D&D of the French High Enrichment Gaseous Diffusion Plant

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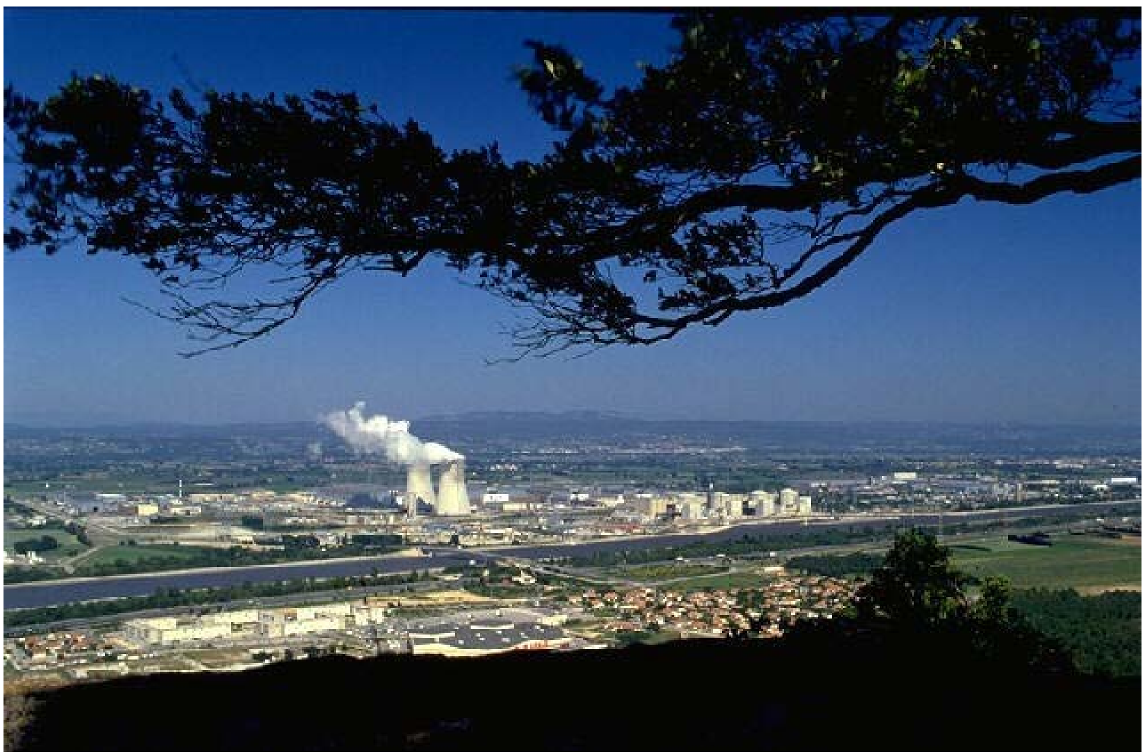


ABSTRACT
This paper describes the D&D program that is being implemented at France's High Enrichment Gaseous Diffusion Plant, which was designed to supply France's Military with Highly Enriched Uranium. This plant was definitively shut down in June 1996, following French President Jacques Chirac's decision to end production of Highly Enriched Uranium and dismantle the corresponding facilities.

INTRODUCTION

The following is a timeline of key events in the French Military Program to produce Highly Enriched Uranium:

- October, 1945: President Charles de Gaulle created the CEA, the French Atomic Energy Commission, which was divided into two sections: the first dedicated to the development of civil nuclear applications, the second, CEA/DAM, the Military Application Department, dedicated to the development of the French nuclear military program.

- 1958: Pierrelatte, located in the South of France, is selected as the site at which the High Enrichment Gaseous Diffusion Plant will be built.

- 1960-1964: Construction of the four Gaseous Diffusion Enrichment Units:
  - Unit UB: low enrichment plant
  - Unit UM: medium enrichment plant
  - Unit UH: High enrichment plant
  - Unit UTH: Very high enrichment plant

- 1964 – 1967: Four enrichment units are commissioned.

- 1967: HEU production begins at Pierrelatte.

- November, 1982: Shut-down of the UB/UM enrichment units.

- 1996:
  - Completion of the last French nuclear tests in the Pacific Ocean
  - Signature of the CTBT, Comprehensive Test Ban Treaty by France
  - End of HEU production at Pierrelatte

After the shut-down of the UH and UTH high enrichment units, CEA/DAM, the plant owner, and AREVA/COGEMA, the plant operator, began preliminary studies to decommission and dismantle the facilities.

At the very beginning of the decommissioning process, CEA/DAM decided that, rather than separate the project into two distinctive programs, one for the UB and UM units and another for the UH and UTH units, it would run a single project that would address each enrichment unit in turn. This decision facilitated some of the most challenging elements of the D&D process , including disassembly and waste management.

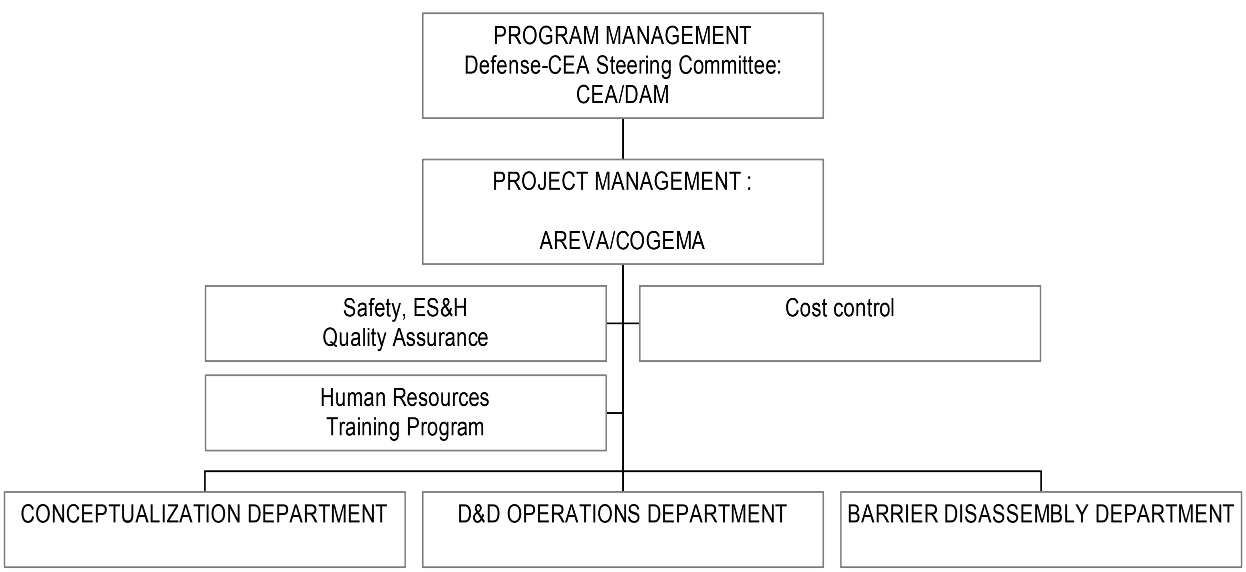
The French Minister of Defense requested that CEA/DAM and AREVA/COGEMA work in concert on the D&D program. CEA/DAM was designated Program Manager and AREVA/COGEMA its Prime Contractor. The first contractual agreement was signed on May 26, 1997, and established the primary lines of the D&D program.

Fig I. Site of the Four Buildings that make up the Pierrelatte D&D project

DEVELOPMENT OF THE D&D PROGRAM

A. Organization

A program management system was established as demonstrated in the following chart:



As plant owner, CEA/DAM chairs a steering committee "Defense-CEA" for overall Program Management

As prime contractor, AREVA/COGEMA is responsible for Project Management. Project Management is divided into three core operational departments and three major corporate functions.

The conceptualization department includes the project team in charge of designing new workshops, equipment, and devices required for the D&D program. In addition, this department supervises project engineering, including subcontractors, and is responsible for communication with other departments and corporate offices.

The D&D operations department directly manages all D&D operations and is responsible for the uranium except during the diffuser disassembly process.

The barrier disassembly department is in charge of the diffuser disassembly and of the facility that is specifically designed for this purpose.

Corporate functions are contained as key functions within the Project management group.

B. Program scope

The scope of the D&D program for the Pierrelatte High Enrichment gaseous diffusion plant is as follows:

- Recover Uranium,
- Remove process equipment, piping, valves and related components from the four enrichment units and auxiliary buildings,
- Dismantle and decontaminate the process equipment, piping, valves and related components in a manner that preserves the confidentiality of their design,
- Manage waste,
- After having achieved IAEA stage 2 conditions in the buildings, definition of additional criteria to set up the D&D objectives between the IAEA stage 2 and IAEA stage 3
- The entire D&D program is implemented with safety, minimization of environmental impact, and cost efficiency in mind.

C. Description of the High Enrichment Diffusion Plant currently undergoing D&D

The gaseous diffusion process was applied to the production of Highly Enriched Uranium (HEU)for the French national defense program.. The High Enrichment Uranium plant is a succession of four units, placed in four separate buildings. The UH-UTH units are adjacent. Each building contains gaseous diffusion sub-units, which consist of cells. Each cell contains the stages comprising process equipment, process piping, valves, the coolant and circulating cooling fluids piping systems, and other support equipment.
The chief characteristics of each enrichment unit building are listed in Table I.

Table 1. Chief characteristics of each unit building

	UB	UM	UH	UTH	Total
Building size (m^2)	51 000	33 600	12 700	22 700	120 000
Cells/building	60	48	20	57	
Stages/cell	8	8	16	16	
Stages/Building	480	384	320	912	2096

Although the four enrichment buildings are structurally sound, they do not conform to all new and potential future seismic criteria, which limits the possibility of industrial reuse.

The Tricastin site in Pierrelatte is the location of the High Enrichment Plant. During the 1980's, this site evolved into a nuclear mega-complex extending over 600 hectares and featuring research laboratories and industrial units, including Eurodif, the civilian uranium enrichment plant. This concentration of resources and activities offers genuine advantages for the D&D program especially in the fields of decontamination, waste stream, and waste management.

The four buildings are situated between 0.5 to 1 km from each other.

Intermediate storage, decontamination, and Uranium recovery facilities are located from 1 to 3 km from the High Enrichment Buildings.

As a result of this arrangement, on-site transportation is an important issue for the program.

AREVA/COGEMA designed overpacks specifically adapted for on-site transportation of process equipment such as diffusers.

Fig. 2 : On-site transportation of diffusers.

Most of the equipment is either contaminated or considered to be contaminated with radiological and hazardous substances linked to UF6, and the chemical rinsing agent routinely used in the enrichment cascade. Asbestos is present in some auxiliary facilities. The most common contaminants are Uranium and its daughter products. The facilities never enriched or re-enriched reactor-recycled Uranium, with the exception of one cell from the UM unit, which was isolated after it was shut down to evaluate the behavior of some contaminants during the enrichment process. As a result, the process equipment is free of any TRU or Fission Products.
A new barrier disassembly facility (see D3) was installed in a part of the UB building, which was originally designated to be a maintenance sub -unit.

D. Description of the High Enrichment Diffusion Plant D&D project phases

D1. Facilities pre treatment

In each of the four enrichment units, the primary pre-treatment consisted of pumping, vacuuming, and returning to atmospheric pressure with nitrogen, so as to remove a maximum of uranium from process equipment with potential material hold-up.
In addition, the UH and UTH enrichment units were pretreated, using a rinsing agent as a fluorination process to convert solid deposits within the process equipment to volatile fluoride compounds that could be again recovered by pumping. This process was uniquely dedicated for the UH and UTH enrichment units as an essential step for criticality management during the following phases and to optimize waste management.
Exploratory tests were then employed to provide radiological data and to estimate the quantity of uranium remaining in the process equipments.

D2. D&D progress phases

To facilitate waste management, especially for materials designated for beneficial re use, the first task was to divide each of the four enrichment units into two areas:

- One zone for all equipment, piping, valves and associated components with no contamination risk, i.e. :
    - Outside of the nuclear area of the plant
    - Equipment of the corresponding area
- One zone for all equipment, piping, valves and associated components with contamination or chance of contamination, i.e.:
    - Inside of the nuclear area of the plant
    - Uranium and non-uranium process equipment of the corresponding area

The main goal of dismantling is then to break down the successive units into manageable elements that can be safely transported from the high enrichment plant to the next D&D process unit. Each piece of equipment is then identified using a bar code system
Most of the process equipment, with the exception of diffusers, has to go to two decontamination facilities, one dedicated to the UB,UM equipments, one for the UH,UTH equipments. Size reduction using specific cutting devices and characterization prepares equipment and components for decontamination.

The diffusers are directed to the new barrier disassembly facility.

D3. Barrier disassembly facility (Fig.3)

The aims of this specifically designed facility are to:

- Decouple and remove barriers from the diffusers,
- Direct shells and internal devices to the decontamination facilities,
- Crush the barriers,
- Blend crushed barriers from UB, UM, UH, UTH in order to optimize the residual U235 quantity close to a maximum of 20 g / 220 l drum base waste packaging.
- Encapsulate the mixed crushed barriers in a concrete matrix and seal this in standard 220 l drum, base waste packaging
- Dismantle and scrap the classified equipment.

Tracking the Uranium and managing criticality are major issues associated with the diffuser dismantling process. AREVA/COGEMA designed a gamma volumetric analyzer apparatus that is able to determine the quantity of U235 inside each diffuser before disassembly. Since the diffusers have already been identified with bar codes ,. the quantity of U235 is known at all times during any part of the diffuser dismantling process.
In addition, a computer program determines the best combination of UB, UM, UH, and UTH crushed barriers to come as close as possible to the maximum 20 g of U235 per drum that is required for waste management.

Fig 3: Inside the barrier disassembly facility.

D4. Waste management

To conform with current French legislation, AREVA/COGEMA has restricted release of material into the external market to materials coming from the non-nuclear zone as defined in section D2.

Any material coming from the nuclear zone, even if this material is a non-process one, is considered contaminated.
The applicable French current regulation classifies this type of material as TFA, very low activity. This same designation is applied to material which has been decontaminated to low levels of contamination (average specific activity : less than 10 Bq/g)

Any material with specific activity exceeding 100Bq/g and less than 185Bq/g is classified as FA, for low activity.

The disposal options for the original materials, as well as any secondary waste streams arising from the process routes utilized are then identified.

In France, FA material is taken to the FMA waste disposal site, which is managed by ANDRA, the French National Agency for radioactive residues disposal management. Material must contain less than 0.1g of U235 /l per 2201 drum, the basic package, to be suitable for disposition at this site. . This criterion is the guideline for the packaging of each FA material category, especially for the crushed barriers, in order to minimize the corresponding disposal cost.

The TFA material is currently stored on-site in dedicated intermediate storage, until the opening of the French TFA waste disposal site.

To reduce cost disposal too, especially for the TFA, the D&D process includes a volume reducing step for each category of material.
Most of the TFA will be treated in a volume reducing facility including a pressurizing crushing device , with the exception for some already compact pieces of equipment.

The projected quantities for the main waste categories are indicated in Table 2

Table II: Projected quantities in principle waste categories

Clean Equipment	TBD
TFA	14000 t
FA – Crushed Barriers in concrete	5000 drums
FA – Technological Waste	5000 drums

D5. Summary of the D&D project phases

Fig.4 summarizes the successive phases of the D&D project

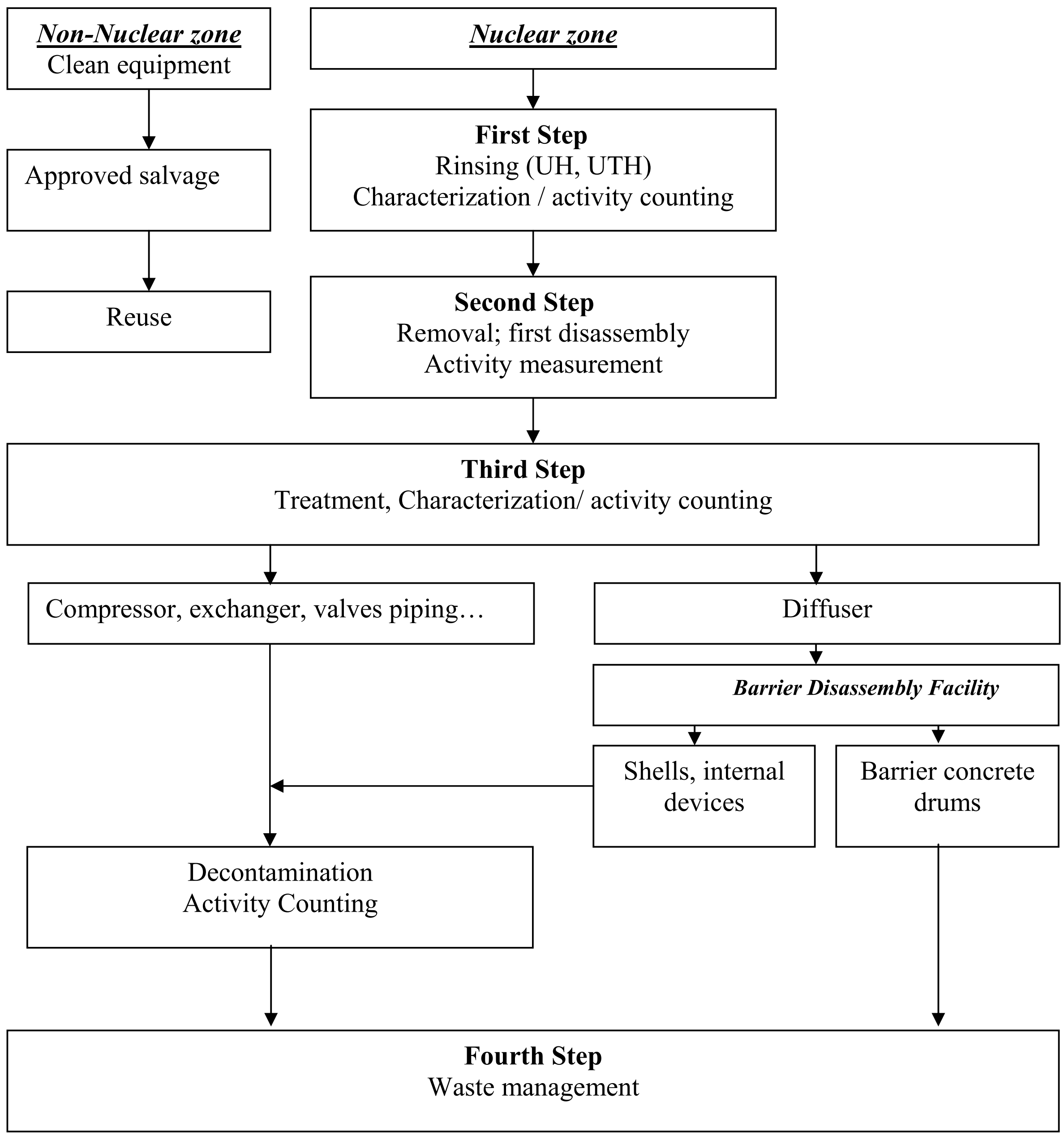
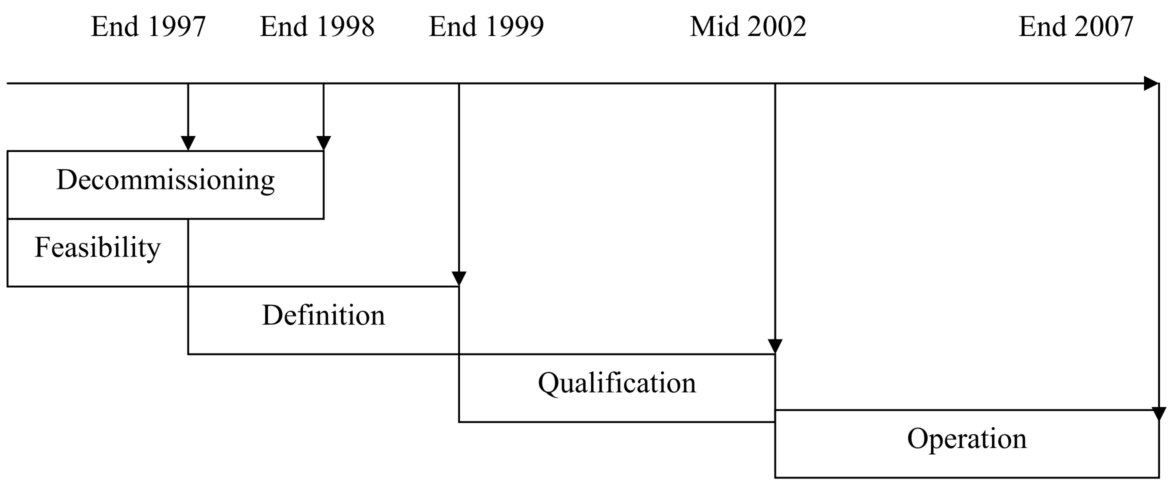


Fig.4 : Summary of the D&D project phases

E. Project Planning and progress status

During preliminary discussions between CEA/DAM and AREVA/COGEMA, the following project planning were established as follow:



The overall D&D program was based on a ten-year plan. The initial decommissioning step lasted two years, including the rinsing step. At the same time, the feasibility of the entire project studied.This study was completed before the final terms of the program were defined.

All project documents, inculding the management plan, implementation plan, quality assurance plan, health and safety plan, nuclear material control and accountability plan, criticality management plan, waste management plan, permit documentation for the French nuclear safety authorities, and safety basis documentation, including the radioprotection files, were prepared during this program definition step. The definition step also included a number of test-pilot operations and tool testprior to the critical qualification phase.

The qualification phase was undertaken jointly by CEA/DAM and AREVA/COGEMA.

During the qualification phase, CEA/DAM reviewed all procedures, documents, test pilot operations, and estimated costs prior to a step by step qualification of the entire program.

The first step to be qualified was the primary dismantling step and the last was the complete diffuser barrier disassembly process.

A major milestone was reached in mid 2002 when the D&D project was almost completely qualified, with the exception of some auxiliaries facilities that contained asbestos and those that required additional criticality surveys. In mid–2002, the D&D program entered the operations phase.

By the end of 2002, 30% of the cells had been disassembled, and 10% of the diffusers had been completely dismantled. The compacting station for TFA is scheduled to be in operation by the end of 2004, and procedures for auxiliaries facilities are to be completed by the end of 2003.

LESSONS LEARNED

There are several key elements to the successful completion of a project of this size.

Priority is given to the setting of a clear and rigorous quality standard which strictly establishes the organization chart and distribution of tasks between the owner and the prime contractor, defines the scope of work, checks the adequacy between the projected schedule and realization, controls performance, and supervises the project documentation. The quality standard used is the RG Aero 40 which usually applies to huge and complex aeronautic projects.

Safety is of primary concern for the management of any nuclear project. Dismantling work is long and exacting and often takes place under rather difficult conditions. The French D&D program has always seen the minimization of risk for cleanup workers as a priority, especially when considering the potential for radiation exposure and the potential for contact with contaminants.

Cost efficiency is also one of the keys for success. For this reason, cost control is directly supervised by the upper levels of the D&D project organization. A significant cost reducing decision made on this project was to adopt a comprehensive solution for classified clearance. CEA/DAM made a list of information and data that were classified. The minimum possible number of workers was given high enough clearance to access this material. This plan reduced the number of background investigations required in connection with these classified processes.
Under the French system, the beneficial reuse principle was not considered to augment the cost savings generated by the project. Since most of the recovered material comes from nuclear equipment or from a nuclear zone, these materials are very difficult to reuse, especially under current French regulations. Even if the High Enrichment Plant D&D were to provide tons of quite uncontaminated material such as very pure aluminum it would be difficult to recycle this material on the external market. As a result, CEA/ DAM and AREVA/COGEMA only considered the external market for materials used and generated outside of the nuclear zone. The consequence is that reuse can not be considered as a barometer of the success of the D&D operation.

Some other apparently minor items were, in fact, key to the success of this project and deserve to be highlighted.
Management must be sensitive and react to a change in culture. Dismantling is a concept that is difficult to accept for people trained to design, construct, and operate nuclear facilities.
Since the French high enrichment plant is located within a large nuclear complex at Tricastin, there were opportunities to transfer operators and managers to the civil uranium enrichment plant Eurodif on the same site.
It was clear, however, that the program needed experienced people to perform the D&D work. Key people were identified and promoted within the D&D organization. Today, the D&D program employs 250 people: 100 from AREVA/COGEMA, 150 as subcontractors, and the key population represents less than 10% of the workforce. Others were specifically trained for the D&D program, especially in the areas of safety, productivity and quality.

CONCLUSION

The D&D of the HEU plant at Pierrelatte is but one of a host of D&D projects carried out by CEA and AREVA over the past twenty years; project experience totaling hundreds of thousands of man-hours.

The techniques chosen for the D&D of the HEU plant as well as all viable alternatives were carefully studied and tested prior to implementation. The resulting technologies have undergone rigorous testing and have been proven safe. They can thus be applied to other nuclear D&D projects, a fact that is especially important for nuclear processing plants where criticality is a concern because of the high uranium assays.

These tools and techniques could be applied to other D&D high enrichment plants such as K23-K25 in Oak Ridge, TN. CEA and AREVA are uniquely qualified to successfully manage the D&D of complex nuclear facilities.