting units.—Design and experimental tests of devices for controlling rate of reaction in piles.

Cooling of reacting units.—Physical studies of coolant material, engineering problems of circulation, corrosion, erosion, etc.

Instrumentation.—Development of instruments and technique for monitoring pile and surveying radiation throughout plant area.

Protection.—Shielding, biological effects of radiation at pile and clinical effects of operations associated with pile.

Materials.—Study of physical (mechanical and nuclear) properties of construction and process materials used in pile construction and operation.

Activation investigations.—Production of experimental amounts of radioactive materials in cyclotron and in piles and study of activation of materials by neutrons, protons, electrons, gamma-rays, etc.

Pile operation.—Study of pile operation procedures such as materials handling, instrument operation, etc.

Process design.—Study of possible production processes as a whole leading to detailed work in other categories.

"Product Recovery Studies.—These include all aspects of the work necessary for the development of processes for the

possible by-products from the ation in purified form. Major laboratory will be on a single 1943 for the production of will continue to be studied laboratory and Clinton with ble.

solution of uranium, extrac- mination by removal of

and product reduction.—Proc- of plutonium as pure metal, tonium necessary to its pro-

sible methods of recovery of on wastes.

ment and testing of instru- cal processes and surveying i.

fies, determination of bio- ists, liqu- tive me- uipmen- rity an-

ls.—De- ated m- ted m-

Operations studies.—Equipment performance, process control, material handling operations, etc.

Process design.—Study of product recovery processes as a whole (wet processes, physical methods) leading to detailed work in other categories.

"Fundamental Research.—Studies of the fundamental physical, chemical and biological phenomena occurring in chain-reacting piles, and basic properties of all materials involved. Although the primary emphasis at Clinton is on the semi-works level, much fundamental research will require Clinton conditions (high radiation intensity, large scale processes).

Nuclear physics.—Fundamental properties of nuclear fission such as cross section, neutron yield, fission species, etc. Other nuclear properties important to processes, such as cross sections, properties of moderators, neutron effect on materials, etc.

General physics.—Basic instrument (electronic, ionization, optical, etc.) research, atomic mass determinations, neutron, α -, β -, γ -radiation studies, x-ray investigations, etc.

Radiation chemistry.—Effects of radiation on chemical processes and chemical reactions produced by radiation.

Nuclear chemistry.—Tracing of fission products, disintegration constants, chains, investigation of nuclei of possible use to project.

Product chemistry.—Chemical properties of various products and basic studies in separation and purification of products.

General chemistry.—Chemistry of primary materials and materials associated with process, including by-products.

General biology.—Fundamental studies of effects of radiation on living matter, metabolism of important materials, etc.

Clinical investigations.—Basic investigations, such as hematology, pathology, etc.

Metallurgical studies.—Properties of U, Pu, Be, etc.

Engineering studies.—Phenomena basic to corrosion and similar studies essential to continued engineering development of processes."

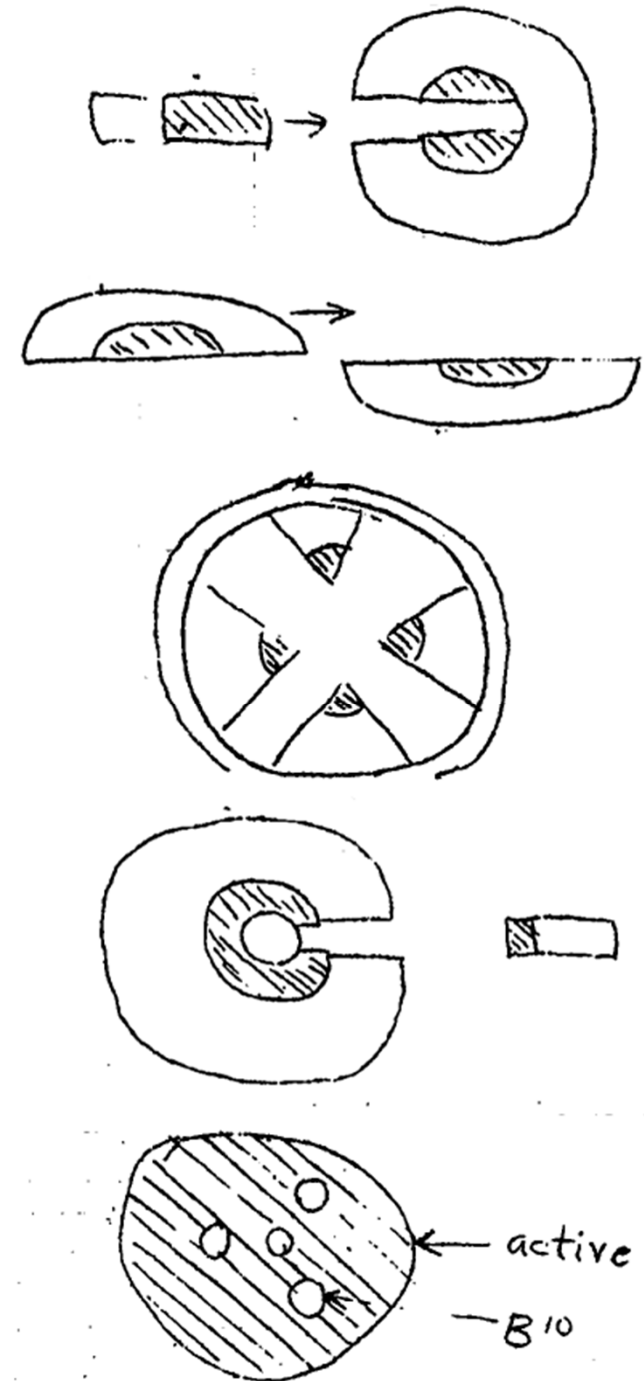
7.47. An examination of this program gives an idea of the great range of investigations which were considered likely to give relevant information. Many of the topics listed are not specific research problems such as might be solved by a small team of scientists working for a few months but are whole fields of investigation that might be studied with profit for years. It was necessary to pick the specific problems that were

Highly generative
design space

Alternative bomb designs (july 1942)

A number of the different fission bomb assembly methods explored during the summer 1942 conference, later reproduced as drawings in *The Los Alamos Primer* :

- Gun method
- Implosion method
- Autocatalytic method
- ...



“Never in history has anyone embarking on an important undertaking had so little certainty about how to proceed as we had then.

General Leslie R. Groves, Manhattan Project Director
(in Groves, *Now it can be told*, 1962, p. 72).

III. Le management de l’exploration dans l’inconnu

Is it manageable ?

A typical case of *unforeseeable uncertainties* or *unknown unknowns* (Loch & al., 2006)

Groves : “*the whole endeavour was founded on possibilities rather than probabilities. Of theory there was a great deal, of proven knowledge, not much*” (1962, p. 19) .

=> Nobody can predict the unfolding of the project

Proceeding in the dark

(Met Lab, Chicago, october 5 1942)

“As the meeting was drawing to a close, I asked the question that is always of uppermost in the mind of an engineer : with respect to the amount of fissionable material needed for each bomb, **how accurate did they think their estimate was ? I expected a reply of “within twenty-five or fifty percent,” and would not have been surprised at an even greater percentage, but I was horrified when they quite blandly replied that they thought it was correct within a factor of ten.**

This meant, for example, that if they estimated that we would need on hundred pounds of plutonium for a bomb, the correct amount could be anywhere from ten to one thousand pounds. **Most important of all, it completely destroyed any thought of reasonable planning for the production plants of fissionable materials.** My position could well be compared with that of a caterer who is told he must be prepared to serve anywhere between ten and a thousand guests. But after extensive discussion of this point, I concluded that is imply was not possible then to arrive at a more precise answer.

“While I had known that **we were proceeding in the dark,** this conversation brought it home to me with the impact of a pile driver. **There was simply no ready solution to the problem we faced, except to hope that the factor of error would prove to be not quite so fantastic.**” (Groves, 1962, p. 40)

Groves's strategy : concurrent engineering and parallel strategy

- Considering unforeseeable uncertainties Groves adopted a **parallel strategy** i.e. **explore and implement simultaneously the different solutions.**
- Given the importance of time, they proceed concurrently **doing fundamental research, designing and building the plant simultaneously.**
 - Ex : the building of K25 begins long before the gaseous diffusion process was stabilized; 13 processes were under study when Hanford building starts, etc.
- As Groves explains
 - « *I had decided almost at the very beginning that we have to abandon completely all normal orderly procedures in the development of the production plants. We would go ahead with their design and construction as fast as possible, even though we would have to base our work on the most meager laboratory data.* » (Groves, 1962, p. 72).
 - « *Always we assumed success long before there was any real basis for the assumption; in no other way could we telescope the time required for the over-all project. We could never afford the luxury of awaiting the proof of one step before proceeding with the next* » (ibid. p. 253).

Groves's strategy : concurrent engineering and parallel strategy

- Considering unforeseeable uncertainties Groves adopted a **parallel strategy** i.e. **explore and implement simultaneously the different solutions.**
- Given the importance of time, they proceed concurrently **doing fundamental research, designing and building the plant simultaneously.**
 - Ex : the building of K25 begins long before the gaseous diffusion process was stabilized starts, etc.

- As Groves ex
 - « I had de
all norma
would go
though we
(Groves,

– « Always
assumptio
all projec
before pro

Groves's Philosophy

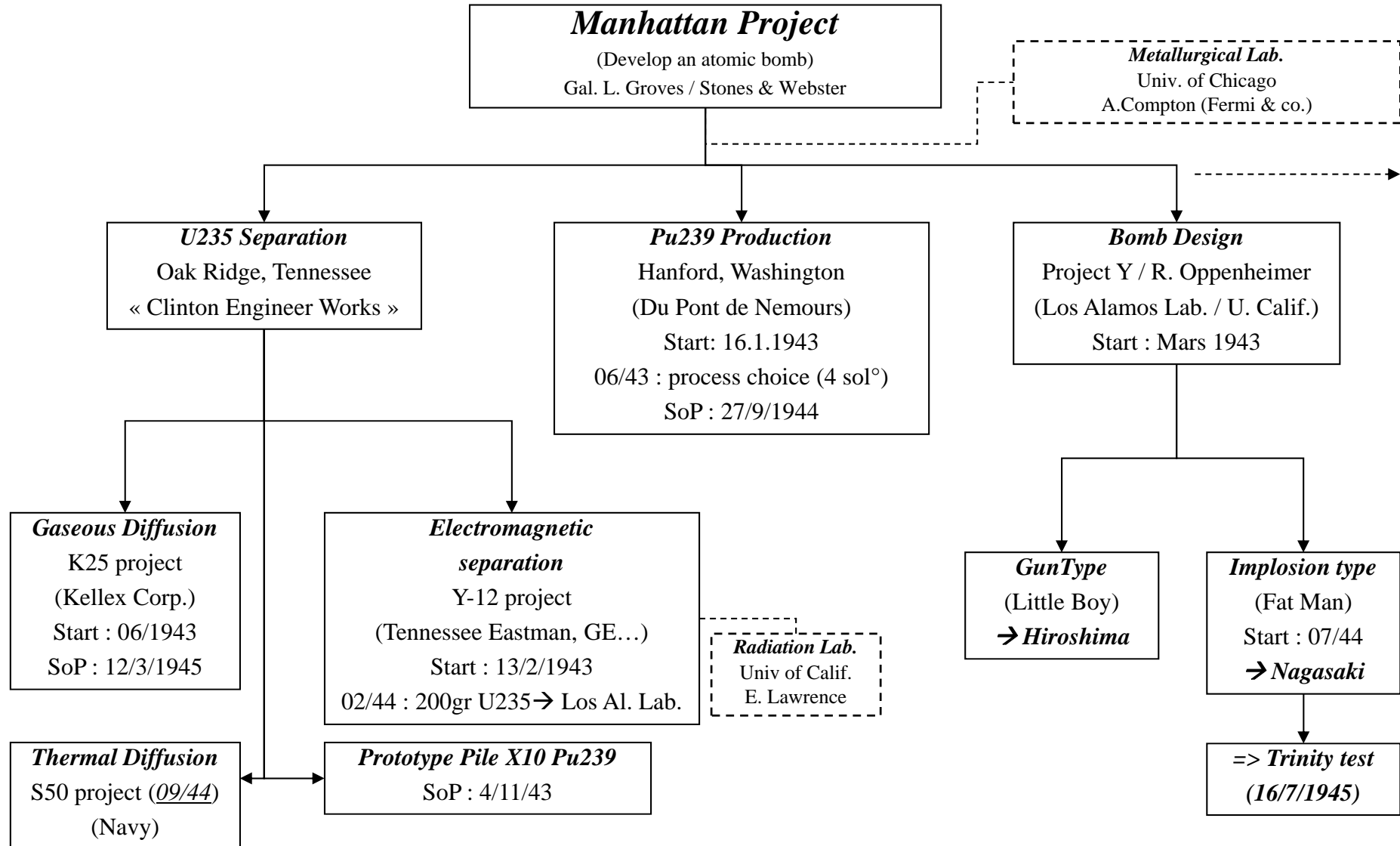
“A wrong decision that brought quick results was better than no decision at all. If there were a choice between two methods, one of which was good and the other promising, build both. Time was more important than money, and it took times to build plants.”

(during the Technical Council, October 5, 1942 in Hewlett & Anderson, 1962, p. 181).

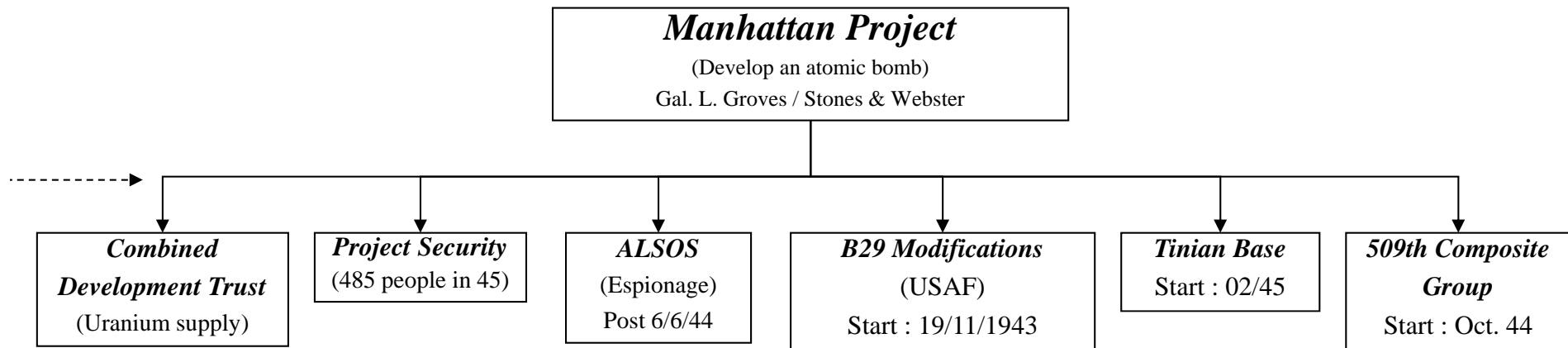
don completely
on plants. We
ible, even
ratory data. »

s for the
for the over-
f of one step

Ex-post « WBS » of the Manhattan Project

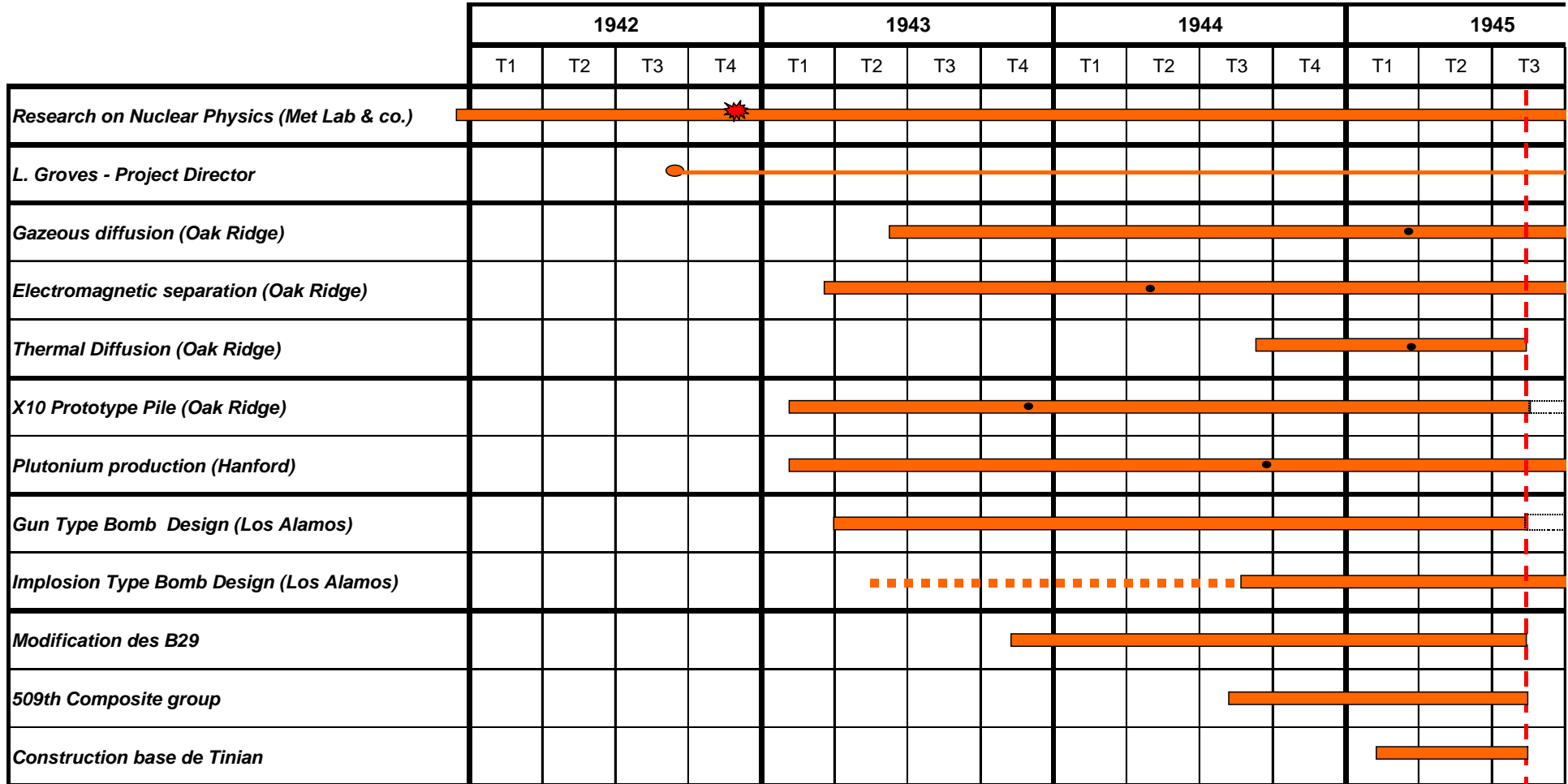


Ex-post « WBS » of the Manhattan Project



« From the problems of reactor design to the health of fish in the Columbia River and the condition of women's shoes covers a considerable range of problems, and obviously they were not of equal importance. But they all mattered in the job we were trying to do. » (Groves, 1962, p. 93).

« Planning » of the Manhattan Project

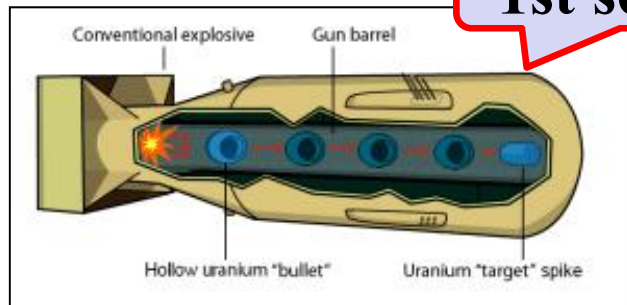


Hiroshima (6 août 1945)

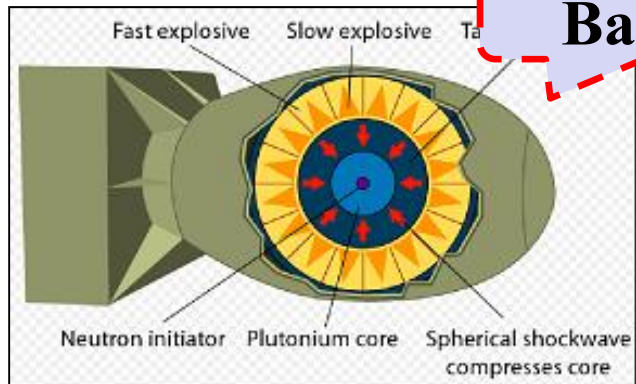
Nagasaki (9 août 1945)

The spontaneous fission crisis (april 1944)

Bomb designs



1st solution



Back-up

Fissionable materials

1st solution

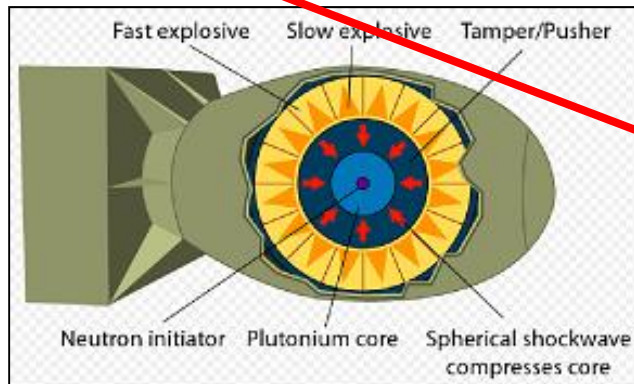
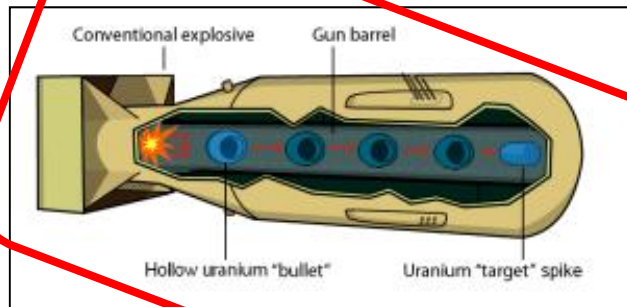
Uranium 235

Back-up

Plutonium 239

The spontaneous fission crisis (april 1944)

Bomb designs



Fissionable materials

Very hard to produce

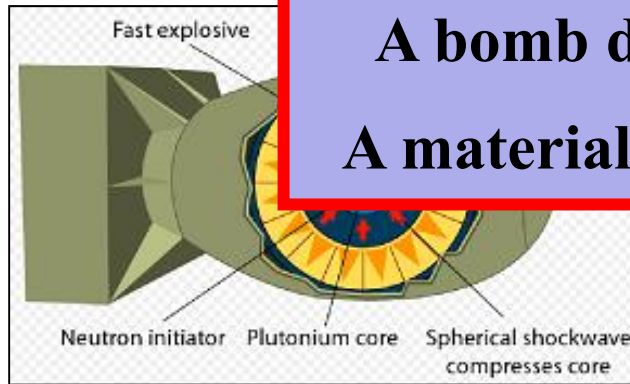
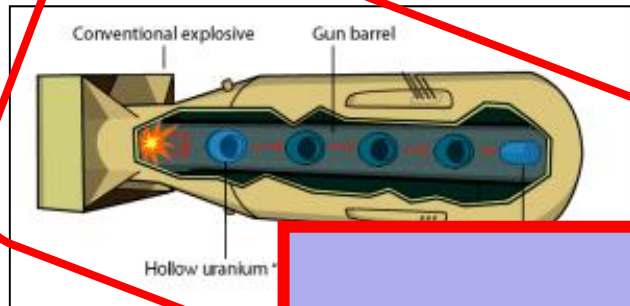
Uranium 235

Plutonium 239

**First priority :
Gun + Pu 239.**

The spontaneous fission crisis (april 1944)

Bomb designs



Fissionable materials

Very hard to produce

Uranium 235

The deadlock :

A bomb design (Gun) without a material

A material (Pu 239) without a bomb design

Plutonium 239

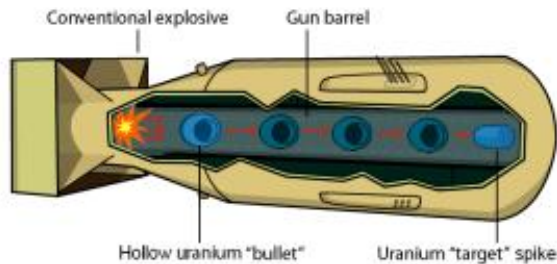
First produced
Gun + 1

*Spontaneous fission of
Pu => impossible*

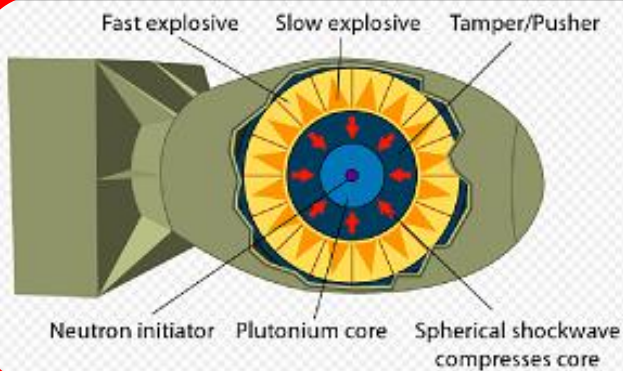
The spontaneous fission crisis (april 1944)

Bomb designs

Fissionable materials



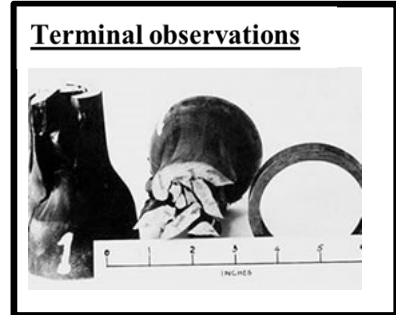
Uranium 235



Plutonium 239

In 2 weeks (end of July 44) Oppenheimer entirely reorganized Los Alamos to tackle the implosion problem => 2 solutions designed in parallel

Experimenting on implosion : multiple and overlapping approaches



Date of the experiment	1943	1944	1945
1 Terminal observations	[Timeline bar from early 1943 to early 1945]		
2 X-ray photography	[Timeline bar from mid-1943 to mid-1944]		
3 Optical photography	[Timeline bar from mid-1943 to early 1945]		
4 RaLa method	[Timeline bar from mid-1944 to early 1945]		
5 Betatron method	[Timeline bar from mid-1944 to early 1945]		
6 Magnetic method	[Timeline bar from mid-1944 to early 1945]		
7 Electric pin method	[Timeline bar from mid-1944 to early 1945]		



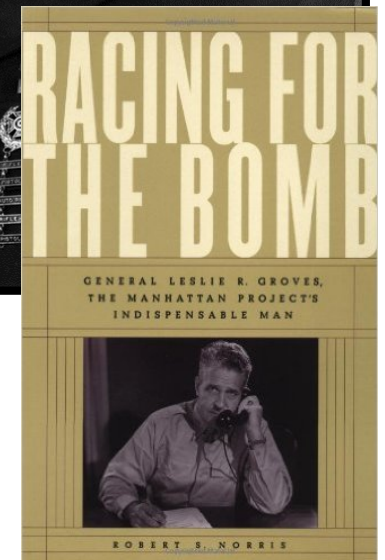
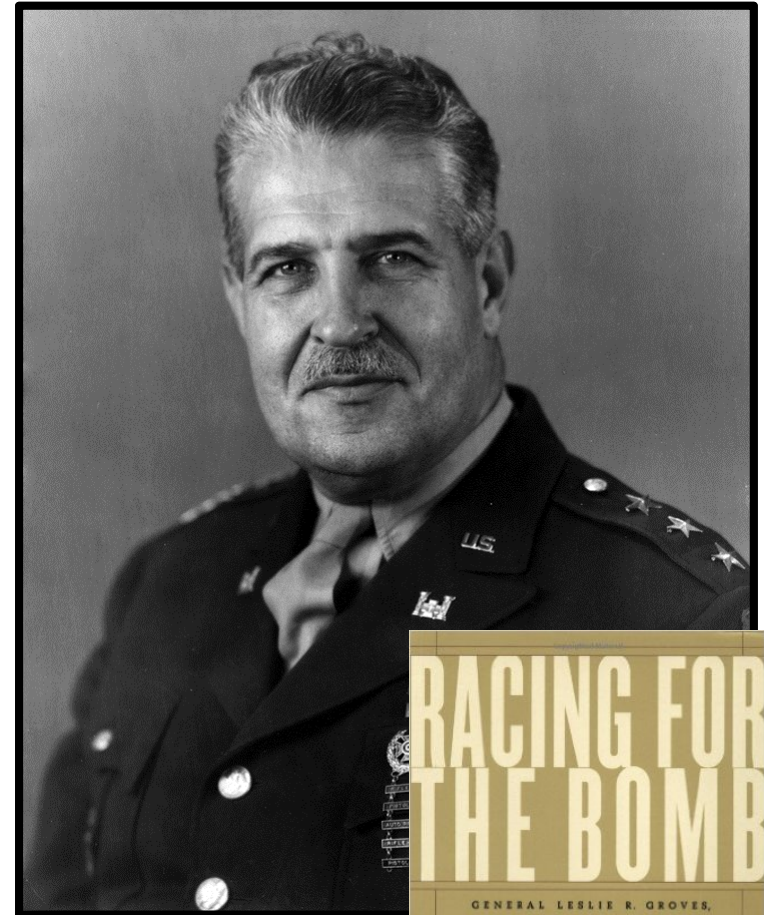
“The history of the seven-pronged experimental program to study implosion (...) is one of *painstaking progress with few highlights or definitive measurements, many ambiguous steps, and numerous failures*” (in Hoddeson & al., p. 268).



II. La création d'une organisation pour l'exploration (rapide)

Le PROJET Manhattan

- Jusqu'en septembre 1942 le travail est réparti entre les principales universités américaines... et avance lentement.
 - La situation change radicalement avec la nomination du Général Leslie Groves comme directeur de projet.
 - Manhattan est, avec le Rad Lab du MIT, l'archétype de l'alliance entre la science, l'armée et l'industrie à une échelle inédite jusque-là.
- => rupture sociale et organisationnelle qui va permettre une exploration extraordinairement riche et efficace.



« *Manhattan Project's indispensable nan* »

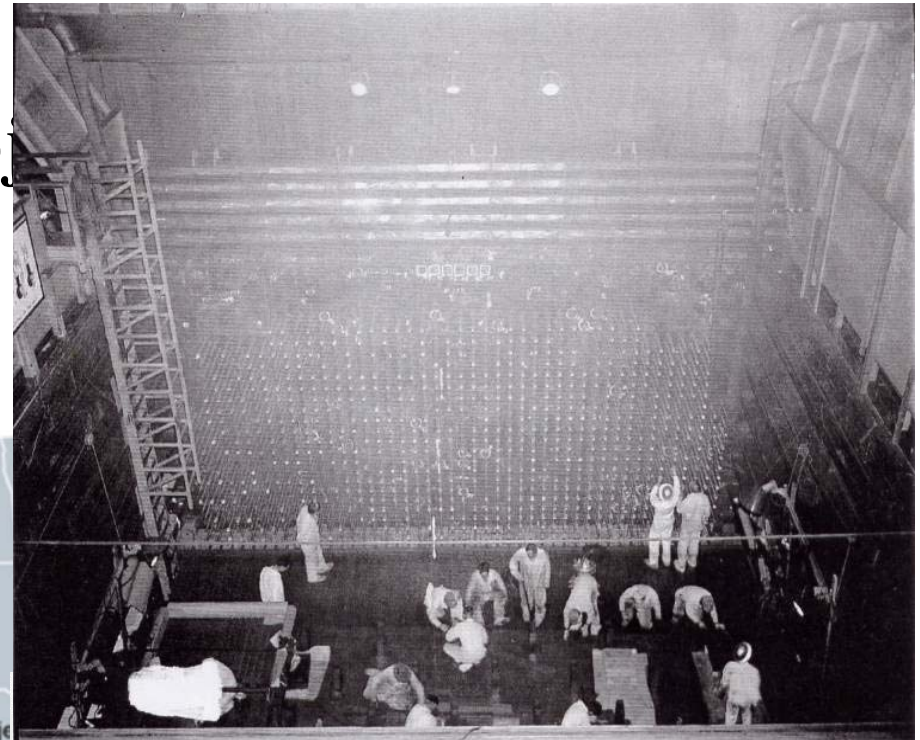
“General Groves is the biggest S.O.B I have ever worked for. He is most demanding. He is most critical. He is always a driver, never a praiser. He is abrasive and sarcastic. He disregards all normal organizational channels. He is extremely intelligent. He has the guts to make timely, difficult decisions. He is the most egostical man I know. He knows he is right and so sticks to his decision. He abounds with energy and expects everyone to work as hard or even harder than he does... if I had to do my part of the atomic bomb project over again and had the privilege of piking my boss I would pick General Groves” (K. Nichols, in Reed, 2014, p. 165).

“General Groves is a man of extraordinary ability and capacity to get things done. Unfortunately, it took more contact with him than most people had to overcome a bad first impression. He was in fact the only person I have known who was every bit as good as he thought he was. He has intelligence, he had good judgment of people, he had extraordinary perceptiveness and an intuitive instinct for the right answer. In addition to this, he had a sort of catalytic effect on people. Most of us working with him performed better than our intrinsic abilities indicated.” (J. Lansdale, Head of Security, *ibid*)

Les sites du projet Manhattan



Les sites du projet



L'alliance science / armée / industrie : Hanford

- Les différentes parties du projet fonctionnent sur un tryptique :
 - Maitrise d'ouvrage militaire
 - Maitrise d'œuvre confiée à des entreprises privées (sauf Los Alamos = University of California)
 - Laboratoire de recherche

Ex Hanford : Army (col. Matthias) / Du Pont / MET Lab (Univ. of Chicago)

Chez DuPont : TNX Division + C. Greenewald, liaison avec le MET Lab

=> Sur les différents sites il y a donc une double hiérarchie militaire / civile.

- Les sites sont « government owned / contractor operated ». Contrats « Cost plus fixed fee » souvent sans appel d'offre (fee de DuPont = 1\$)
- On note aussi de multiples comités de pilotages (politiques/militaires/scientifiques) pour discuter de l'évolution du projet chemin-faisant.

When Science meet Engineering :

Designing Hanford's B Pile

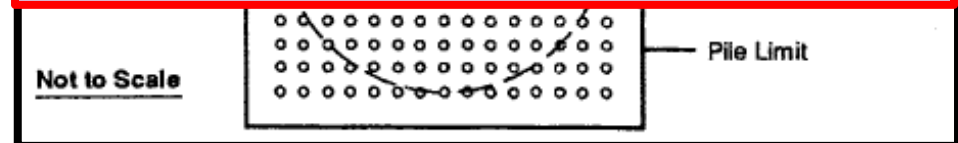
Conflict between DuPont Engineers and MetLab Scientists.

- **Scientists** (E. Wigner) claimed the leadership because of the novelty of the process and balked at the idea of a semi-work to learn before full-scale production
- **DuPont** (C. Greenwalt), on the contrary plead for
 - a progressive approach based on his experience of industrial scale-up
 - overdesign of the pile to manage uncertainty

=> *Overdesign help to overcome the unknown « xenon poisoning effect ».*

“No mechanism yet devised for unloading and sorting, no flow sheet, operating manual or program. No clear idea as to what Du Pont is expected to do — Hell! The first thing to do is to work out an operating organization. ... I believe we *must* infiltrate pile design in spite of the fact that we aren't very welcome.”

C. Greenwalt diaries, 28 december 1942,
in Galison, p. 254.

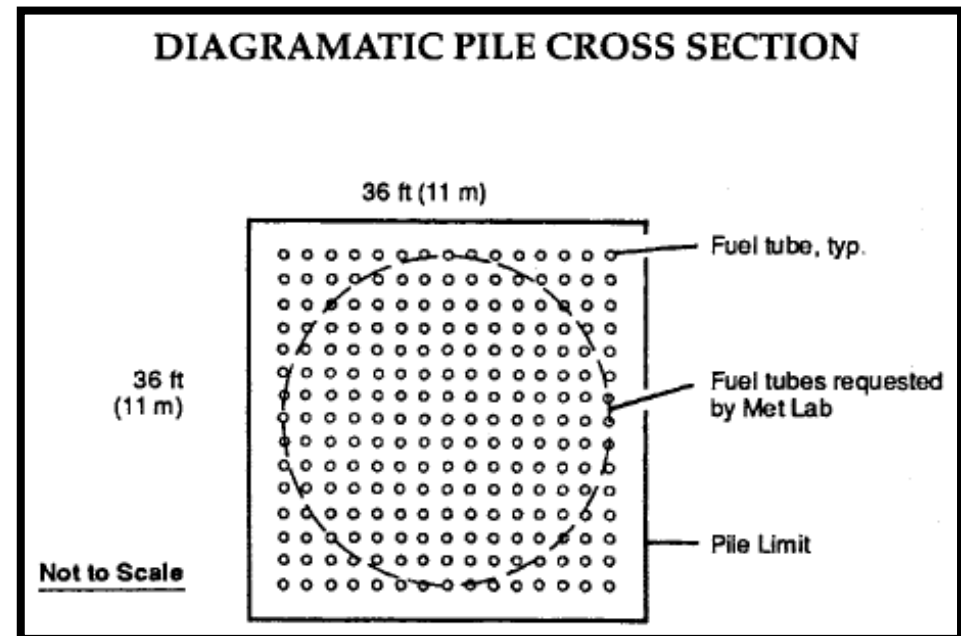


When Science meet Engineering :

Designing Hanford's B Pile

Conflict between DuPont Engineers and MetLab Scientists.

- **Scientists** (E. Wigner) claimed the leadership because of the novelty of the process and balked at the idea of a semi-work to learn before full-scale production
- **DuPont** (C. Greenwalt), on the contrary plead for
 - a progressive approach based on his experience of industrial scale-up
 - overdesign of the pile to manage uncertainty



=> *Overdesign help to overcome the unknown « xenon poisoning effect ».*

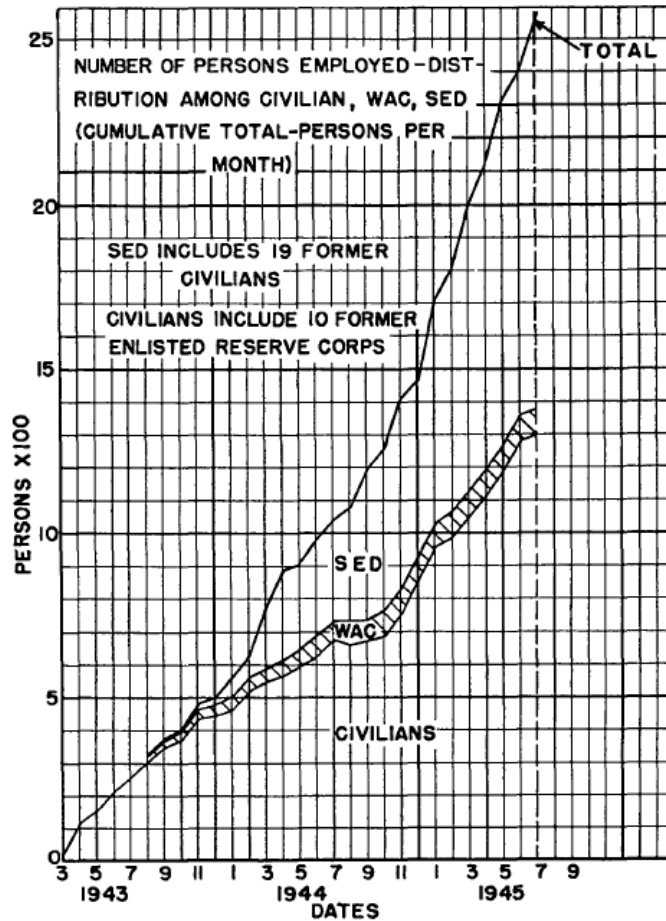
Les sites du projet Manhattan



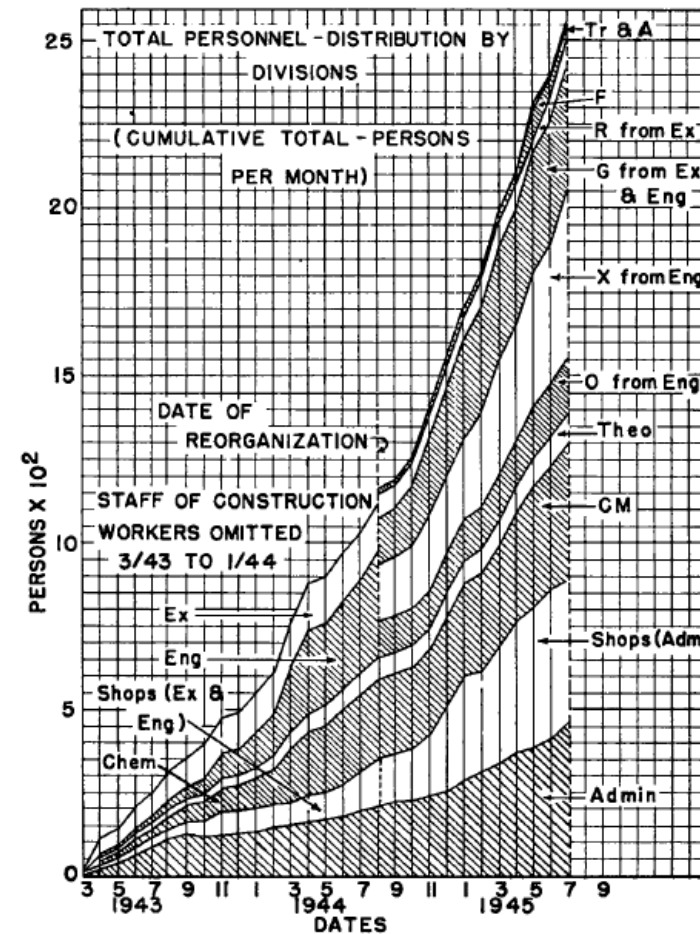
Los Alamos as a prototype organization (1)

- Los Alamos is not a “research laboratory”, it is project-oriented and closer to an “innovation” logic i.e. exploring a new design space in C/K (Le Masson & al., 2006)
 - ⇒ new type of “trading zone” between scientist and engineers (Galison, 1997).
- Los Alamos
 - Has to manage an exponential growth of a 2 years period
 - Experienced a sequence of reorganization during the war

Los Alamos as a prototype organization



Graph Number 2. Number of Persons Employed - Distribution among Civilians, WAC, SED



Graph Number 5. Total Personnel - Distribution by Divisions

« ...a continual state of flux and turbulence »

« Construction on the project began in January 1943 with approximately 1500 workers. Scientific personnel began to arrive on a permanent basis in March 1943 and, by the end of the year, the population has reached an estimated 3500. This rose to 5765 by December 1944, and by June 1945 the total population has reached a wartime peak of 8750. *These figures stand in marked contrast with early projections, by Oppenheimer and his fellow scientists, about the likely scale of the project. Oppenheimer's original guess was that perhaps as few as six scientists (or, with support personnel, several hundreds) might do the job.* (...) Both the laboratory and the post expanded beyond all expectations as new configurations of scientific knowledge, technological activity and organizational form were thrown up as emergent properties of the work ». (p. 556). [As a result] « throughout the war, the organisation of Los Alamos was in a continual state of flux and turbulence ». (p. 557)

Los Alamos as a prototype organization (2)

- The laboratory structure “*was by nature ephemeral; experiments and responsibilities changed overnight as priorities that the war gave to the project changes*” (Hoddeson & al, 1993, p. 247). Ex : the spontaneous fission crisis
- It moved from an academic-like laboratory to a huge scientific-industrial complex => Los Alamos became more and more structured (*weaponized* in Thorpe & Shapin, 2000) moving quickly from research to development and production in late 1944 and throughout 1945.

Example

- The implosion design was frozen very late (probably on February 28, 1945). Oppenheimer then created the “cowpuncher committee” to manage the final phase of the work like a crash program...
- ... without stopping long-term research (the “Super”,...)

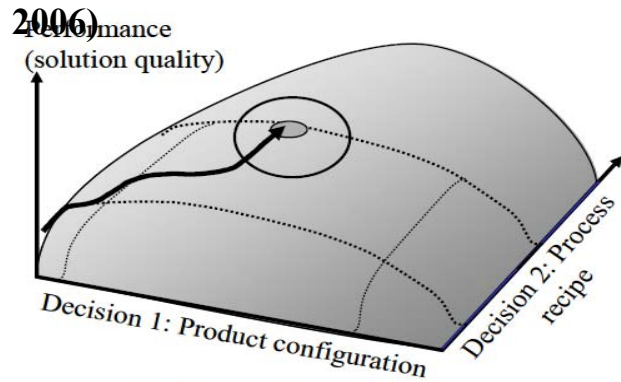
A sensemaking process

- « The basic idea of sensemaking is that reality is an ongoing accomplishment that emerges from efforts to create order and make retrospective sense of what occurs. (...) It is about contextual rationality. It is built out of vague questions, muddy answers, and negotiated agreements that attempt to reduce confusion » (Weick, 1993, pp. 634-636)
- « The task of sensemaking resembles more closely the activity of cartography. There is some terrain that mapmakers want to represent, and they use various modes of projection to make this representation. What they map however depends on where they look, how they look, what they want to represent and their tools for representation. (...) The terrain is not itself already mapped such that the job of the sensemaker is to discover this preexisting map. For mapmakers the idea of a pre-ordered world has no place or meaning » (Weick, 2001, p. 9).

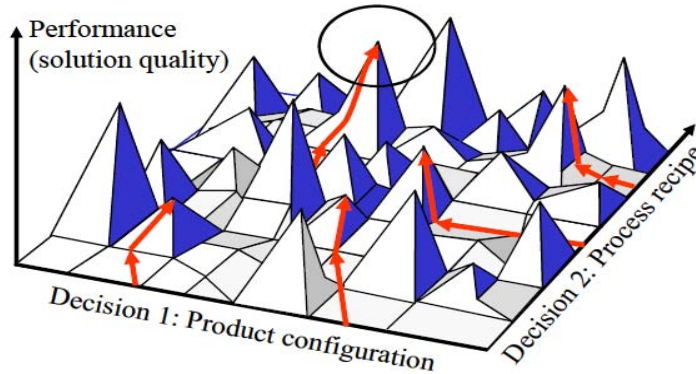
=> How to manage the dynamic of this type of project

- Role of Project Management : Groves / Oppenheimer
- Plenary meetings e.g. the Colloquium at Los Alamos

Search on « rugged landscapes » (Loch & al., *Managing the unknown*,



Performance landscape: a design parameter configuration is associated with a performance, or “solution quality”, measure. Here, the landscape is non-complex (non-rugged), with a small number of “good” solutions (here: one performance peak). The team can find the best solution by incrementally changing the two design parameters in a series of steps in the direction of increasing performance.



Complex, or “rugged”, performance landscape. It has many “good” solutions (performance peaks), and low and high performance configurations are adjacent. Complexity prevents global search (the peaks are not known); only incremental search (step wise improvements) is possible. However, any incremental search will get “stuck” at a local peak. It is known from systems engineering that higher complexity demands more parallel searches, as shown.

Figure 1: Planning and Selectionism under Low Unforeseeable Uncertainty

accomplishment that
sense of what occurs.
questions, muddy
confusion » (Weick,

of cartography.

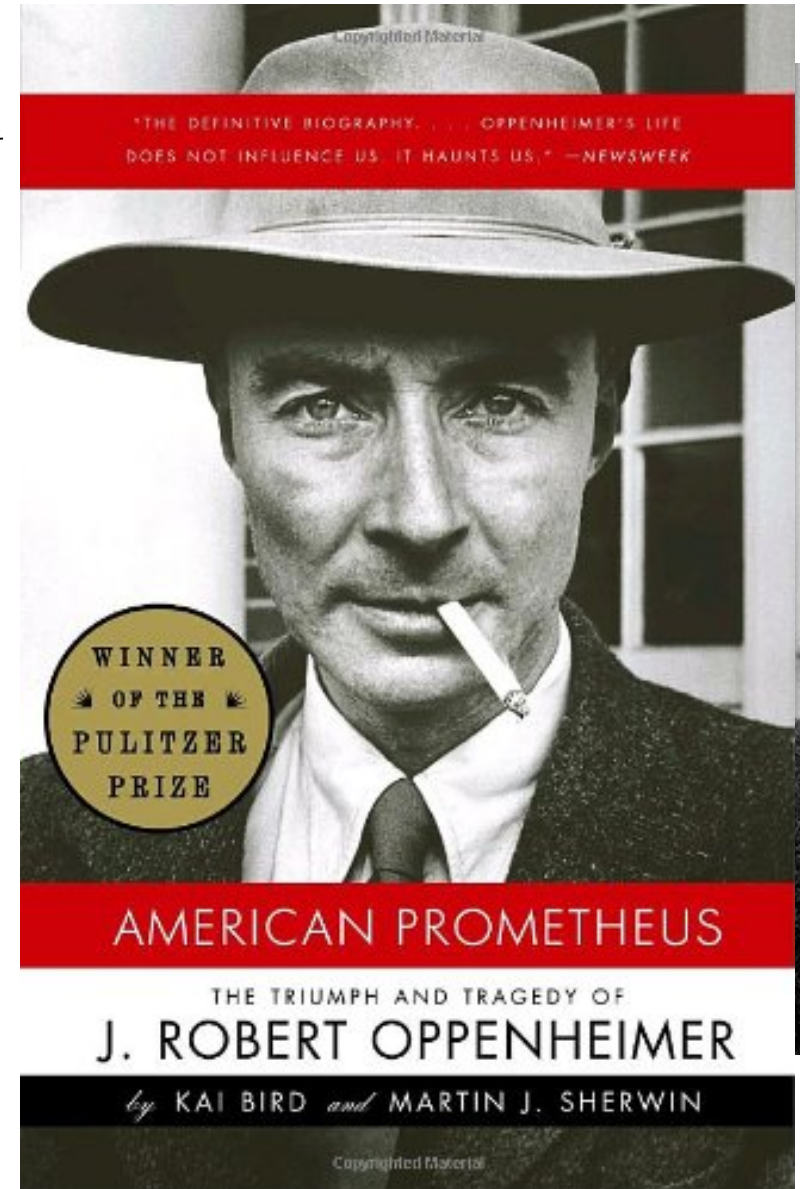
“Like scouts on a vital mission through unexplored territory, Lawrence’s subordinates could not wait for maps to be prepared for their journey; they would have to strike out for their destination and hope that they would stumble on the shortest and easiest route. Experiments, not theory, had been the keynote at Berkeley. The magnetic shims, sources, and collectors that gave the best results were used, although no one could explain their superiority” (Hewlett & Anderson, p. 142)

T
m
O
re
th
P
=> H

J.R. Oppenheimer

“He did not direct from the head office. He was intellectually and even physically present at each decisive step. He was present in the laboratory or in the seminar rooms, when a new effect was measured, when a new idea was conceived. It was not that he contributed so many ideas or suggestions; he did so sometimes, but his main influence came from something else. It was his continuous and intense presence, which produced a sense of direct participation in all of us; it created that unique atmosphere of enthusiasm and challenge that pervaded the place throughout its time”.

V. Weisskopf, A memorial to Oppenheimer,
Physics Today, vol. 20, n°10, 1967



The colloquium

“The Colloquium, more than any other local organizational form, was understood both to express and to enable solidarity and integration. Los Alamos scientists were, almost without exception, highly concerned that each should have an overall sense of how their specialized work fitted into the specialized work being done by others, and into the instrumental goals of the laboratory as a whole. Information, they reckoned, should circulate throughout the laboratory as efficiently as practicable. (...) The solution was simply to provide for more face-to-face and free interaction, to encourage meetings and discussions at as many levels as possible and among as many specialized work groups as possible. This is how and why the weekly Colloquium for all staff members assumed such importance. The Colloquium was considered important as a means of disseminating information, and also as a way of creating solidarity and face-to-face accountability. (p. 570) (...) General Groves agreed that the Colloquium 'existed not so much to provide information as to maintain morale and a feeling of common purpose and responsibility'.”

On retrouve ce type de dispositif (war rooms) partout (Atlas, Polaris, Sidewinder...)

Los Alamos :organizational charts as sensemaking

- [In this context] « the production and displays of organizational charts were interesting to participants as *symbolic representation of coherence and stable order amid uncertainty and change*. So the mathematician Stanislaw Ulam write of the Los Alamos ‘fascination with organizational charts. At meetings... whenever an organizational chart was displayed, I could feel the whole audience come to life with pleasure at seeing something concrete and definite’. *This symbolic display of coherence was one way of making the organization appear legitimate and functional* » (p. 557)
- However this does not preclude colonel Tyler, post commander in early in 1945 to say « ‘that he had been unable to find any organizational chart which had any meaning’ » (p. 558)

IV. L'héritage expansif du projet Manhattan

End result

Hiroshima, August 6, 1945, 8:16 am



Nagasaki, August 9, 1945, 11:01 am



**Surrender of Japan,
August 14, 1945**

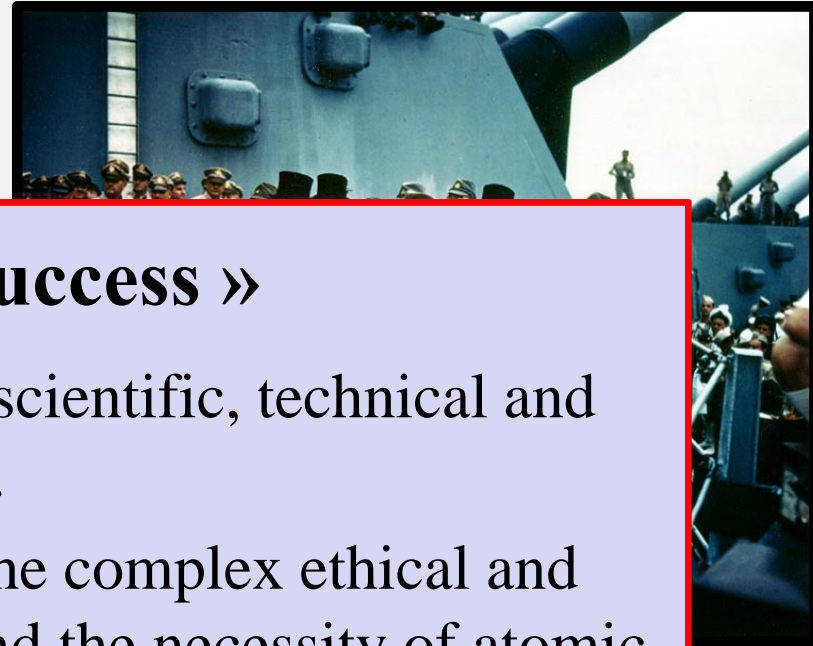


End result

Hiroshima, August 6, 1945, 8:16 am



Surrender of Japan,
August 14, 1945



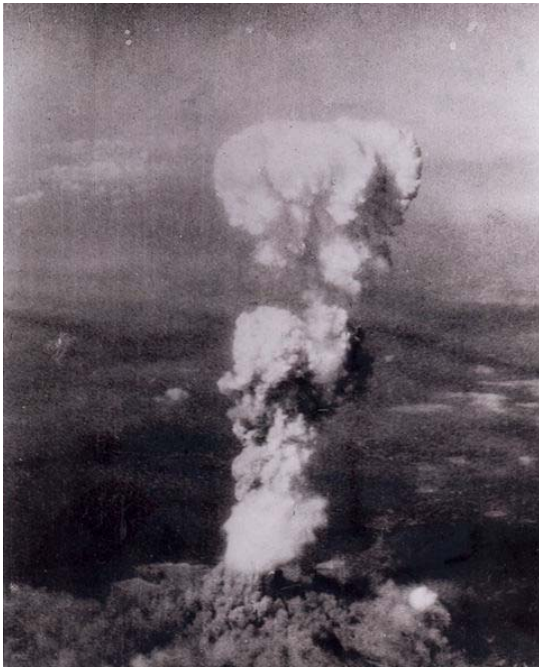
Nagasaki



→ **Complete « success »**

Remains an incredible scientific, technical and military achievement...

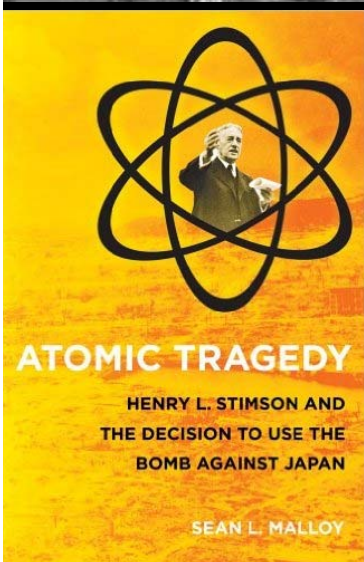
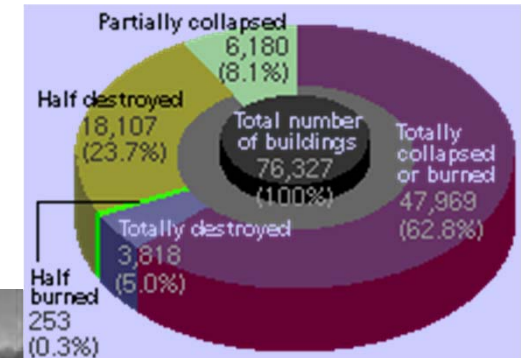
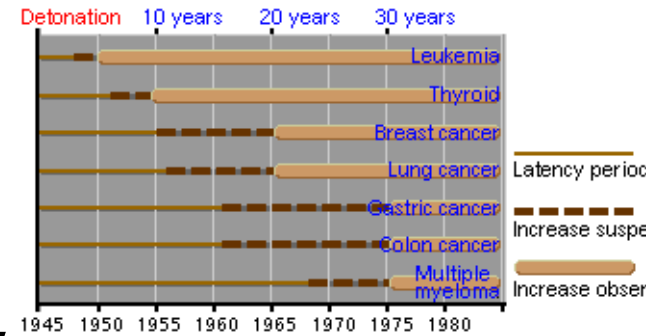
... but we leave aside the complex ethical and historical debates around the necessity of atomic bombing and the long-term consequences (ensuing Cold War, arm race, etc).



Never forget...

Hiroshima, August 6, 1945

140 000 people killed at the end of 1945



« La civilisation mécanique vient de parvenir à son dernier degré de sauvagerie. Il va falloir choisir, dans un avenir plus ou moins proche, entre le suicide collectif ou l'utilisation intelligente des conquêtes scientifiques. »

Albert Camus, *Combat*, 8 août 1945.



Los Alamos as « *an ideal republic* ».

« Now I could see at first hand the tremendous intellectual power of Oppenheimer who was the unquestioned leader of our group... The intellectual experience was unforgettable (...) There was other laboratories of high achievement... but I've never observed in any one of the other groups quite the spirit of belonging together, quite the urge to reminisce about the days of the laboratory, quite the feeling that this was really the great times of their lives. That this was true of Los Alamos was mainly due to Oppenheimer. »

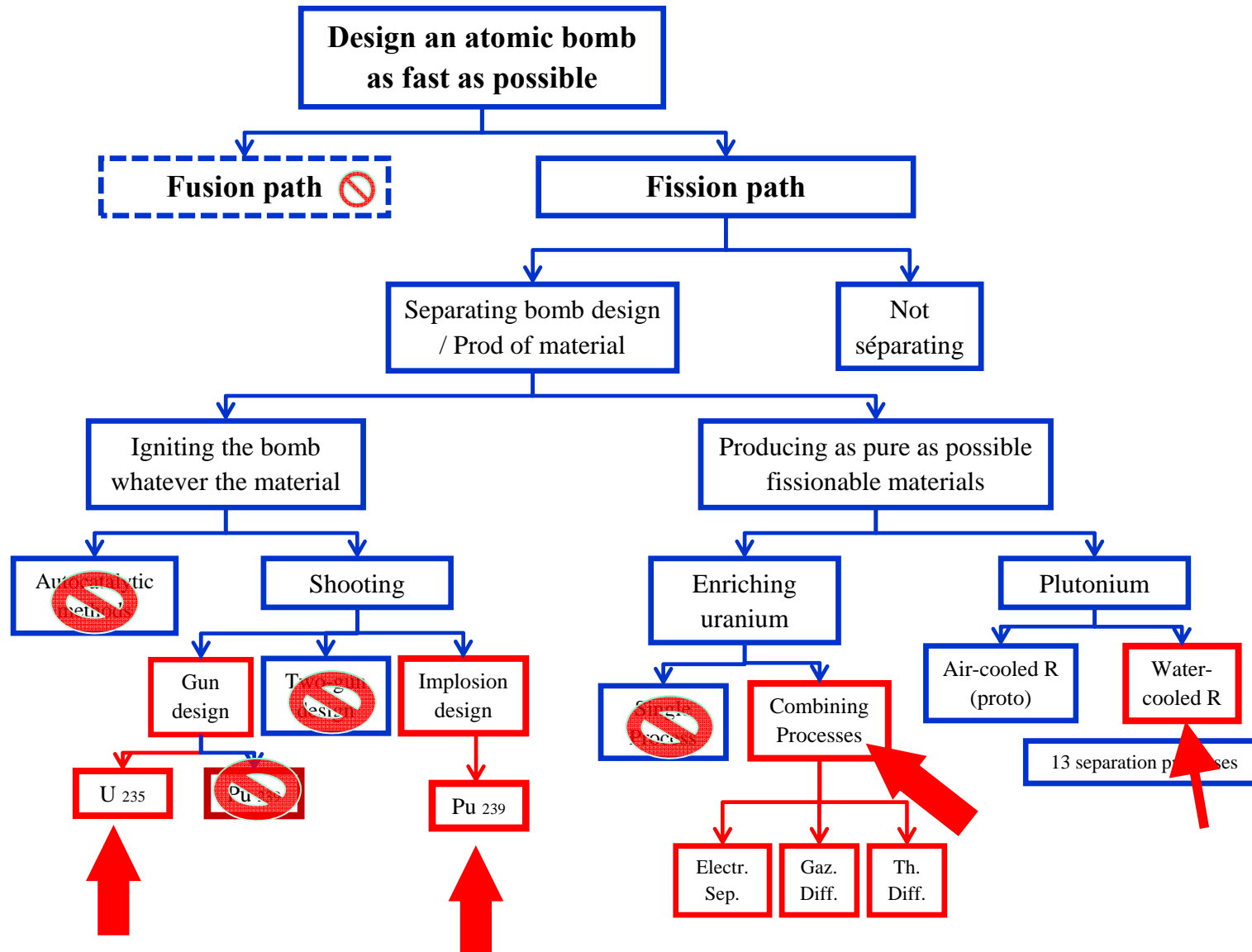
Hans Bethe, (quoted in Bird and Sherwin, 2005).

« Here at Los Alamos, I found a spirit of Athens, of Plato, of an ideal republic »

J. Tuck, (quoted in Bird and Sherwin, 2005).

Building the foundations for lineages of « products »

(Lenfle, 2012 ; Lenfle, Le Masson & Weil, 2016)



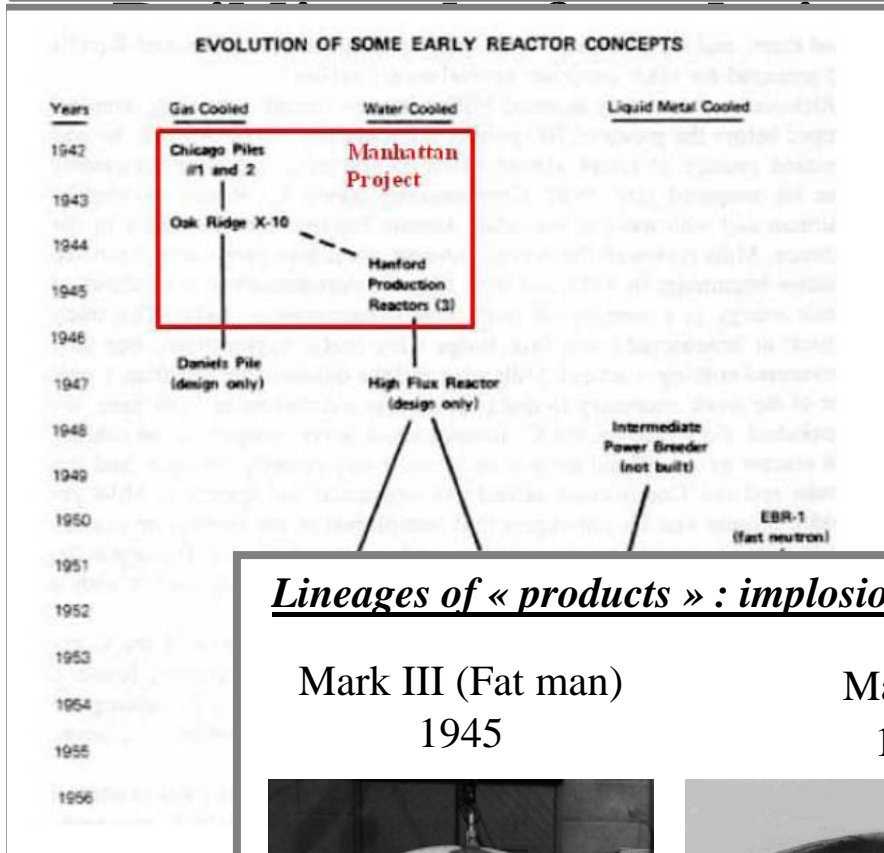
Decision to
 > combine enrichment process
 > add thermal diffusion (navy)

DuPont overdesigned the reactor => Xenon poisoning pb solved

Switch to Implosion / Pu as first priority => new K
 > hydrodynamics of implosion
 > Electronics
 > Science of explosives
 > ...

Uranium / Gun design proceed

Nuclear reactor design (1942 – 1956)



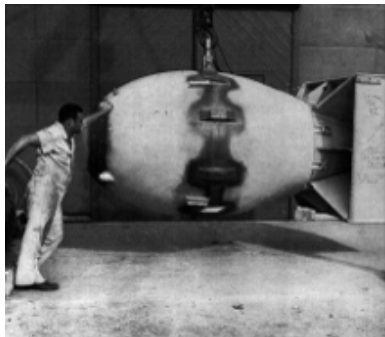
S
e.

pa

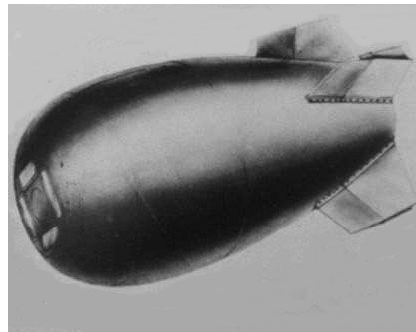
- “Technological contributions cover the full range of science and technology, from chemistry, physics and the science of explosives to the revolutions in electronics and microelectronics”. (Hoddeson & al, 1993, p. 416)
- This knowledge was transmitted through people, articles, blueprints, plants, labs, books and courses via the Atomic Energy Commission (founded august 1, 1946)

Lineages of « products » : implosion bombs (1945 – 1954 & after)

Mark III (Fat man)
1945



Mark IV
1949



Mark VI
1951



- Mark 13 (1952 ?)
- Mark 18 (1953)
- ...

Automatic

G
de

U 235

Sources : <http://nuclearweaponarchive.org/Usa/Weapons/Allbombs.html> / Rosenberg, 1983 / Wikipedia.org

“The ‘nominal’ 20 kiloton yield of the Mark 3 bomb was multiplied by 25 times between 1948 and 1952.” (Rosenberg, 1983)

Early Computing at Los Alamos

N. METROPOLIS AND E. C. NELSON

Computing at the Los Alamos Scientific Laboratory evolved during World War II from hand calculation through punched-card computation to electronic computing on the ENIAC. The paper describes the evolution of the methods and their applications: computations of equations in nuclear reactions in developing the atomic bomb.

Categories and Subject Descriptors: K.2 [History of Computing]—hardware, people

General Terms: Human Factors, Performance

Additional Key Words and Phrases: Los Alamos, hand computing, punched-card computation, ENIAC, J. von Neumann



**JOHN VON NEUMANN
and THE ORIGINS OF
MODERN COMPUTING**
WILLIAM ASPRAY

1. Introduction

During World War II, computing at the Los Alamos Scientific (now National) Laboratory (LASL) evolved from hand computing (1943), supported by mechanical calculators, through punched-card computation, to electronic computing on the ENIAC (1945). Computing applications ranged from computational support for experimental work to critical-mass calculations and the hydrodynamics of implosions and explosions. They required solution to practical numerical computational problems of singularities in integral-equation kernels, extrapolation techniques, stability in partial-differential-equation integration, and propagation of numerical errors. Because only limited testing of the final products (atomic bombs) of Los Alamos research and development was possible, the results were critically dependent on detailed calculations of the new physical phenomena being exploited. These phenomena involved extremely high densities, pressures, and temperatures, requiring nonlinear mathematics for which

analytic techniques and solutions were not available; consequently, the only recourse was a computational approach, and the new field of experimental mathematics was entered, with computation stimulating new analytical approaches.

To tell this story of computing evolution at Los Alamos, we describe how computing began with hand computing (Section 2), quickly moved on to punched-card computing (Section 3), and then took advantage of the electronic computing technology developing elsewhere (Section 4). Next we describe, within limits prescribed by security classification, the applications driving the computing (Section 5). Then we discuss the numerical-analysis challenges that arose and the practical solutions developed under the severe time pressures of the project (Section 6). We conclude this story with a few remarks (Section 7).

2. Hand Computing

Early recognition of the importance of computing to Los Alamos scientific work derived from experience at the University of California, Berkeley, where Stanley Frankel and one of the authors (Nelson) in 1942 set up a hand-computing activity to support development of the electromagnetic isotope separator and early critical-mass calculations. We were asked in early 1943 to order a complement of mechanical calculators to support the initial theoretical work at Los Alamos. Keeping in mind the cost as well as the capability of the calculators, we ordered both economical eight-digit calculators and high-speed ten-digit calculators (Marchants and Fridens) in a mix thought to be balanced. This turned out to be misguided economy, for

© 1982 by the American Federation of Information Processing Societies, Inc. Permission to copy without fee all or part of this material is granted provided that the copies are not made or distributed for direct commercial advantage, the AFIPS copyright notice and the title of the publication and its date appear, and notice is given that the copying is by permission of the American Federation of Information Processing Societies, Inc. To copy otherwise, or to republish, requires specific permission.

Authors' Address: N. Metropolis, Los Alamos National Laboratory, T-DOT, Mail Stop B210, P.O. Box 1663, Los Alamos, NM 87545. E. C. Nelson, TRW Defense Systems Group, One Space Park, R3/2408, Redondo Beach, CA 90278.

This work was performed under the auspices of the U.S. Department of Energy.

© 1982 AFIPS 0164-1239/82/040348-357\$01.00/00

Un modèle pour les projets militaires post-45...

- La référence pour gérer les grands projets d'armements post-45.
 - B. Shriever discute cette question avec Groves & Oppenheimer
- Même logique
 - Création d'organisations dédiées : USAF/WDD ; Navy/SPO...
 - Stratégies parallèles

<u>Parallel strategy on the Atlas Project (1954–1959)</u>	<i>Atlas</i>	<i>Titan</i>
Airframe	Convair	Martin
Guidance 1. Radio-Inertial	General Electric	Bell Telephone
Guidance 2. All inertial	A.C. Spark Plug	American Bosch / MIT
Propulsion	North American	Aerojet General
Nose cone	General Electric	AVCO
Computer	Burroughs	Remington Rand

Table 2. Navy Nuclear Propulsion Program in 1953

	Water-Cooled Reactor	Sodium-Cooled Reactor
AEC Field Office	Pittsburgh	Schenectady
AEC Contractor	Westinghouse (Bettis Laboratory)	General Electric (Knolls Atomic Power Laboratory)
Land Prototype	Submarine Thermal Reactor (STR) Mark I, National Reactor Testing Station, Idaho	Submarine Intermediate Reactor (SIR) Mark A, West Milton, New York
Nuclear Submarine	<i>Nautilus</i> SSN 571 STR Mark II	<i>Seawolf</i> SSN 575 SIR Mark B
Shipyard	Electric Boat Division, Groton, Connecticut	Electric Boat Division, Groton, Connecticut

... mais paradoxalement : où sont passées les stratégies parallèles ? (PM BoK, 5th ed., 2013)

work, 548

O

Objective, 548
OBS. *See* Organizational breakdown structure
Observations, 116, 282, 548
Operational stakeholders, 13–14
Operations management, 12
OPM. *See* Organizational Project Management
OPM3®. *See* Organizational Project Management Maturity Model
Opportunities, 345–346, 548
Optimistic duration, 548. *See also* Duration
Organization(s)
 project management and, 14–15
Organizational breakdown structure (OBS), 245, 261, 548
Organizational characteristics, 21–26
Organizational charts, 131, 258, 292
Organizational culture. *See also* Cultural diversity
 project team composition and, 37

matrix organizations, 22–24
overlapping project phases, 43–44
projectized organization, 25
project-related characteristics, 21
reporting relationships and, 17

Organizational theory, 263
Organization charts and position descriptions, 261–262
 hierarchical-type charts and, 261
 matrix-based charts, 262
 text-oriented formats, 262
Output(s), 548
Overlapping project phases, 43

P

Parametric estimating, 170, 205, 548
Pareto diagram, 237, 548
Path convergence, 548
Path divergence, 548
Payment systems, 383, 548
PBOs. *See* Project-based organizations (PBOs)



Manhattan in the PM literature

- The Manhattan Project “*certainly displayed the principles of organization, planning and direction that typify the modern management of projects.*” (Morris, 1997, p. 18)
 - It “*exhibited the principles of organization, planning, and direction that influenced the development of standard practices for managing projects.*” (Shenhar A., Dvir D. 2007. p. 8).
- ⇒ These are false interpretations of Manhattan (Lenfle, 2008; Lenfle & Loch, 2010)

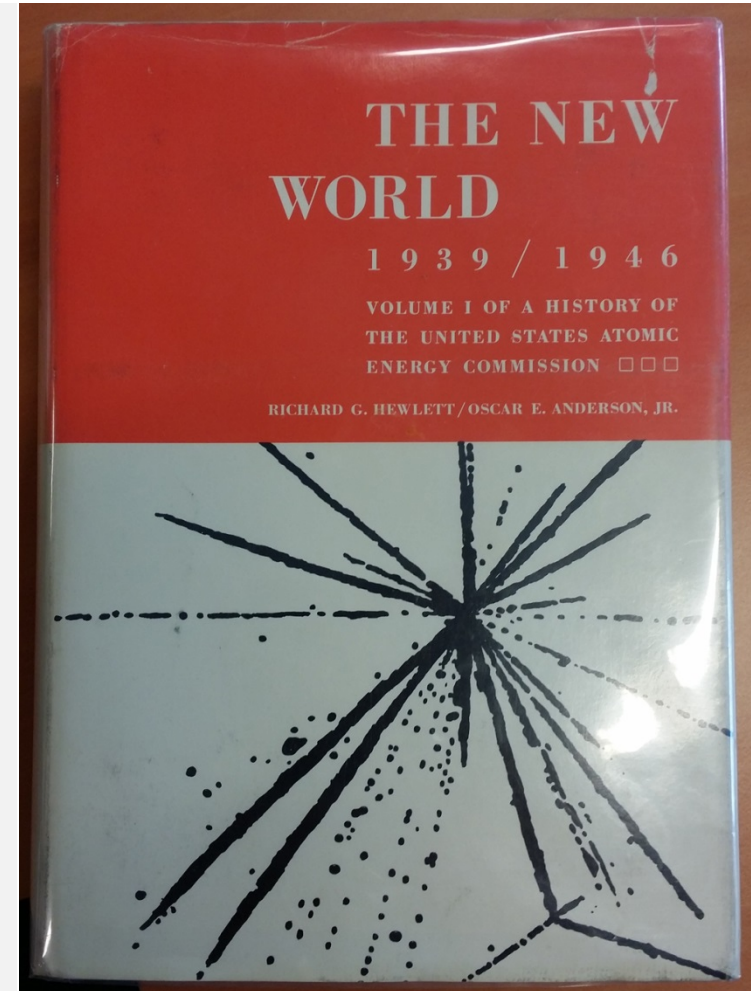
Manhattan et l'anthropocène

"The whole enterprise constitutes...a far deeper interference with the natural course of events than anything ever before attempted, and its impending accomplishment will bring about a whole new situation as regards human resources. Surely we are being presented with one of the greatest triumphs of science and engineering, destined deeply to influence the future of mankind."

Niels Bohr to F.D. Roosevelt, June 1944

"This project should not be considered simply in terms of military weapons, but as a new relationship of man to the universe".

H.L. Stimson, Secretary of War, to the Interim Committee, Washington D.C, may 31, 1945



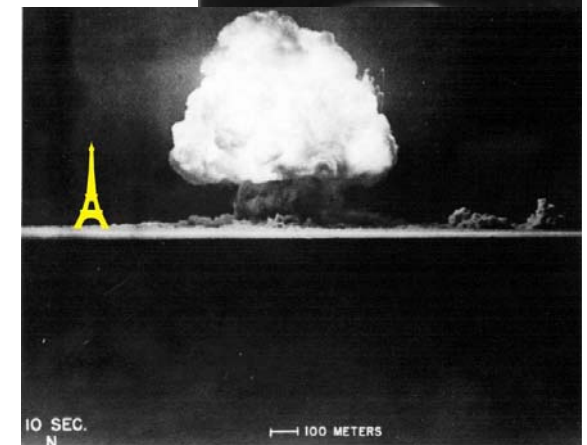
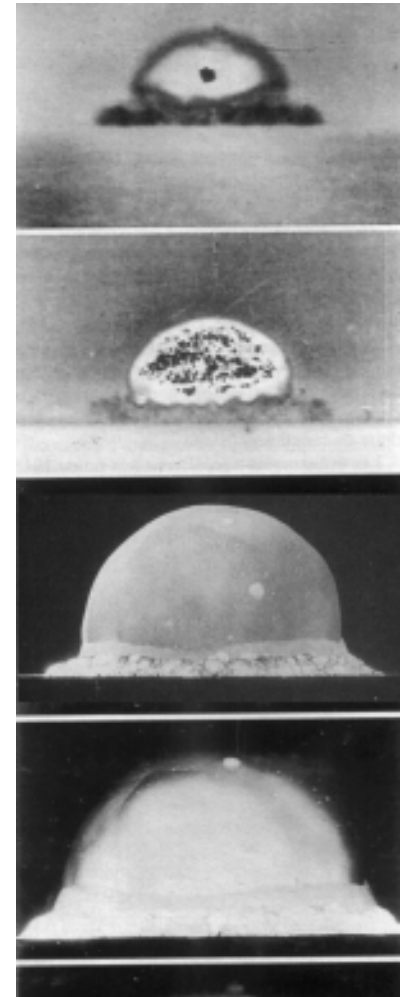
The Trinity Test

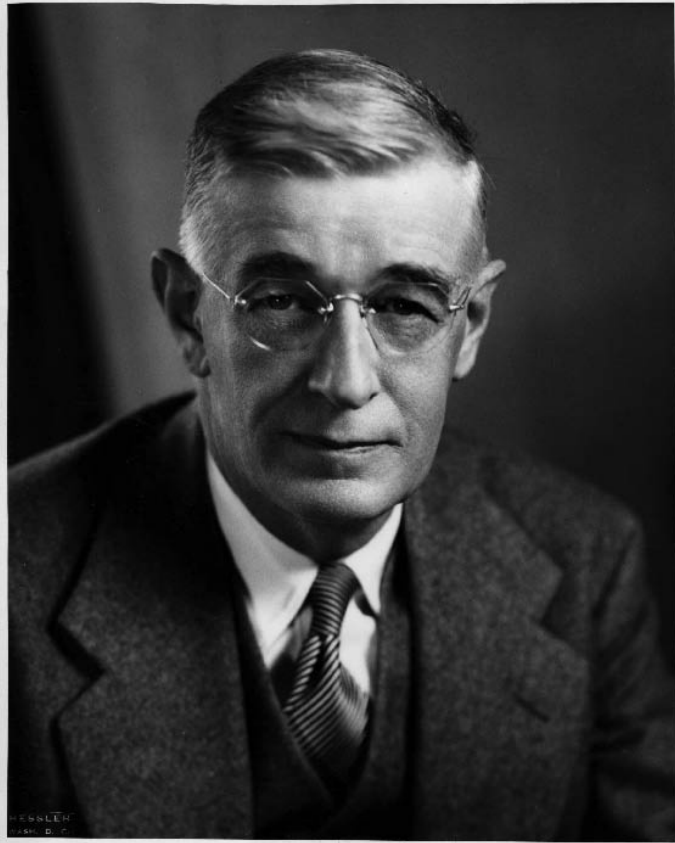
(July 16, 1945... during the Postdam Conference)

J.R. Oppenheimer on NBC (1965).

« We knew the world would not be the same. A few people laughed, a few people cried, most people were silent. I remembered the line from the Hindu scripture, the Bhagavad-Gita. (...) 'Now, I am become Death, the destroyer of worlds.' I suppose we all thought that one way or another »

- ⇒ Not another weapons that fit into « old concepts » (H. Simpson)
- ⇒ Great difficulty to define a military strategy concerning nuclear weapons... that persisted long after WWII (Rosenberg, 1983).
- ⇒ Only three weeks before Hiroshima !!





SCIENCE THE ENDLESS FRONTIER

*Report to the President on a
Program for Postwar Scientific Research
by Vannevar Bush, Director of OSRD*

Manhattan project for climate change ?

Les spécificités de Manhattan

- Situation de guerre totale => la question des incitations est résolue (classé AA+, « *Time was more important than money* »)
- Permet la mobilisation massive de l'industrie (130 000 personnes en 1945)...
- ... et de tout ce que les USA comptent comme prix Nobel : E. Fermi, J. Franck, E. Lawrence, A. Compton, J. Chadwick, E. Wigner, L. Alvarez, H. Bethe, G. Seaborg
- Un projet fermé :
 - Objectif « circonscrit »
 - Direction de projet « lourde »
 - Totalement secret => pas de problème de gestion des stakeholders



=> La métaphore a des limites pour aborder la question du changement climatique



mail@sylvainlenfle.com
<http://www.sylvainlenfle.com>