COMMISSION OF THE EUROPEAN COMMUNITIES

COM(75) 350 final

Brussels, 18 July 1975

PROPOSED PLURIANNUAL PROGRAMME OF THE COMMUNITY FOR THE YEARS 1976/80 IN THE FIELD OF CONTROLLED THERMONUCLEAR FUSION AND PLASMA PHYSICS

(submitted by the Commission to the Council)

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Controlled Thermonuclear Fusion
and Plasma Physics Programme
Research Programme 1976 - 1980

P R O P O S A L

Summary

PROPOSED PLURIANNUAL PROGRAMME OF THE COMMUNITY FOR THE YEARS 1976/80 IN THE FIELD OF CONTROLLED THERMONUCLEAR FUSION AND PLASMA PHYSICS

I. INTRODUCTION

1.1. Long and medium term objectives

The final aim of the Community's continuing Fusion programme is to assess whether it is possible to produce, at a competitive cost, useful energy from the reactions between light nuclei, and if so to proceed to the joint construction of prototypes with a view to their industrial scale production and marketing. The realization of this aim requires the solution of many scientific and technological problems.

An intermediate aim is to provide continuous assessments of the potential of fusion power and of the volume of effort still required to achieve it.

These two objectives carry an intrinsic importance independently of the present energy crisis.

1.2. Community nature of the programme

The progress made in the last few years, together with the substantial benefits for Europe of eventual success in fusion research, suggest that an increase of effort to accelerate progress is justified. This continuing programme is, by decision of the Council, a long term cooperative project embracing ; all work carried out in the member states of the Community in the field of fusion and plasma physics, and is partly financed by the Commission. In order to pursue the most effective programme at reasonable cost this Community character of the programme must be maintained and improved. This is especially important because of the need for a very large experiment which can only be envisaged as a common effort, and because it allows an increasing specialization of the Associated Laboratories.

1.3. Motivation of the initiative of the Commission

Since the creation of the European Community for Atomic Energy the Commission has contributed funds and manpower first to promote the activities in the laboratories of the Member States and then to integrate all these activities in a common programme.

The principal motives for such an initiative on the part of the Commission are as follows :

- the scale of human and financial resources necessary makes impossible the carrying out of such an enterprise on national basis
- such an activity meets a collective need common to all the member States
- it needs a long term effort extending towards the end of the century
- the benefits of realizing these objectives will be particularly important for Europe because of the high population density and the relatively limited energy resources. The main advantages of fusion reactors will lie in their safety, in the relatively low environmental effects and the wide availability of fuels.

1.4. The JET (Joint European Torus)

The essential new element of the proposed programme is the construction of the large device JET. This device belongs to the Tokamak line in which important progress has been achieved during the last years. Forecasts based on present experiments involve some uncertainty, and it has become evident that the construction of a much larger device is necessary in order to be able to make progress. To this end, the Associated Laboratories have already set up a joint design team which is currently finishing a detailed design of this large tokamak.

This device should allow the study of plasma properties in a regime which is practically unexplored so far, and which is near to the regime required in a thermonuclear reactor. The results expected from this experiment are therefore of primary importance.

The implementation of this project is one of the most effective ways of increasing collaboration between the Associated Laboratories and progressively involving Industry with the technical aspects of

fusion.

1.5. The programme

Apart from JET no major expansion is proposed in the programme. This is essentially the prolongation of the preceding pluriannual programmes, with some changes in priorities. The criterion applied is concentration in all the cases in which the state of the art allows it and the distribution of tasks between the Associated Laboratories is well defined, in coordination with JET, notably for the tokamaks, which form the essential line of the programme.

1.6. Short term objectives

In the fusion programme the objectives of this 5-year period are :

- to achieve the construction of the JET which should be done by 1980. The experimental results which will be obtained at the start of the next plan should give the answer on the scientific feasibility of a tokamak reactor;
- to obtain much other information essential to the realization of controlled fusion along the tokamak line which is expected from the intermediate sized devices;
- to obtain a clear answer on the potentialities of the stellerator which must be given by the relatively important work still developing on this line;
- to obtain the information expected from the other lines which might be necessary for the choice of a possible alternative to the tokamak.

1.7. World context

A comparison between the content of the proposed programme and that of other programmes developing in the world shows that the former fits well in a world context. It is in some parts complementary especially with the USA programme.

including the training of personnel, the construction of further small and relatively cheap experiments may possibly be useful.

If present expectations for tokamaks are confirmed, preparations for the design and construction of the next major step, a tritium burning experiment, could be considered during the five-year programme. This experiment, which would operate with deuterium-tritium fuel for most of its life and will generate large numbers of neutrons, should demonstrate energy production without a large energy gain. The energy density in the plasma should be high enough to allow as a secondary aim the study of blanket problems.

2.2. Low-beta stellarator

A stellarator is a closed toroidal system in which the magnetic field is determined entirely by windings outside the plasma. This gives the advantage, in principle, of greater flexibility and continuous operation. Several alternative configurations of external conductor are possible so that the magnetic field can be precisely designed for optimum confinement. Because of the similarity of the tokamak and stellarator systems, work in the two areas is complementary.

Work will continue on existing stellarators and similar experiments (WII, Torso, Cleo, W VII a, Levitron) and their performance will be compared with results from tokamaks. The second stage of the largest experiment (W VII b) will be completed during the programme, and no new experiment is envisaged until its operation has demonstrated significant advantages for the stellarator geometry.

2.3. High beta configurations

If it eventually appears necessary to use in a more effective manner the magnetic fields which confine the plasma, in order to achieve power economically from a reactor, there

are several other toroidal configurations which offer the prospect of a higher value of the ratio, beta, between the plasma and magnetic pressures. At the present time the development of these systems is not so advanced as the development of the tokamak nor the scale of experiments so large, with the result that the plasma temperatures and confinement times obtained are not so high. Research will be continued along several lines, of which some may be considered as modifications of a tokamak and others are alternative systems. The reversed field pinch (HBTX) is an axisymmetric configuration of medium pulse duration, which might develop as an alternative to the tokamak reactor, especially if the problems connected with the collisionless regime or increased beta appear more difficult in the tokamak than expected. The high-beta stellarator (HBS) which is a very high aspect ratio non-axisymmetric configuration involving wall stabilization, offers the possibility of continuous operation and also has potential as a reactor. The development of other axisymmetric configurations, including the screw pinch and belt pinch (SPICA, Belt. Pinch, TEE, TENQ) requires further study, but these systems can also be considered as both direct and indirect support to the tokamak line and might merge with it.

The aim of the work in all these configurations is to understand more fully the behaviour of high beta plasmas and to evaluate their potential as alternative reactor systems. During the next programme it should be possible to concentrate this work into fewer lines, and specific criteria have been suggested which should be met before the extension of each line to the following stage of development.

2.4. Heating and injection

The heating of plasmas is an essential aspect of fusion research. Some confinement systems involve heating methods which are an intrinsic part of the system, such as ohmic, adiabatic, or shock heating. Other auxiliary methods of

heating a plasma are important for both future tokamak experiments and several reactor concepts, and the continuing work on neutral injection, high-frequency, turbulent, and other methods of heating is aimed at establishing the most suitable methods for development.
Heating by neutral beams is being vigorously developed in a coordinated way by at least two of the Associated Laboratories to meet the requirements of the JET project and other confinement experiments. A comparable effort will be maintained on high-frequency heating, and further clarification of the many alternative possibilities is expected with experiments now under construction (mainly Petula and Wega). Activities in this area also include cluster injection and refuelling studies.

2.5. Open configurations

Work on open magnetic configurations (magnetic mirrors), which were originally an important area of activity, has decreased during the present programme because the plasma confinement appears less adequate than in the closed configurations for an energy gain in a reactor. This work will be discontinued in the next programme in view of the expansion required for more promising lines. Contact will be maintained with continuing work elsewhere.

2.6. Very high density plasma

The coordinated venture of several laboratories on the Plasma Focus will be maintained, especially in order to extend the scaling laws. No new major experiment is foreseen until the results of the 1 MJ experiment now under construction are available.
Experiments with imploding liners were discontinued at the beginning of the present programme, but contacts continue to be maintained with similar work elsewhere.

Concerning inertial confinement (fusion by laser or by relativistic electron beams), some theoretical and experimental activities already exist in some Associations. To keep in touch with the subject, these activities will at least be maintained. The possibility of the extension of such a collaboration will be considered with flexible procedures taking into account the particular situation in some Member States where those activities are developed as part of classified programmes.

2.7. Supporting physics research

All the areas of work above involve both experimental and theoretical studies. In addition, continuing theoretical and experimental activities in fundamental plasma physics are envisaged in support of the main confinement systems and in order to extend the underlying science of fusion. To help reach this objective, it is desirable to develop links between the programme and universities, as exist in some countries. Such links should be encouraged, in principle through the existing Associations, and would have the additional benefits of creating the reserve of young scientists and engineers which will be required by an expanding programme.

2.8. Technology

The ultimate success of the fusion programme will depend as much on technological developments as on the solution of physics problems. An increasing activity in this field should be envisaged with the following aims :

a) Provide the necessary expertise for JET and other new experiments, in areas such as plasma-wall interactions, vacuum techniques, materials selection and fabrication, magnetic field systems design and construction, power supplies and control;

b) Develop the necessary expertise to design and construct the following generation of experiments, in areas such as supraconducting coils, plasma,control, materials activation, tritium handling, and safety;

c) Continuation of studies on the technological and economic feasibility of fusion reactors and the indentification of critical areas. Modest experimental activities in support of these studies are envisaged.

These three aims can be covered by activities inside the Associated Laboratories and by external sub-contracts on well defined and limited subjects placed through the Associated partners. Strong coordination and continuous interaction with the plasma physics laboratories are required.

III. VOLUME AND STRUCTURE OF THE PROGRAMME

3.1. Total Staff of the Associations and of JET.

The rapid growth of the JET construction team must be assured by contributions from each Association. To allow this growth and maintain the programme indicated above will require an increase of the total professional staff of JET and of the Associated Laboratories of 10% at the beginning of the programme and a slight expansion during the following years. This increase should introduce new expertise into the fusion programme, and allow the preparation of the trained staff who will be needed for the next stage of deve - lopment.

3.2. Cost of the programme

The total expenses of the Associations in 1975 will be about 72 Mua, and the total expenditure on fusion research including the design phase of JET, laser fusion, and some reactor technology which is in the Community programme but not supported by the Commission, is about 80 Mua.

In the next five years, including the construction of JET, an increasing scale of experimental assemblies in other lines, and an increase in the total fusion staff, the necessary total budget of the Associations, the Commission and JET, is estimated to be 615 Mua at March 1975 prices. The cost of constructing JET and operating it for one year will be 135 Mua *. These costs are consistent with the estimate of 550 Mua made in mid-1974 and already given by the Commission to the Council in the framework of its proposal on energy for Europe (Ref: -COM(74) 2150).

In the present situation the Commission proposes to ask year by year to the Council to make the necessary arrangements in order to adapt the ceilings to the actual economic position.

3.3. Commission's appropriation

The Commission should participate in this activity as it has done till now, by providing scientific and technical staff, and by a financial contribution which should amount to:

- 25% of the general expenses of the Associated Laboratories(salaries, running costs etc...).This uniform support of all the activities developed in the Community in this field is essential to maintain the integrated nature of the programme, and to increase the distribution of tasks between the Associated Laboratories;

- 45% of the construction costs of large devices which will be available for experiments to all the partners. The system of preferential support in accord with the priority actions of Community interest has proved stimulating and effective during the last 5-year programmes;

- 80% of the total cost of JET. This relatively high participation by the Commission allows the Associated Laboratories to pursue the rest of the programme with concentration but without any reduction in the objectives. On the other hand, the Associated Laboratories will also be involved in the financial plan in the construction of this large common project;

- 100 % of the cost of a limited activity with well defined objectives on reactor technology at JRC,Ispra.

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*) Note: The cost of JET, was expressed in Belgian Francs and converted to units of account at the rate of 1 ua=.50 BF.

The Commission's appropriation for the next five year programme will therefore be:

General support		89 Mua
Preferential support	45% of 130 Mua =	58 Mua
JET support	80% of 135 Mua =	108 Mua
JRC Ispra	100% of 6 Mua =	6 Mua
Mobility of personnel		2 Mua
Management and administration		2 Mua
		265 Mua

It is necessary to adjust, year by year the Commission's appropriation concerning the rest of the five-year period. The Commission will submit every year to the Council a proposal in order to adapt the ceiling to the actual economic position.

This adaptation is necessary for reasons specific to the fusion programme:

- Most of this programme consists of the construction of large devices, involving technical difficulties; the case of JET is just a particularly clear example. Many pieces of equipment and components must be ordered in Industry and their construction often requires several years. The contracts relating to these orders necessarily include price adjustment clauses involving price indexes of materials(e.g. copper,stainless steel, molybdenum ...) and of labour.
  The Associations cannot engage in such contracts if their own financial resources are not secured in case of strong increase of prices.
- The fusion programme covers the whole activity of the Community in this field and has a long term objective. Its financing system should then allow its coherent development on a sufficiently long time scale.

3.4. Personnel of the Commission

The Commission staff necessary to carry out the programme apart from JET is 117. This represents a reduction of 15 in the number stated in the last five-year plan.

The staff needed to build JET (about 260 persons a year, including 80 professionals, averaged over 5 years) will partly have to be seconded from the Associated Laboratories, and the remainder supplied by the Commission. Their status will need to be temporary with contracts for the duration of the programme. The exact number depends on the choice of a site and can be proposed as soon as a decision on this matter has been taken.

The staff of the head office in Brussels should be brought to about 20 employees of the three categories, included in the ceiling of 117 mentioned above, in order to allow a reinforcement of the coordination of the programme and to undertake the part of the JET management which is the duty of the Commission.

3.5. Collaboration

It should be mentioned again, as already expressed in the past, that it is only possible to ensure a stronger repartition of activities between the Associated Laboratories if the total Community programme is placed on an integrated basis. In so far as this can be guaranteed and implemented, both a diversified activity and a distribution of the lines of research between laboratories is acceptable, in such a way that the institutions of each country can rely on the differing activities of the others. Such an interdependence implies, however, a stronger coordination of the activities.

It is also important, in order to maintain the integrated basis of the programme that procedures should be developed for the initiation of collaboration outside the Associated Laboratories in areas such as basic physics at universities, technological activities in external laboratories, and collaboration with other countries and with international organisations, in particular when activities in the Associated Laboratories may be involved.

3.6. Structure

For the continuing development and effective management of the fusion programme, it is necessary to extend the organizational structure of the programme. The role of the Commission should be increased. For this purpose the staff of the head office in Brussels should be strengthened.

The Liaison Group will continue to be responsible for advising the Commission and the Council on general policy, the annual programmes of the Associations, and the allocations of preferential support.

The Committee of Directors will be in charge of the implementation of the programme, and of the exchange and mobility of personnel, and will be consulted for all the problèms concerning collaboration outside the Associated Laboratories and outside the Community. The Committee of Directors should play a more important role as managing body. Both the Liaison Group and the Committee of Directors will continue to be assisted by Advisory Groups and Coordinating Committees.

An additional structure for the management of the construction phase of JET has been agreed. This structure will be intimately linked with the original structure for the planning and execution of the whole programme.

As the fusion programme progresses, the Commission, in cooperation with the Associations, will continue to evolve a suitable structure for the work.

PROPOSAL FOR A

COUNCIL DECISION ADOPTING A FIVE-YEAR RESEARCH AND TRAINING PROGRAMME OF THE EUROPEAN ATOMIC ENERGY COMMUNITY IN THE FIELD OF FUSION AND PLASMA PHYSICS.

THE COUNCIL OF THE EUROPEAN COMMUNITIES,

Having regard to the Treaty establishing the European Atomic Energy Community, and in particular Article 7 thereof,

Having regard to the proposal from the Commission submitted after consultation with the Scientific and Technical Committee,

Having regard to the Opinion of the European Parliament.

Whereas in account of the extent of the effort still necessary to reach the stage of the practical application of controlled thermo-nuclear fusion, from which the Community could benefit, particularly as regards, in the most general sense, the security of its long-term energy supplies, the work hitherto undertaken in this field should be continued, at the various stages of development thereof, on a joint basis.

Whereas the progress achieved during the third five-year programme shows that it is necessary, particularly for Tokamak-type devices, to build larger, complex and more costly devices that no single Association could contemplate buildings unaided.

Whereas the action proposed by the Commission constitutes adequate means of pursuing this operation ; whereas, therefore, it is in the common interest to adopt a multiannual programme in the field of controlled fusion and plasma physics.

Whereas it is clearly important that the Community should continue to encourage the construction of certain equipment relating to activities accorded priority status, both by granting a preferential rate of participation in the expenditure on such equipment and by encouraging the carrying-out of major projects conducted jointly by all the associated laboratories.

Whereas the mobility of staff should be promoted between laboratories which cooperate in the implementation of the programme,

HAS DECIDED AS FOLLOWS :

Article 1

A research and training programme in the field of controlled thermonuclear fusion and plasma physics shall be adopted for a five-year period from 1 January 1976. This programme is set out in the Annex, which forms an integral part of this Decision.

Article 2

The upper limit for expenditure commitments, and for staff necessary for the implementation of this programme shall be fixed at 265 million units of account and 109 Community servants, plus 8 temporary Community servants and those temporary servants necessary for the JET project.(The unit of account is defined in Article 10 of the Financial Regulation of 25 April 1973 applicable to the general budget of the European Communities.)

Article 3

On proposal of the Commission the Council will annually take the necessary dispositions to adjust the upper limit given in Article 3 to the actual economic position.

Article 4

The Commission will submit a proposal to the Council in the course of the year 1977 in order to ensure the prolongation and a possible revision of the programme.

FUSION AND PLASMA PHYSICS

1. The subject-matter of the programme which will be executed shall be :

   - general physics in the sector concerned, in particular studies of a basic character or relating to confinement of plasmas with suitable devices and to methods for producing and heating plasmas ;
   - research on the confinement in closed configurations of plasmas of widely varying density and temperature ;
   - production of and research on plasmas of high and very high density ;
   - improvement of diagnostic methods ;
   - investigation of technological problems connected with current research and of problems relating to thermonuclear reactor technology ;
   - the construction stage of the JET project.

   This work shall be carried out under contracts of association or contracts of limited duration for the purpose of attaining the results necessary for the accomplishment of the programme.

2. The programme set out in point 1 shall be part of a long-term cooperative project embracing all work carried out in the Member States in the field of fusion and plasma physics. It is designed to lead in due course to the joint construction of prototypes with a view to their industrial-scale production and marketing.

3. An amount of 265 million units of account shall be allocated to this objective. This amount is intended to cover :

- the expenditure on equipment concerned with operations accorded priority status ;
- the expenditure on the construction stage of the large Tokamak device JET ;
- costs of procuring mobility of staff ;
- other expenditure on action to be taken within the framework of this programme.

4. Within the upper limit of 265 million units of account :

a) a maximum amount of 58 million units of account shall be allocated to the financing of the operations defined as in point 5, a uniform rate of participation equal to or less than 45 % being applied. In return therefore, all the Associations shall be entitled to take part in the experiments carried out with this equipment.

b) a maximum amount of 2 million units of account shall be set aside for expenditure for procuring mobility of research personnel from the Member States, to enable them to work in the laboratories which cooperate in the implementation of the programme ;

c) a maximum amount of 108 million units of account shall be set aside for the expenditure covering the construction stage of the JET project. This amount shall be used both for financing at a rate of 100 % by the Commission work to be done under contracts other than contracts of association, and also to partially cover other expenditure on the JET project;

d) a maximum amount of 6 million units of account shall be allocated for expenses related to work to be undertaken at J.R.C. Ispra.

e) The amount which shall not have been set aside for the operations and expenditure specified in sections a),b), c), and d) shall form the upper limit of financial participation by the Community in other expenditure of the Associations and in the management of the programme. This participation shall be uniform, taking into account the cost of the staff seconded by the Commission, at a rate of about 25 %.

5. After a technical examination of the various projects, the Commission will be able to finance at a rate of 45% the operations accorded priority status by the Liaison Group.

OPINION OF THE SCIENTIFIC AND TECHNICAL COMMITTEE (STC) ON THE PROPOSAL FOR A FIVE-YEAR PROGRAMME 1976-80 ON CONTROLLED THERMONUCLEAR FUSION AND PLASMA PHYSICS

The STC has examined the proposal for a five-year programme presented by the Commission.

While recognizing that fusion still constitues an uncertain long-term objective, but that its success will entail substantial benefits, the Committee's opinion on the proposed programme as a whole is favourable, bearing in mind the Commission's intention, expressed in its covering note to the Committee, to ensure that activity is focused on specific objectives. The Committee recognizes the need to build a large experimental device in order to make significant progress in understanding the behaviour of plasmas in conditions similar to those required by a thermonuclear reactor; while realizing the risks inherent in such an undertaking it approves the implementation thereof. The Committee attaches great importance to the project being implemented in such a way that, as the work proceeds, benefits may be derived from the results obtained with other devices.

The Committee notes the fact that, in addition to JET, the scale of the programme has been substantially increased. It recommends due caution in the choice of projects to be undertaken during the first two years of the programme, mainly by setting a limit to investment in priority projects to be launched during the first two years. The Committee regards as positive the Commission's intention to provide for a review of the situation at mid-programme and for a rolling programme; it recognizes the need for a mechanism to make allowances for economic fluctuations.

The Committee asks the Commission to pay special attention, when the revision is undertaken, to fusion by inertial confinement and to technological problèms.

30 April 1975

SUMMARY OF ACHIEVEMENTS OF THE CURRENT PROGRAMME IN CONTROLLED THERMONUCLEAR FUSION AND PLASMA PHYSICS.

I. Fusion, a Community Enterprise

1.1. The aim of controlled fusion research is to realize a new source of energy, using an abundant, widespread and very easily stockable fuel and reducing substantially environmental effects.
Due to the high density of energy consumption, this aim is more important for Europe than for many other parts of the world, because only fusion is likely to secure a real independence in energy supplies.
Other possible energy sources depend in fact on the geographical situation in such a way that Europe is in an unfavourable position.
Although the research is long-term, this factor was taken into account and measures were taken so that the level of knowledge acquired in Europe when success is achieved would allow new energy supplies to be developed in complete independence, if the situation requires it.

1.2. The development of Fusion has been a task of the Commission since the foundation of the EAEC, because it is explicitely included in the annex to the Treaty of Euratom.
Since 1958, in the course of successive quinquennial programmes, the Commission has fulfilled this task by enabling member States to obtain the maximum benefit from research carried out in their specialized institutions.

The experts concerned have continually felt that because of the size of the effort and cost involved, it was better for the countries of the Community to develop different activities during the research phase and to share the risks in order to share the benefits of success.
The balance between the efforts to be invested, the risks to be run and the calculated chances of gain justified the establishment of a programme defined in the framework of the Community.

1.3. The following contracts of Association were concluded between the Commission and the national organisations concerned:

Associations	Countries	Dates	Fusion Laboratories
EUR-CEA	France	1959	Fontenay-Aux-Roses Saclay and(later) Grenoble.
EUR-CNEN/ CNR	Italy	1960	Frascati and(later) Padoua and Milan
EUR-IPP	Germany	1961	Garching
EUR-FOM	Holland	1962	Jutphaas
EUR-KFA	Germany	1962	Jülich
EUR-EB	Belgium	1968	ERM and ULB
EUR-UKAEA	U.K.	1973	Culham
EUR-DAEK	Denmark	1973	Risø

The Associations cover all the work pursued in this field within the Community in non-classified Laboratories. Fusion is one of the few fields in which all the institutions of member States have recognized the benefit of being completely involved in a programme of Community interest. This phenomenon continues to develop by the interest of institutions outside the Community who now wish to join in the programme.

II. Technical Objectives Attained.

2.1. The most important results have been obtained in the Tokamak line which is presently considered to have the best prospects of leading to a reactor. A Tokamak programme, differentiated but well co-ordinated, has been mounted during the plan. Tokamaks of differing sizes and characteristics have been built or are in construction at Garching, Fontenay, Culham, Grenoble and Frascati. The exploitation of some of them allowed us to explore a wide field of parameters, and to acquire a technical expertise and a physical understanding which puts the Community in a leading position in the world scene. The results obtained in USA and USSR have been confirmed and improved, and the performances achieved on the tokamak at Fontenay-Aux-Roses are presently the best yet realised.

Due to the speed with which expertise has been acquired, we have been able to undertake JET, which is presently the first executive project for the next generation of experiments.

2.2. Much of the technological experience in plasma experiments which has been well used in tokamaks was gained in work carried out on open-ended machines; a line which has just been abandoned because the plasma confinement seemed less favourable for a reactor than in closed systems. In particular, experience in the field of neutral injection, originally developed for open systems, has been capable of direct application to tokamaks.

2.3. In the Stellarator line, considerable progress has been made by comparison with the first experiments in this line. In particular, results at Garching have contributed, together with the first tokamaks, to prove that the losses from closed systems could be reduced to a tolerable level. The Stellarator currently under construction at Garching is the largest experiment of this type in the world scene.

2.4. The field of plasma heating, which is an essential complement to all lines of magnetic confinement, was characterised during an exploratory phase by a considerable dispersion. During the last programme, the criteria for a choice of methods of heating most suited to large experiments have been isolated. Radiofrequency heating has been developed for application to intermediate size experiments. The work has been concentrated at Grenoble with collaboration with Garching and the ERM.

2.5. The very effective plasma heating obtained in different pinch experiments at Jülich and Garching is at the base of the line called high beta . This could represent an alternative to the tokamak line, to which it is very close. Original contributions in this line have also been made at Culham , Jutphaas and Garching.

2.6. In the field of very high density plasmas a distribution of the tasks between Frascati, Julich and Culham allowed the construction of the large Plasma Focus experiment.

Concerning Laser fusion, exploratory work has been developed notably at Frascati, Garching and at the Université Libre of Brussels.

2.7. Theoretical studies and numerical computing have been developed in parallel with each of the lines mentioned. Among the most important results in the field of plasma theory, one must mention the magneto-hydrodynamic theory of equilibrium and stability developed at Fontenay and the study of diffusion developed at Garching.

2.8. During the last quinquennial programme, under the scheme of the contract for mobility of personnel, about 40 physicists and engineers of the associated laboratories have spent periods of several months in other laboratories of the Community.

2.9. Concerning the resources, the European Community has presently available :

a) a staff of 700 qualified research workers, having many years of experience in this field.
It should be noted that the average period of post - graduate training of each of them corresponds to many years of effort.
If one includes technical and administrative support, the total rises to 3000 people.
It is undeniable that this group does not presently constitute the sum of sub-groups geographically dispersed, but a very homogeneous complex of research workers, capable of working together on a European scale.

b) an assembly of specialised laboratories, possessing modern equipment such as power supplies, capable of meeting needs for many years.

c) organisational structures created through the actions of the Commission, and through wich the work of each Laboratory is accomplished in the light of the work in the others. These structures, by maintaining a coherent European re - search grouping, places the member States of the Community in a competitive position in regard to other programmes in the world.

2.10. The results acquired during the third programme confirm that the capacities established were utilised during the third plan quite as effectively as the comparable or greater capacities of the USA and USSR.

E.P. - P.E.

Doc. - 222/75

COMMISSION OF THE EUROPEAN COMMUNITIES

HILLMAN

COM(75) 350 final/2

Brussels, 21 October 1975

PROPOSED PLURIANNUAL PROGRAMME OF THE COMMUNITY FOR THE YEARS 1976/80 IN THE FIELD OF CONTROLLED THERMONUCLEAR FUSION AND PLASMA PHYSICS

FINANCIAL STATEMENT

(submitted to the Council by the Commission)

PROPOSED PLURIANNUAL RESEARCH PROGRAMME (1976-1980)

"CONTROLLED THERMONUCLEAR FUSION AND PLASMA PHYSICS"

Doc. COM (75) 350 final of 18th July 1975

FINANCIAL STATEMENT

FINANCIAL STATEMENT "FUSION"

Part I

1. Identification of the statement : legal and administrative information

1.0. Number of statement :

1.1. Date of statement : 2.10.1975

1.2. Budgetary item : chapter 3.20 of the statement of revenue and expenditure for 1976 relating to research and investment activities (Annex I of Section III "Commission" of the Budget of the European Communities).

1.3. Financial years : 1976-1980

1.4. Legal basis : Proposal submitted to the Council on 18.7.1975 having regard to Article 7 of the Treaty establishing the EAEC.

1.5. Authorizing department : DG XII (Research, Science and Education).

2. Title of operation

Pluriannual research programme 1976-1980 "Controlled Thermonuclear Fusion and Plasma Physics".

3. Description of operation / Persons involved

3.0. Description

This is the 4th five year period of a programme which shall be, according to the preceding decisions of the Council a long-term cooperative project embracing almost all the work carried out in the Member States in the field of Controlled Thermonuclear Fusion and Plasma Physics. This programme is carried out in close collaboration between the competent organisations of the Member States and the Commission and is coordinated by a system of bilateral association contracts between Euratom and these organisations *.

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* See the list of the Associations on page 2 of the Annex to the proposal of 18.7.1975.

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The research and development work is aimed at the final objective defined under 4.0. The present five-year period includes :

- the construction phase of the large JET device
- the continuation of the work complementary to the JET in the Tokamak line
- the continuation of work in the magnetic confinement lines , alternative to the Tokamak (Stellarator, High Beta devices)
- the continuation of work on very high density plasmas and in the fields of theory and fundamental support physics as well as the development of the technological activity concerning fusion.

3.1. Persons involved in this operation

Commission :

3.1.0. Category : Commission's staff, categories A, B, C.

3.1.1. Number : 113 (75 A + 35 B + 3 C)*

3.1.2. Geographical location : distributed in the Associations in the Member States (see list on page 2 of the Annex to the proposal), Brussels for management and administration, and the site of JET.

Contractual Partners :

3.1.3. Category : Research personnel and research workers, personnel of the contractants.

3.1.4. Number : About 650 professionals and the corresponding technical support personnel.

3.1.5. Geographical location : in the Associations (see list quoted above).

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* The construction phase of the JET project will require an average of 260 men/year for five years. This personnel, seconded for a large part by the Associated Laboratories, will have a temporary statute. The corresponding expenditure is included in the overall cost of the construction of JET, given under 6.3.0.

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4. Objective of the operation

4.0. General objectives laid down by the Treaties :

Development of a new nuclear energy source (Art.1 and Art.2.a), c), g), h), of the EAEC Treaty). The programme proposal is based on Art. 7 of the Treaty. The field of research is explicitly mentioned in the Annex 1, Title II, 1.e) of the Treaty.

4.1. More specific objective of the operation and contribution of the operation to the general objective :

The final aim of this programme is to assess whether it is possible to produce, at a competitive cost, useful energy from the reactions between light nuclei, and if so to proceed to the joint construction of prototypes with a view to their industrial scale production and marketing. The realization of this aim requires the solution of many scientific and technological problems. The project embraces almost all the work carried out in the Member States.

The specific actions of this five year period are listed under 3.0 and are aimed at :

- confirming the possibility to confine in a Tokamak-type device a thermonuclear plasma
- providing an assessment of the potential of the lines alternative to the Tokamak
- providing the necessary technological expertise in order to carry on the development towards the final aim.

The construction of JET represents a necessary step on the way to the fusion reactor based on magnetic confinement.
The complementary work on the Tokamak are equally necessary in order to reach this aim.
The continuation of work in the other magnetic confinement lines keeps open the alternative options to the Tokamak line which might come out to be necessary.
The other activities constitute a normal and necessary support to the programme.

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5. Reasons for the operation chosen to attain the objectives

From the technical point of view, the proposed programme was prepared in close collaboration with the competent Organisations in the Member States, it has been formulated by the "Liaison Group" for Fusion who approved it unanimously.

From the execution point of view, the system of Association contracts and the coordinating structures set up ensures an effective utilisation of the means available.

The operation chosen is an optimisation at the european scale of the chances to reach the final aim and allows the Fusion Programme of the Community to maintain its credibility and consequently to have access to the results obtained by other important programmes in the world.

6. Expenditure

6.0. Overall expenditure for the operation for the entire proposed duration ..... 615 MUC

6.0.0. Expenditure charged to the Community Budget ..... 265 MUC

6.0.1. Expenditure charged to the national administrations . 350 MUC

6.0.2. Expenditure charged to other sectors at national level ..... 000 MUC

6.1. Appropriation authorized, commitments made and payments

Current Programme

	Current financial year		
	1973	1974	1975
6.1.0. Commitments	8.424.924	14.622.717	9.811.122
6.1.1. Payments	11.399.046	19.264.400	21.379.524

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PROGRAMME 1976-1980

6.1.0. Commitments

- Appropriation for staff

1976	3.652.301,-	
1977	4.200.146,-	
1978	4.830.168,-	
1979	5.554.693,-	
1980	6.387.789,-	24.625.097,-

- Infrastructure

1976	33.642,-	
1977	38.688,-	
1978	51.165,-	
1979	58.840,-	
1980	67.666,-	250.001,-

- Administrative expenditure

1976	99.700,-	
1977	111.400,-	
1978	123.100,-	
1979	135.300,-	
1980	147.500,-	617.000,-

- Operational expenditure (JRC-ISPRA)

1976	989.941,-	
1977	1.138.432,-	
1978	1.309.197,-	
1979	1.505.577,-	
1980	1.731.413,-	6.674.560,-

- Expenditure for contracts (JET, Associations, Preferential support)

1976	157.834.313,-	
1977	20.000.000,-	
1978	20.000.000,-	
1979	24.000.000,-	
1980	10.999.029,-	232.833.342,-
		265.000.000,-

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6.1.1. Payments

- Appropriation for staff

1976	3.652.301,-	
1977	4.200.146,-	
1978	4.830.168,-	
1979	5.554.693,-	
1980	6.387.789,-	24.625.097,-

- Infrastructure

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- Administrative expenditure

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1980	147.500,-	617.000,-

- Operational expenditure (JRC-ISPRA)

1976	989.941,-	
1977	1.138.432,-	
1978	1.309.197,-	
1979	1.505.577,-	
1980	1.731.413,-	6.674.560,-

- Expenditure for contracts (JET, Associations, Preferential support)

1976	34.095.363,-	
1977	49.773.775,-	
1978	57.737.667,-	
1979	57.238.317,-	
1980	33.988.220,-	232.833.342,-
		265.000.000,-

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Programme 1976-1980

Summary

	Commitments	Payments
1976	162.609.897,-	38.870.947,-
1977	25.488.666,-	55.262.441,-
1978	26.313.630,-	64.051.297,-
1979	31.254.410,-	64.492.727,-
1980	19.333.397,-	42.322.588,-

6.2. The comparison between the appropriations authorized for the period 1971-75 and the appropriations proposed for the period 1976-80 is meaningless since two new association contracts with the organisations of two new Member States (United Kingdom and Denmark) have been concluded and since the economic position has evolved during the last 5 years.

6.3. Explanation of overall cost and appropriations requested

6.3.0. Method of Calculation

	Overall expenditure	%	Commission Appropriation
General expenditure	335	25	89*
Preferential support	130	45	58
JET construction phase	135	80	108
Technology work (JRC)	6	100	6
Mobility of personnel	2	100	2
Management and administration	2	100	2
Total	615*MUC		265 MUC

Justification of the rates of Commission's appropriations

- The 25% rate of appropriation towards the general expenditure of the Associations (covering almost all the work carried on in the Member States in this field) allows the Commission to participate by right in the decisions concerning the planning and execution of the work.

* Including 5 MUC for complement of salaries of seconded staff.

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- The 45% rate of preferential support to investments accorded priority status by the Liaison Group allows the Commission to ensure the common interest of new investments, to encourage actions undertaken jointly by several Laboratories and to entitle all the Associations to take part in the experiments on the devices accorded priority status.

- The majority appropriation (80%) of the Commission in the construction of JET is necessary due to the financial and high level staff requirements of this project which could not be undertaken on a national basis. A 100% appropriation is not proposed in order to ensure the commitment of the partners also on a financial basis and to ensure the Community character of the project and the close cooperation between the Commission and all the competent national organisations, wherever the site will be.

Justification of the proposed annual distribution of expenditure

- A detailed estimate of commitments and payments concerning the JET construction phase was formulated during the design phase of this project on the basis of study contracts placed in the Industry.

- The total amount of commitments concerning general support to the Associations and preferential support to priority actions are inscribed in the financial year 1976, during which the association contracts will be renewed and will bind the Commission and the Associated Laboratories for all the duration of the five year programme.

- The commitments concerning staff infrastructures and technical operation are calculated on the basis of a 15% rate of annual increase; the commitment appropriations concerning administration (missions, meetings, etc.) on the basis of 10% rate approximately.

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6.3.1. Without object for this long term programme

6.3.2. Principal factors of uncertainty

The financial volume of the programme was estimated on a technical basis, in constant money at March 1975 prices. The principal uncertainty factors are involved by contracts placed in the industries including price adjustment clauses, raw material and man-power prices and expenditure for the staff.

7. Revenue

Without object in the strict frame of the proposal submitted by the Commission on 18th July 1975.

8. Audit and re-examination

8.0. Internal audit arrangements for this operation and, where appropriate, in the Member States :

Scientific control : by the steering Committees of the Associations

by the Committee of Directors

by the Liaison Group for Fusion

The "Financial Control" verifies the execution of the budget

The "Contract Service" of the DG XII controls yearly the expenditures of the contractual partners.

8.1. Complete reappraisal of the operation : to be made on the occasion of the revision of the programme after two years of execution.

PART TWO

(additional information for a new operation)

The 1976-1980 fusion programme is the continuation of the three preceding programmes and is part of a long term action.

The JET project has been set up during the 3rd programme (1). His design phase being achieved, its construction phase will start at the beginning of the 4th programme.

(1) Council decisions of 17.12.73, OJ L 30/74
and 20. 5.75, OJ L 172/75