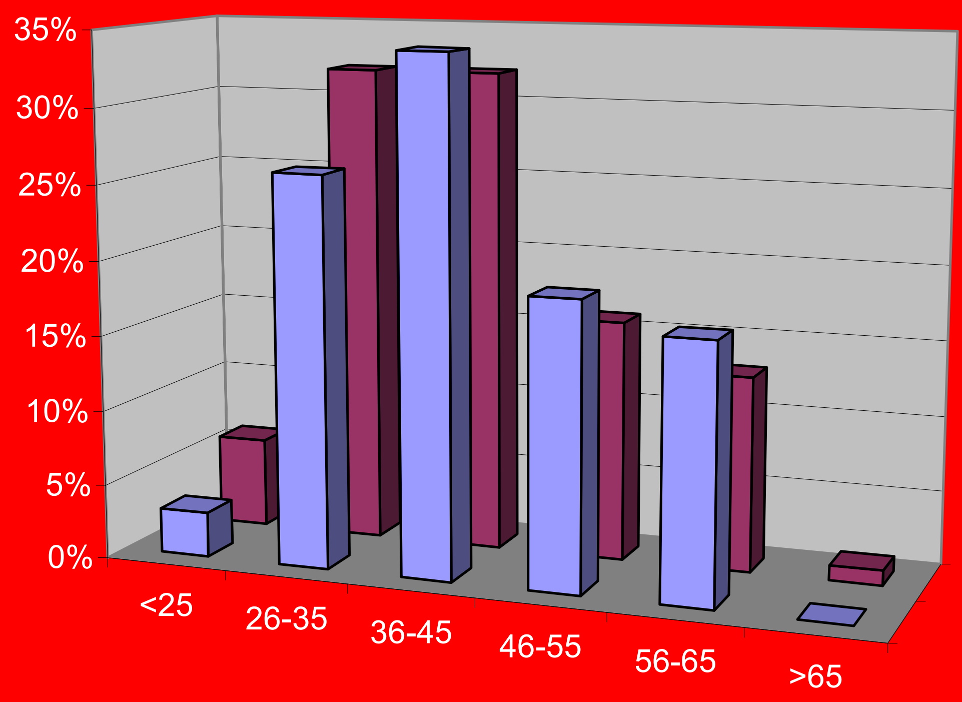
Demography of European Space Science

Results from an ESSC-ESF Study



April 2003

TABLE OF CONTENTS

TABLE OF GRAPHS

TABLE OF TABLES

INTRODUCTION

On 10 April 2002, ESA's Directorate of the Science Programme (D/SCI) invited the ESSC-ESF to carry out a study on "Space science demography in Europe: status, perspectives, proposals". This request was triggered by a letter from Prof. R. Bonnet to Prof. D. Southwood, raising the worrying situation of the space science community in France and, more specifically, to the ageing and retirement of a whole generation of scientists that was actively involved in the first 40 years of space research. CNES had addressed the fact that the expertise and know-how that this generation developed, in terms of instrument design and development, seemed in particular not to have been transferred to the new generation of young scientists, and several possible reasons were invoked for that.

The concept of this study was presented by ESA's Director of Science to the delegations of ESA's Science Programme Committee (SPC), whose reactions were in favour of such an initiative, and who accepted thereby to support the search for available national statistical elements required to conduct such a study.

The study started from a statistical analysis, ESA Member State by Member State, of the age distribution of space scientists, broadly categorised by skills (academic level, project management level, etc), with a major concern being the age distribution of instrument builders, as well as their countries of origin.

In order to concur with this mission statement, a Steering Group was formed to supervise the exercise (cf. Annex D), and a Project Assistant was hired in order to collect all the necessary data, organise and process it, and produce a factual report, which should then be studied by the Steering Group. For this purpose numerous contacts were made in the various Member States, and lists of research groups, laboratories and space research related institutions were established, with the help of the SPC delegations. Similarly, lists of individual scientists involved in space research were prepared while the widest possible coverage of activities being carried out in the different countries was undertaken. To expand these lists, and retrieve the statistical data needed for the study, both at institutional and individual level, internet-based questionnaires were developed, and made available on-line. This allowed the compilation of a database of 67 institutions representing 1769 people involved in such research, complete with all data required for completing the survey. In addition, 442 individual scientists and engineers replied to the individual questionnaire.

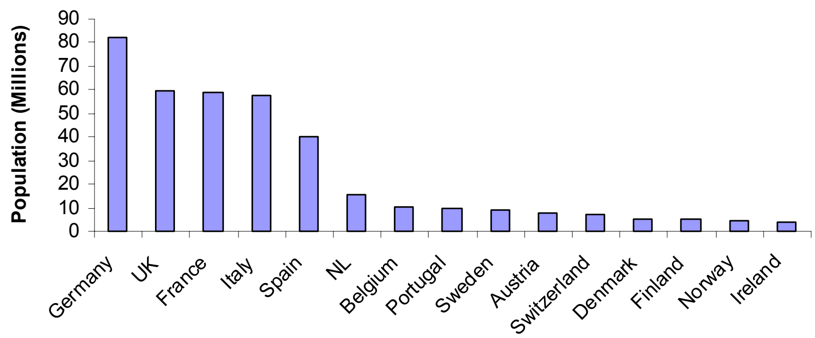
The analysis clearly evidenced the fact that we are facing in Europe a very diverse situation. Different countries show different problems, which can lead to the conclusion that there are different perspectives in the short, medium and long term ranges. However one main element emerges clearly namely the sharp decrease of the under 25 year old population in the space science workforce. This is possibly linked –but only in part – to the decrease of interest of young people in scientific studies. These findings constitute a base for recommendations to be developed, and in our view, actions should now be taken, both at national level, and at ESA or European level, in order to prevent the possible shrinking of the scientist/engineer “pipeline”. As examples of the various available tools, one can list recommendations to Ministries of Research, advocating for workforce mobility among Member States with differing situations, or stressing the need to concentrate efforts at undergraduate level.

1) THE ENVIRONMENT

1.1) ESA Members' Statistics: Demography and Tertiary Education.

1.1.1) Demography and Ageing Population.

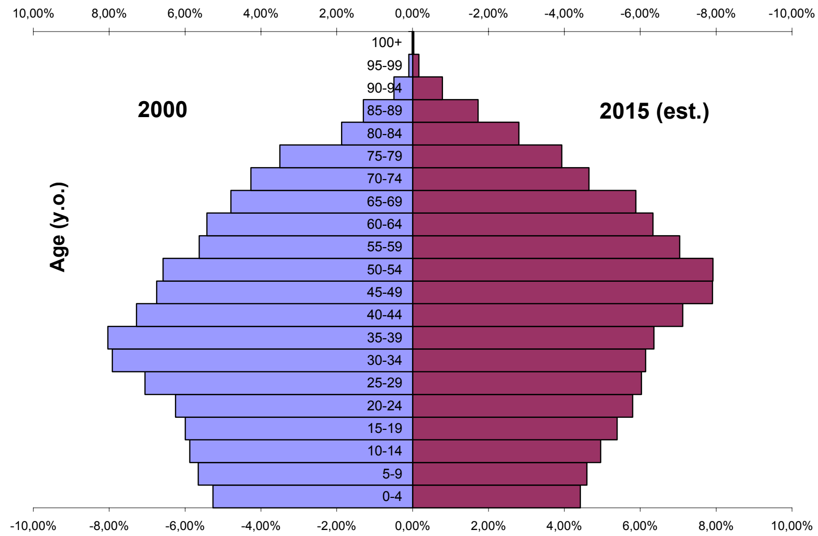
In 2000, the ESA member states global population was set at 377 millions inhabitants.



Graph 1: ESA Members' Population (2000) (Source: [1.1])

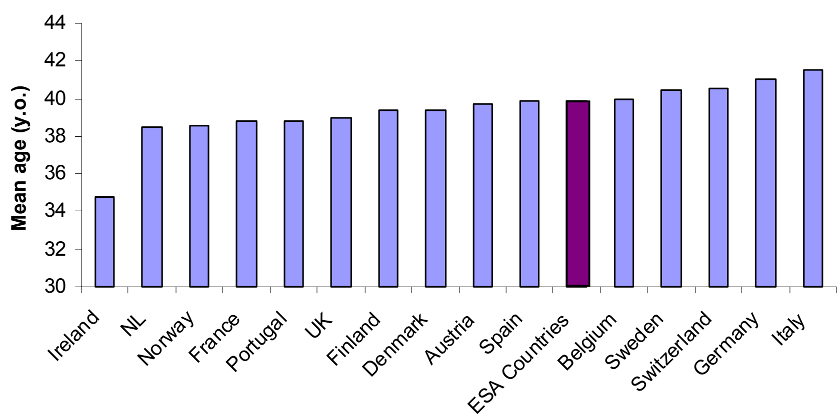
This population is quite irregularly distributed among countries. Five of them (Germany, UK, France Italy and Spain) represent almost 80% of the total, while the seven smallest contributors represent less than 10% of the total.

On the qualitative side, at the end of World War II, European countries, as most western countries, experienced an increase in their birth rate. This phenomenon, identified as the "Baby Boom", lasted about 20 years and dramatically influenced the European demographic situation for decades. Its effects are illustrated by a high share of the 25-44 year population in the European age pyramid.



Graph 2: ESA Members' Age Pyramid (2000 and 2015 estimate) (Source: [1.1])

In ESA member states, the population's mean age was 39.9 in 2000; it is estimated to reach 43.4 by 2015. While the total population will be stable during this period, its composition will change, especially concerning the "seniors": the share of population over 60 years old will increase by 28%. This trend will be emphasised in the 2015-2030 period and a new one will appear: the decrease in the active population share (25-60 years old). The combination of these two trends will be the source of major social concerns.



Graph 3: Mean Age in ESA Member States - 2000 (Source [1.1])

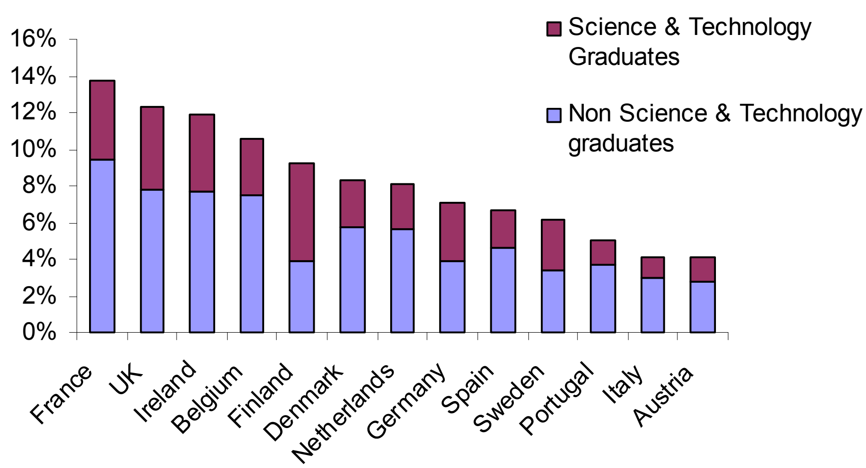
The population mean age varies significantly among ESA member states. Ireland is, by far, the youngest country with a mean age of 34.8, followed by the Netherlands, Norway, France, Portugal and the UK whose mean age varies between 38 and 39. On the other hand, Germany and Italy are the "oldest" with a mean age over 41.

Every ESA member state will experience the ageing of its population, but at a different rate; for the 2000-2015 period, while the global ageing rate for ESA member states will be 2.8 months per year, Ireland's will be the lowest (1.6); France, Denmark and Norway will be below 2.5, while two countries will be well above 3.5 month per year: Switzerland (3.7) and Austria (3.7). The global trend among countries appears to be that older countries are ageing more rapidly than younger ones. Thus the ranking does not change but differences are increasing: in 2015, Ireland's population will still be the youngest (mean age: 36.8) and Germany's will be the oldest (45.5).

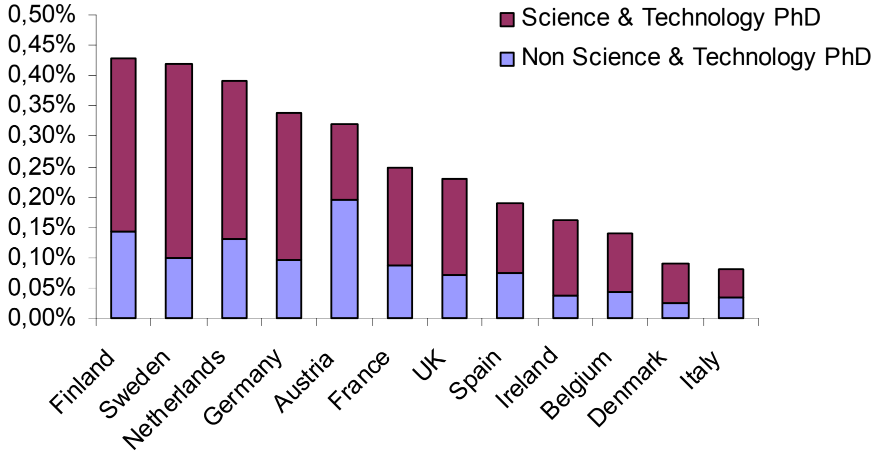
Beside the growing importance of the 60+ population, and since the population will be stable, ESA countries will experience a sharp decrease in their 0-25 year old population. This population, which can be considered as the "workforce tank" for ESA member states, will decrease by 13.3% over the 2000-2015 period, this represents more than 14.5 million young people and potential students.

1.1.2) Decreased Interest for Scientific Studies.

Besides demographic issues, education must be considered as it represents the knowledge building effort of a nation.



Graph 4: Share of 20-24 y.o. Population Holding a Graduate Degree (school year 1996/1997) (Source: [1.2])



Graph 5: Share of 25-29 y.o. Population Holding a PhD (school year 1996/1997) - (Source: [1.2])

Graphs 4 and 5 show a very heterogeneous situation among European countries. It is important to note that the comparison between countries is subject to distortions due to the differences in education policy among countries, for example, British students can graduate or pass their PhD earlier than in France.

The concentration of graduates in the 20-24 year old population is more than three times bigger in France or UK than in Austria or Italy. Looking at the concentration of PhDs in the 25-29 year old population, the differences are even more important: it is more than five times bigger in Finland or Sweden than in Italy. In relative terms to the population distribution among countries, around 77% of both graduate and PhD diplomas are granted in four countries: France, UK, Germany and Spain.

Focussing on the importance of scientific and technological studies in tertiary education, the main feature is the prevalence of these trainings at the doctorate level: while these fields globally represent between 30% and 40% of graduate studies, between 60% and 70% of PhD topics are oriented towards science and technology.

Even if the situation with regards to the importance of scientific studies in tertiary education is relatively homogeneous among ESA countries, some countries like Finland, Germany or the UK are more science and technology oriented; on the other hand, tertiary education in Austria and Spain is less focussed on such matters.

Scientific studies are currently rather important in the tertiary education, but the trend shows that the interest for such vocation is decreasing.

	General student population evolution	Scientific student population			Source
		Global	General scientific university trainings	Technological trainings	
France	-0,80%	-4,70%	-20,10%	11,00%	[1.3]
Germany	0,10%	-8,70%	3,20%	-19,40%	[1.3]
UK	0,17%	-2,3% (1)			[1.4]

(1) Concerns higher education in physical sciences, mathematical sciences and engineering.

Table 1: Evolution of Student Population in France, Germany and the UK Between School Year 1995-1996 and 2000-2001

Table 1 gives the example of the situation in the three most populated ESA countries. In these countries, the erosion of the scientific student population is on its way. This decrease can take different aspects; in France, as university training is experiencing a sharp decrease with respect to the total population, the main problem that might appear is a future lack of teachers and scientists. Conversely in Germany, this situation would appear for engineers [1.3]. These issues seem to be a major concern in Europe as the European Commission has set as a priority objective to "*increase recruiting in technical and scientific training*" (Mathematics, Science and Technology Group – European Council. Barcelona, March 2002).

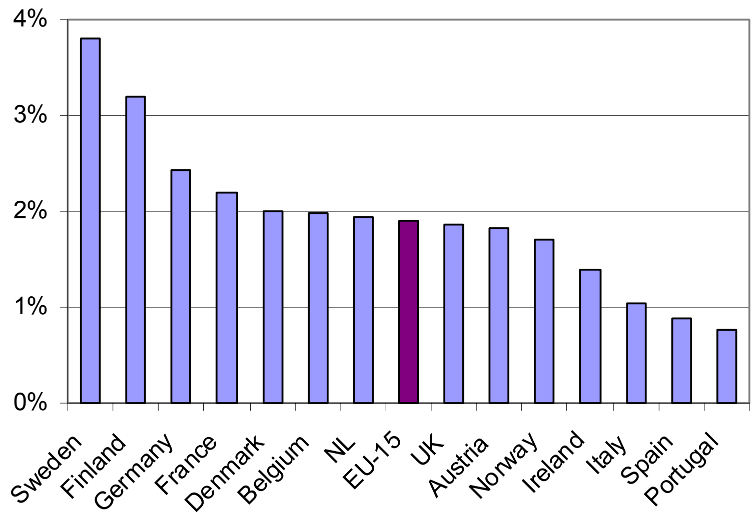
When looking at the reasons of such a lack of interest for scientific studies and careers, an opinion poll [1.11] aimed at European young people still studying in 2001 in EU member states, lists the following reasons:

- Lack of appeal of scientific studies (67.3% of the respondents)
- Difficulty of the subjects (58.7%)
- Young people are not so interested in scientific subjects (53.4%)
- Salaries are not attractive enough (40%)
- Science has too negative an image (34%)

1.2) Competition Aspects.

1.2.1) Research and Development Effort.

R&D activities do not have the same weight among European countries, Graph 6 presents the R&D expenditures in countries in relation to their Gross Domestic Product.

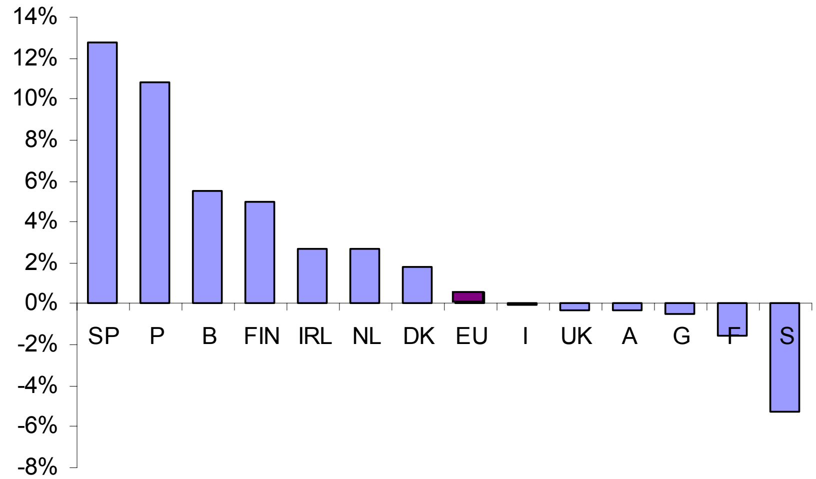


Graph 6: R&D Expenditures as % of GDP (1999, except NL (1998) and Ireland (1997)) (Source: [1.13])

At the EU 15 level, R&D expenditures represent 1.92% of the Gross Domestic Product. A first group composed of Sweden (3.8%), Finland (3.19%), Germany (2.44%) and France (2.19%) can be identified as countries with an intensive R&D effort. A second group stays in the range of the European level, and finally, there is a third group composed of Ireland (1.39%), Italy (1.04%) Spain (0.89%) and Portugal (0.76%) whose effort in R&D is lower than the European figure.

1.2.2) Competition for Public Funding

Looking at the European Union zone, public expenditures in R&D experienced a real annual growth of 0.61% over the 1995-2000 period (Graph 7).



Graph 7: Government R&D Budget – Average Real Growth 1995 to the Latest Year Available (99 B, E, F, IRL, I, UK, EU, all other: 95-2000) (source: [1.5])

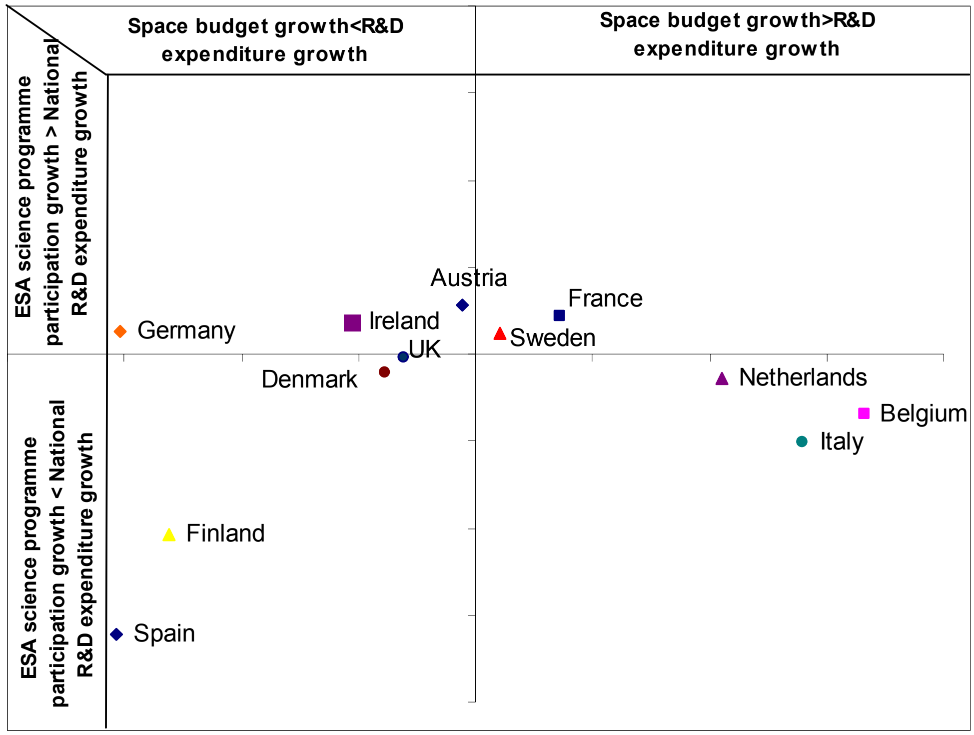
Space science relies predominantly on government budgets. With the emergence of new disciplines in recent years, such as biotechnologies or information technologies, research activities and funding tend to become more oriented towards technology development and applications. The area of high technology matters is growing; thus space science has new competitors in terms of public funding. Table 2 presents the comparison between the mean real annual growth rate of R&D expenditures, national ESA scientific program participation and national space programmes budget (all space activities).

Even if government expenditures for R&D are globally increasing in the EU-15 zone, it seems that space activities, and especially space science, does not fully benefit from this trend. National space programmes budgetary increase is lower than the one of public R&D expenditures, and because of the inflation effect, ESA science budget even decreases.

	Average Real Growth		
	Govt R&D Budget	**National Space Programme Budgets**	**ESA Science Programme Participations**
Period	**1995-2000**	**1994-1999**	**1995-2000**
Spain	12,72%	-2,60%	-3,38%
Belgium	5,51%	22,13%	2,06%
Finland	4,99%	-8,07%	-5,37%
Ireland	2,69%	-2,65%	4,50%
Netherlands	2,68%	13,19%	1,28%
Denmark	1,83%	-2,02%	0,72%
Italy	-0,08%	13,92%	-5,15%
UK	-0,27%	-3,36%	-0,45%
Austria	-0,33%	-0,86%	2,48%
Germany	-0,52%	-15,68%	0,76%
France	-1,52%	2,12%	0,64%
Sweden	-5,28%	-4,23%	-4,09%
Norway	:	-1,81%	2,30%
Switzerland	:	-1,74%	-1,24%
Global	**0,61% (EU-15)**	**0,18%**	**- 0,88%**

Table 2: Average Real Growth of Government Budgets (2000 value Source: [1.5], [1.6], [1.7], [1.8])

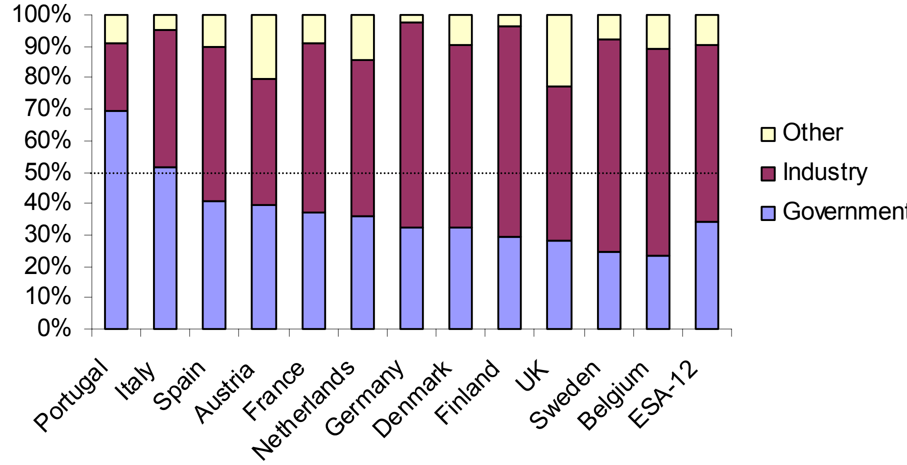
Graph 8 presents graphically the data appearing in Table 2. It shows the relative situation of national space budgets, as compared to public R&D expenditures. Even if the global situation seems to be unfavourable for space activities, at the European level the evolution of each budget is of the same order of magnitude. This trend can be confirmed or invalidated by a political decision.



Graph 8: Evolution of Government Space Budget (in constant currency – 2000 Value) with Regards to Evolution of R&D Public Expenditures (Source: [1.5], [1.6], [1.7], [1.8]).

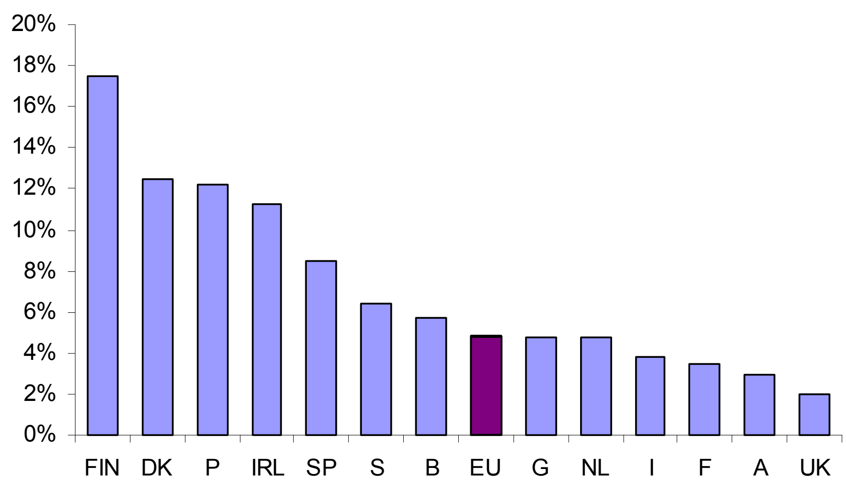
1.2.3) Competition with the Industry

Looking at the demographic trends of major importance in the future and, especially, the decrease of the 15-25 y.o. population, the lack of interest in scientific studies, and the growing importance of some non space-related high-technology activities, it appears that the job market for scientists and engineers is becoming more and more competitive, and it is more difficult for the space fields to attract this workforce. Regarding professional orientation; two important questions appear for scientists and engineers: "public or private sector?" and "which discipline?".



Graph 9: Origin of the Domestic R&D Funding in ESA Countries (1999 - Data for Switzerland, Ireland and Norway not available) (data source: [1.10])

Looking at the source of domestic R&D funding for the 12 countries presented in Graph 9, the industry-financed R&D represents 56.3% of the domestic R&D expenditures, and 34.2% comes from governments; the remaining 9.5% are mainly cross-national R&D investment. Portugal and Italy are the only countries considered where such activities are funded in majority by their governments



Graph 10: Industry Financed R&D budget – Average Real Growth 1995 to the Latest Year Available (D, A, P: 95-00; F: 95-98; IRL, S: 95-97 all other 95-99) (source: [1.5])

Graph 10 shows the average real growth of industry-financed R&D budget in 13 European countries. Not only is industry the main funding source, but also the gap between government and private investment in R&D is growing. In the EU zone, in the 1995-2000 period, the average growth of industry-financed R&D was 4.9% per year, which is more than eight times higher than the growth of publicly-funded R&D. Spain is the only country where public R&D grew faster than the private R&D.

This relative increase of financial resources makes the private sector more attractive in terms of means and infrastructure. From 1990 to 2000, in the EU-15 zone, the share of R&D labour force in the government sector decreased by 13.6% [1.9].

Looking at the attractiveness of disciplines, an opinion poll conducted in 2001 asked a representative panel of the EU population the following question: *"Which scientific and technical development do you find the most interesting?"*. Table 3 presents the results of this poll:

Area	Score
Medicine	60,3
Environment	51,6
Internet	27,9
Genetics	22,2
Economics and Social Sciences	21,7
Astronomy and Space	17,3

Table 3: Areas of Main Scientific & Technological Interest in EU Countries. (Source: [1.11])

Medicine and environment are the two areas of main interest for Europeans, Astronomy and space hold the sixth position only. It is important to note the massive popularity of the Internet area among young people; it appears first for the 15-24 year old population.

Beside this low relative importance of interest in space activities, it seems that the European population is not aware of the European activities and perspectives in space activities: in 1998 a telephone inquiry based on respondents from ESA Member States showed that only 12% of the general public spontaneously knew ESA (with large variations among countries) while 54% spontaneously knew NASA [1.12].

2) THE WORKFORCE

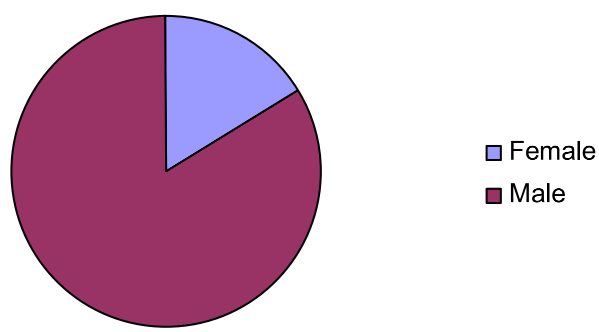
2.1) Workforce Volume and Evolution

The workforce involved in European space science activities will be presented in this section. This analysis will be based upon several characteristics:

- The gender: men or women,
- The type of work contract held: permanent posts or short term/renewable positions,
- The field of activity: Scientific and engineering workforce,
- The research domains:
  - astronomy (High energy, UV and Optical, Infrared and sub millimetric astronomy),
  - physics related research (fundamental physics, solar and space physics) and,
  - planetary exploration.
- The nation.

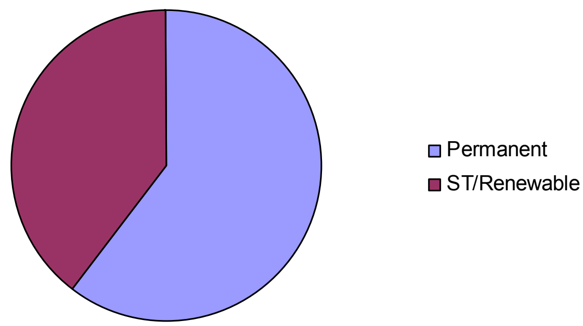
2.1.1) Total Workforce– Volume

Based on the answers to the individual questionnaire, the gender distribution shows a largely unbalanced situation: representing 84% of the population.



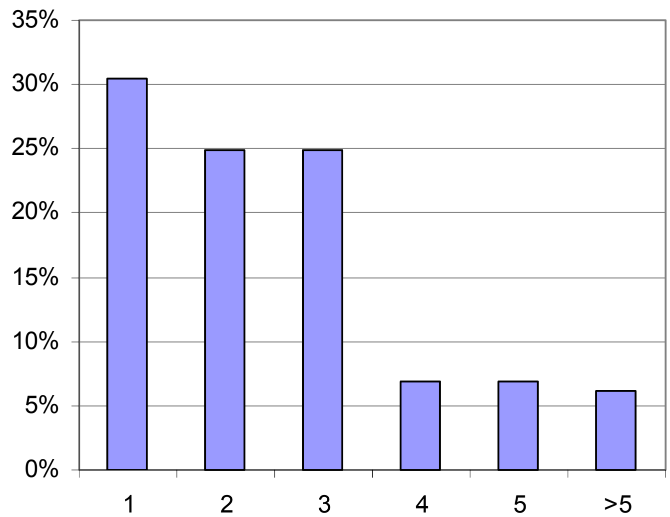
Graph 11: Global Gender Distribution (source: [2.1])

Considering the type of contract, graph 12 shows the importance of the workforce that holds a permanent position. This category represents 60% of the global workforce, against 40% for the short-term work contract holders.



Graph 12: Workforce Distribution by Type of Contract (source: [2.2])

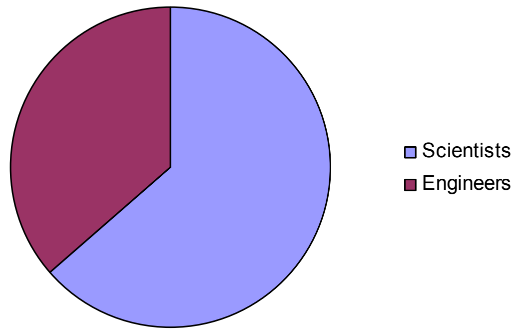
The mean length of short-term contracts is 2.6 years; graph 13 shows the distribution of these contracts as a function of duration.



Graph 13: Short Term Contract Duration Distribution (Years) (Source: [2.3])

The majority (55%) of the short term contracts are set to last no more than two years; on the other hand, only 20 percent of these contracts have a duration of more than 3 years.

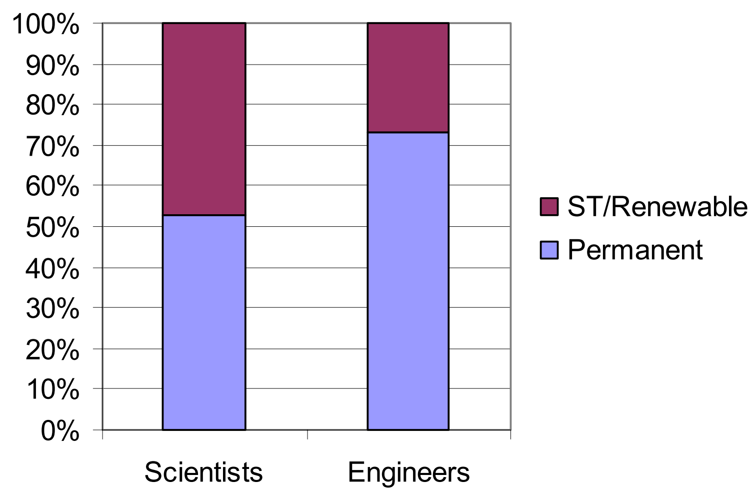
Looking at the field of activity, graph 14 shows the distribution of the workforce between science and engineering areas.



Graph 14: Distribution of the Workforce by Field (Source: [2.4])

Representing 36% of the global workforce, there is about one engineer for two scientists. The gender distribution for scientists and engineers is of the same order of magnitude as the one of the global workforce but it shows a larger female representation in the scientific field (17% of the workforce) compared to the engineering side (13%) [2.5].

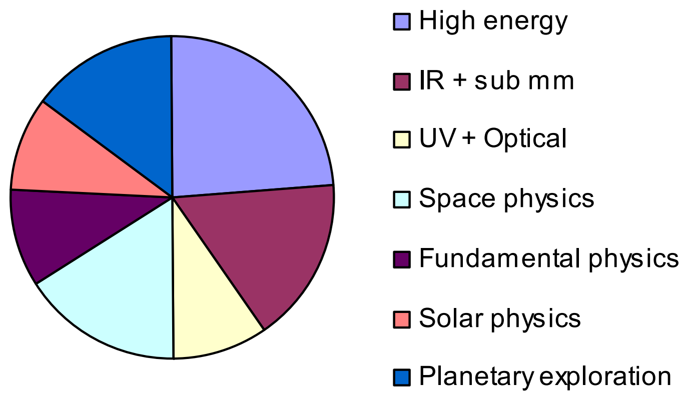
As shown on graph 15, there are larger differences when looking at the type of contracts held in both fields.



Graph 15: Workforce Distribution by Type of Contract and by Field (Source: [2.6])

Whereas there is no clear "standard" work contract on the scientific side (51% of the scientists held permanent posts), the engineers benefit much more from permanent posts: roughly ¾ (74%) of them hold such a contract.

To analyse the distribution among research domains, and as engineers are much less specialised in a particular research domain, only the scientific workforce has been considered.



Graph 16: Workforce Distribution by Research Domain (Source: [2.7])

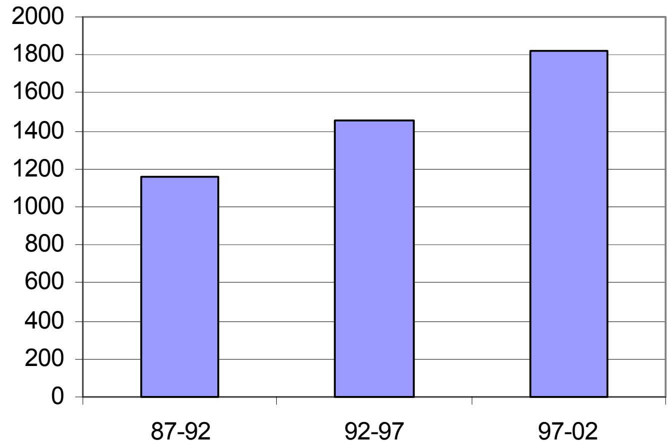
Astronomy-related research domains gather almost half of the scientific workforce (49%). This importance of astronomy related research relies mainly in turn upon high energy astronomy that gathers 23% of the global workforce, infrared and sub millimetric astronomy representing 19% of it, UV & optical astronomy consituting the last 6%.

Physics-related research domains represent 39% of the scientific workforce. In this area, space physics is the main domain (17% of the workforce); the remaining workforce (21%) is quite equally spread over solar physics and fundamental physics.

Finally, the planetary exploration research activities represent 12% of the scientific workforce.

2.1.2) Total Workforce – Evolution.

Looking at the evolution of the workforce volume, graph 17 shows an increase over the last 15 years.

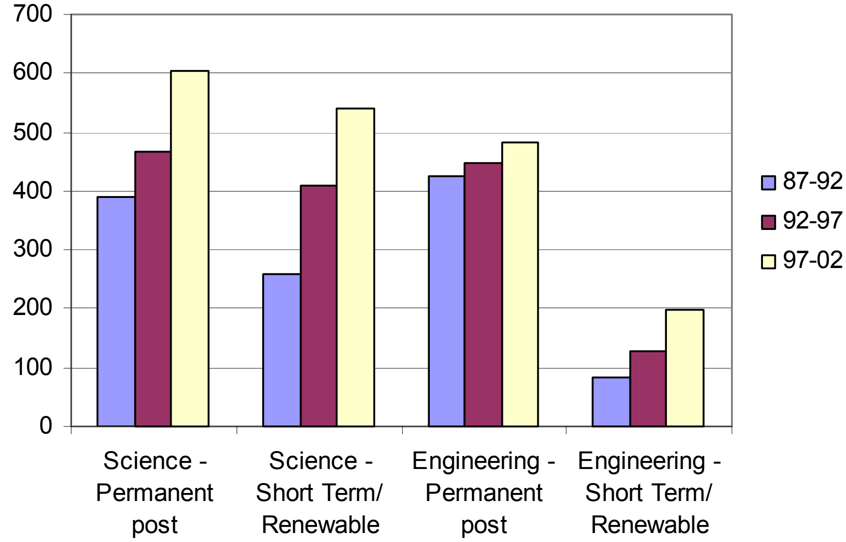


Graph 17: Total Workforce Evolution in Participating Laboratories (Source: [2.8])

In participating laboratories and research institutions, and starting from an estimated total workforce of 1157 in the 1987-1992 period, the population involved in space science grew to reach 1825 people in the 1997-2002 period. This evolution corresponds to an increase of 58% between these two periods.

It is the short-term contracts that benefit the most from this increase. Their number grew by more than twice that of the global workforce (123% over the period). Thus, from 29% in the 87-92 period, the short-term positions represent 40% of the participating institutions' workforce in the 97-02 period [2.9].

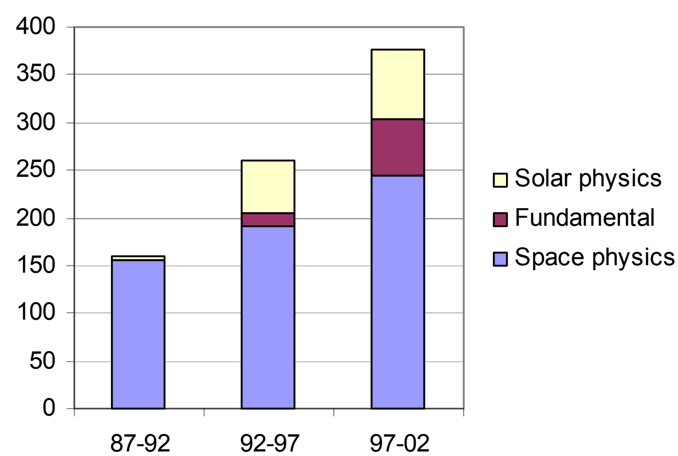
Both categories of scientists and engineers have increased their workforce, but at a different rate: over the period, the scientific workforce increased by 76% while the engineering workforce increase was 34%. Thus, from 56% in the 87-92 period, the scientific positions increased their importance, reaching 63% of the participating institutions' workforce in the 97-02 period [2.10].



Graph 18: Workforce Evolution by Field and Type of Contract (Source: [2.10]).

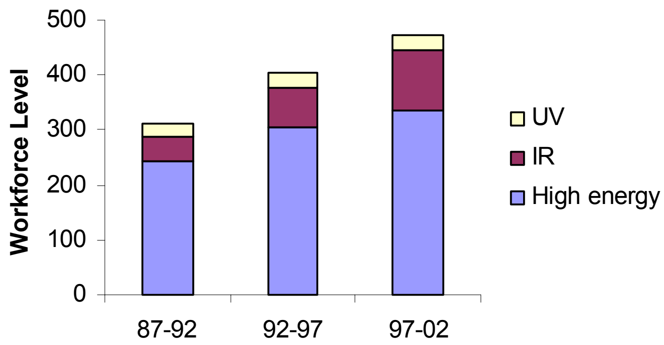
Globally, as shown on graph 18, it is the short term engineering positions that evolve the most over the period, experiencing an increase of 140% while the permanent engineering posts volume only evolves by 13% over the same period.

Looking at the evolution of the workforce by research domains, it is the physics-related domains that benefit the most from the workforce increase. As shown on Graph 19, the institutions whose main research domain is fundamental, solar or space physics, increase their workforce by 135%.



Graph 19: Evolution of the Workforce of Institutions which Main Domain is Related to Physics (Source: [2.11])

Concerning astronomy, the evolution of the workforce in institutions whose main area is related to astronomy, is 53%, which is slightly lower than the average. Of the astronomy research domains, from 46 people in the 1987-1992 period to 110 in the 1997-2002 period, it is infrared astronomy that grew the most (139%).

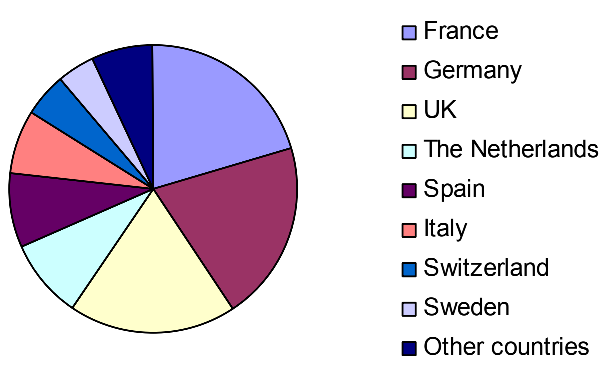


Graph 20: Evolution of the Workforce of Institutions which Main Domain is Related to Astronomy (Source: [2.11]).

It seems that the workforce increase in institutions whose main research area is planetary exploration is in the range of 66% (from 38 people in 1987-1992 to 63 in 1997-2002) but the limited set of data related to this research domain does not lead to a reliable estimation of this increase.

2.1.3) Total Workforce – National Considerations.

Based on the institutions' answers to the questionnaire, graph 21 shows the relative importance of Member States in the workforce involved in European space science.

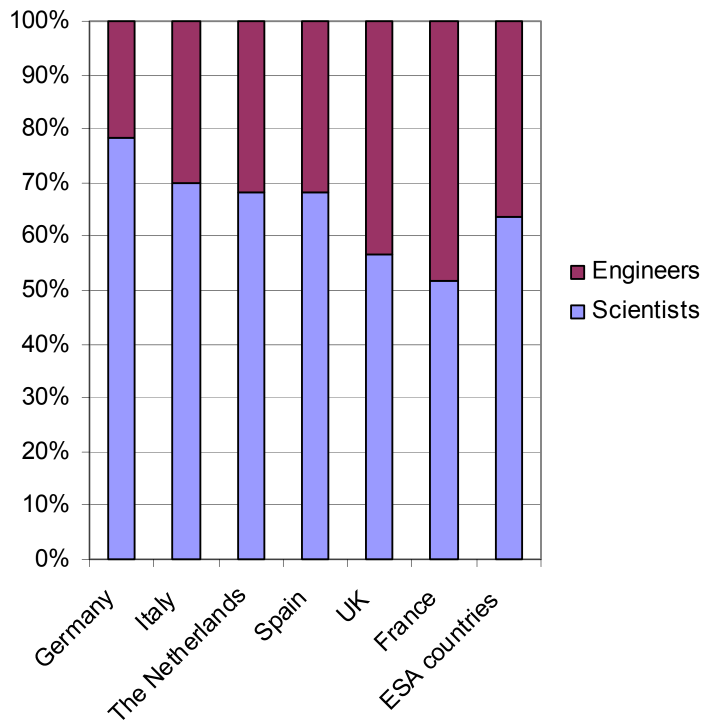


Graph 21: Distribution of the Workforce Working in Participating Institutions (Source: [2.12]).

On a total of 1769 people represented, France (20.6%), Germany (19.9%), and UK (19%) cover almost 60% of the workforce. The remaining workforce is distributed as followed :

- The Netherlands (8.7%)
- Spain (8.4%)
- Italy (7.2%)
- Switzerland (5.1%)
- Sweden (4%)
- Other countries (7.1%)

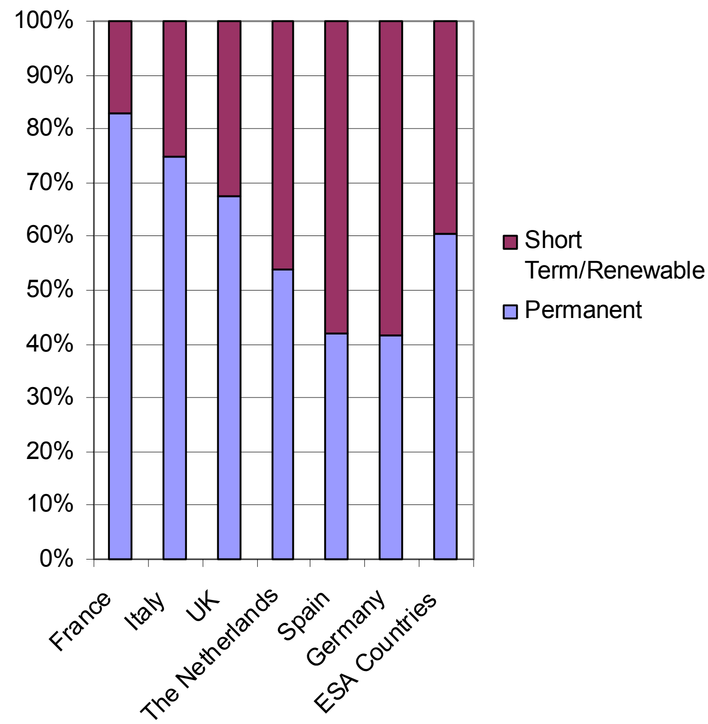
Regarding the composition of the workforce at the national level, some important differences appear. Graph 22 shows the distribution of the workforce by field in countries for which a sufficient amount of data was made available.



Graph 22: Scientists/Engineers Distribution at the National Level (Source: [2.13]).

With 78% of its workforce working on the scientific side, Germany is the country that relies the least on the engineering workforce. Italy, The percentages for Spain and the Netherlands are of the same order of magnitude, i.e. between 68% and 70% of their workforce working in science. On the other side, the UK (57%) has a share of scientific workforce below the ESA Member States average; France, with 52% of scientists and 48% of engineers, is the country which workforce relies the most on the engineering workforce.

Besides the science/engineering dichotomy, the distribution in the type of work contract used at the national level also shows some large differences, as shown on graph 23.

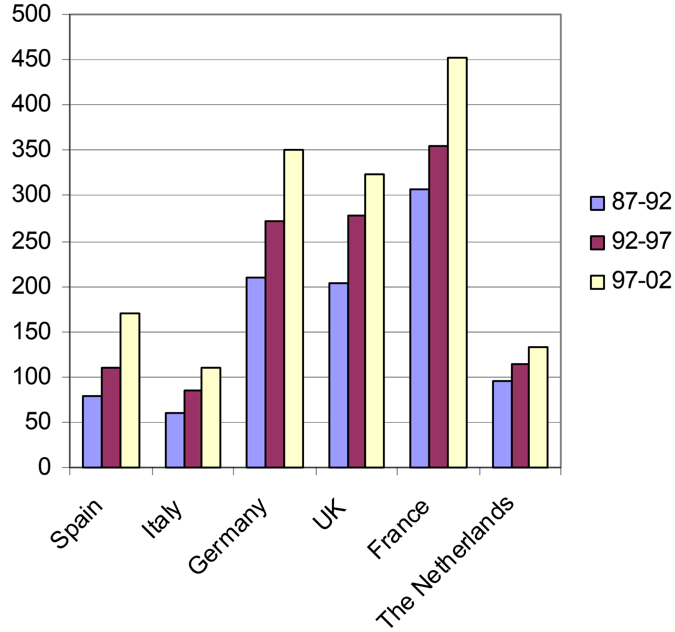


Graph 23: Workforce Distribution by Type of Contract at the National Level (Source: [2.14]).

Among the six countries considered, France, with 83% of its workforce holding a permanent post, is the country where the research activities rely the most upon permanent contracts. Following are Italy and UK with respectively 75% and 67% of permanent posts. The other states are below the ESA Member States average (The Netherlands (54%), Spain (42%) and Germany (42%)). In the last two countries, the majority of the workforce hold Short Term/Renewable positions.

- **Workforce Volume Evolution - National Considerations**

Looking at the evolution of the workforce volume at the national level, some large differences appear; graph 24 presents it for 6 countries.



Graph 24: Evolution of the Workforce in Participating Institutions at the National Level (Source: [2.15])

Of the six countries considered, it is Spain that seems to have increased its workforce the most: from 79 people in the 1987-1992 period to 170 people for the 1997-2002 period, Spanish participating institutions experienced an increase of 115%. Following are Italy (83%), Germany (67%) and UK (58%) these three countries being above, or equal to, the average ESA Member States workforce increase (58%). Finally France and The Netherlands are below the average with respectively a 47% and a 37% increase.

2.2) <u>Mean Age and Age Distribution</u>

In this part is presented the information concerning age for the European workforce and the differences among its categories. Age distribution data come from the institutional questionnaire answers. For the mean age calculation, data from both questionnaires have been compiled, using the age distribution issued from the institutions' inputs, and the mean age per age category issued from the individual ones.

Countries with significant workforce representation from the institutional questionnaire are highlighted; these are:

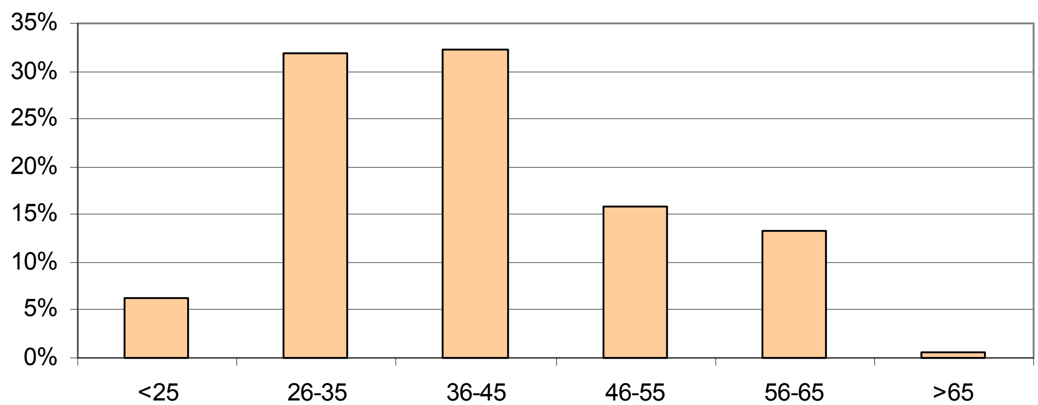
- France (364 people represented)
- Germany (352)
- UK (337)

and, to a lesser extent:

- The Netherlands (154)
- Spain (148)
- Italy (127)
- Switzerland (91)
- Sweden (71)

2.2.4) Age Issues - ESA Global

Of the 1769 people represented by the European participating institutions, Graph 25 shows the global age distribution.

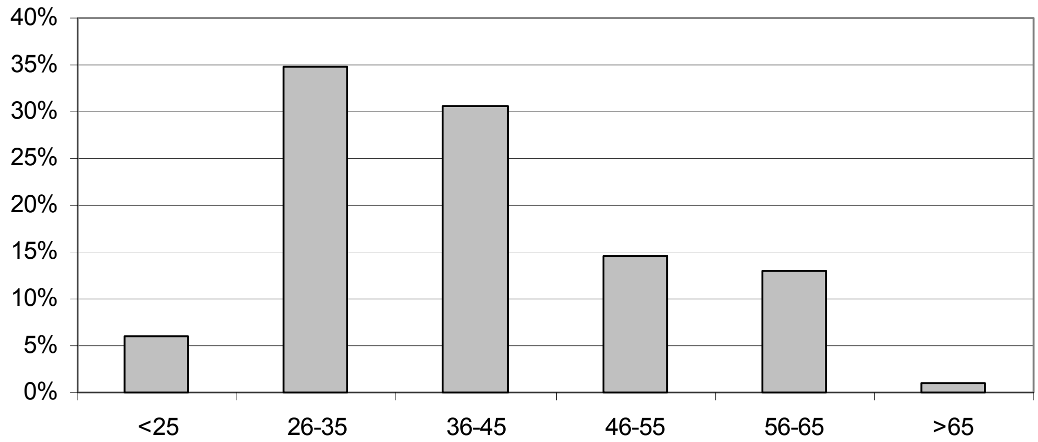


Graph 25: Age Distribution Based on Institutions' Answers (Source: [2.16]).

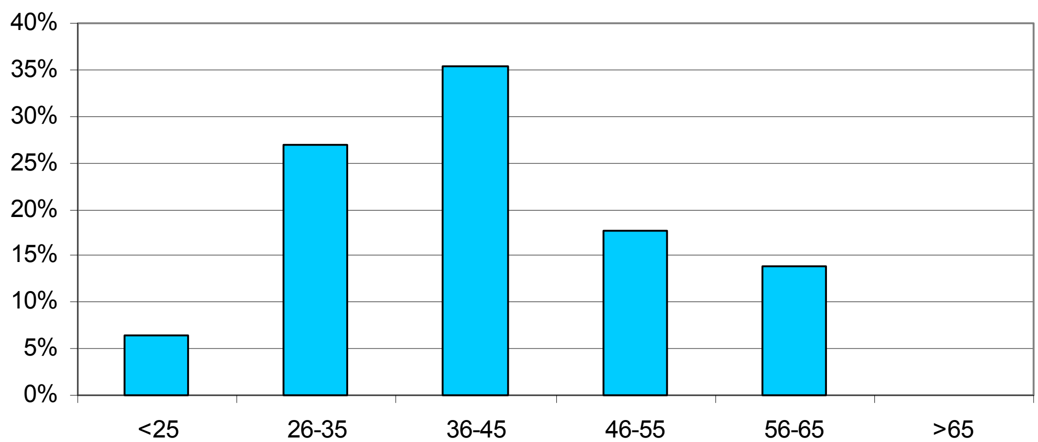
Based on both the individual and the institution questionnaire the mean age of the European workforce involved in space science is set at 40.6 years old. This mean age is very different when looking at gender: the women's mean age is 35; men are much older with a mean age of 42.

Concerning the distribution, 38% of this population is under 36 and 30% over 46.

Age issues present different features between the engineering and the scientific workforce; graphs 26 and 27 present the age distribution of both fields.



Graph 26: Scientific Workforce: Age Distribution Based on Institutions' Answers (Source: [2.17])



Graph 27: Engineering Workforce: Age Distribution Based on Institutions' Answers (Source: [2.17])

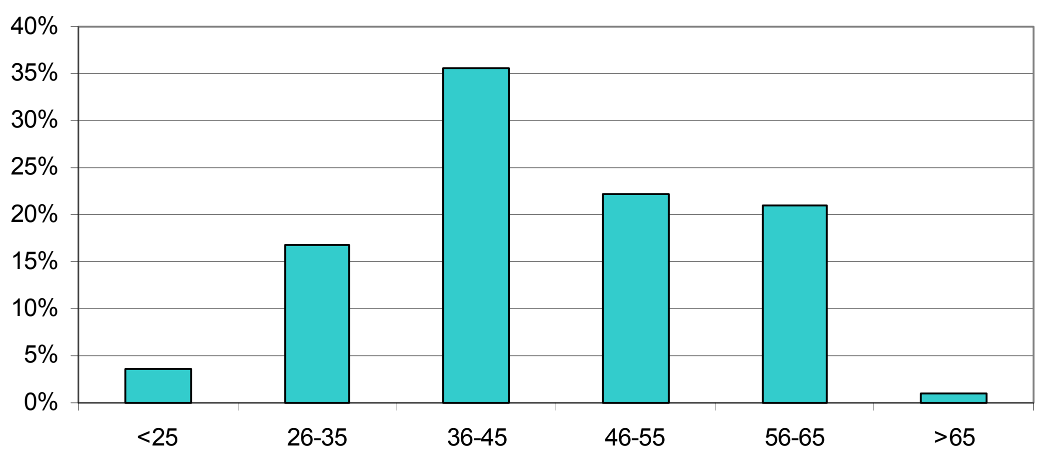
As a first point, scientists are slightly younger than engineers: their mean age is 40.3 against 41.4 for the engineering workforce. Looking at the distributions, as the share of people older than 46 is of the same order in both populations (29% for scientists and 32% for engineers), this difference in age seems to be due to a larger share of people under 36 in the scientific population: 41% against 33% for engineers. It seems important to note that a share, even though marginal (1%), of the scientific population is over 65. This phenomenon does not appear on the engineering side.

Regarding research domains, Table 4 shows the scientists' mean age per research area.

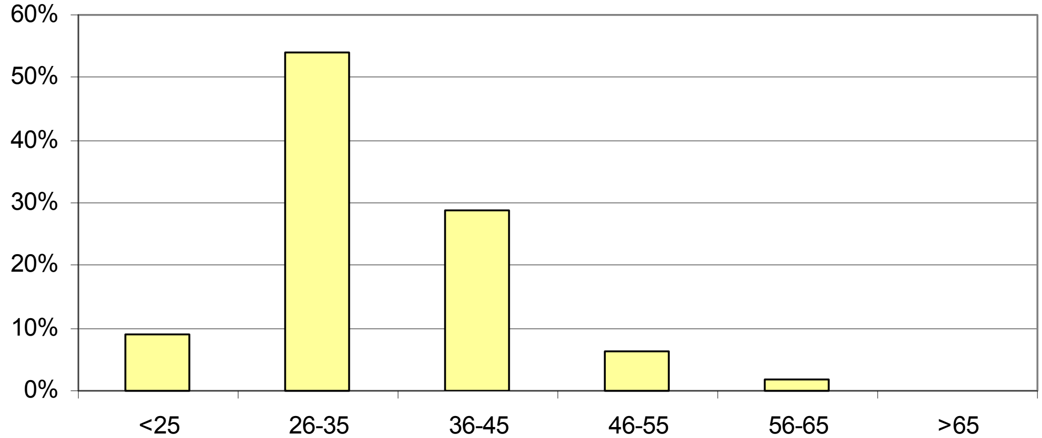
	Population	**Mean Age**
High energy	84	**39.4**
IR + sub mm	57	**40.4**
UV + Optical	33	**39.9**
Astro	**174**	**39.8**
Space physics	56	**41.8**
Solar physics	34	**43.8**
Fundamental physics	34	**40.3**
Physics	**124**	**41.9**
Planetary exploration	**52**	**39.1**
Global	**350**	**40.3**

Table 4: Mean Age per Research Domain (Source: [2.18])

Due to a limited number of inputs for each domain, these data indicate tendencies rather than providing detailed information; but it seems that scientists are older in the physics-related domains (especially space and solar physics) than in the astronomy area. Planetary exploration seems to be the research domain where scientists are the youngest.



Graph 28: Permanent Positions: Age Distribution Based on Institutions' Answers (Source: [2.19])



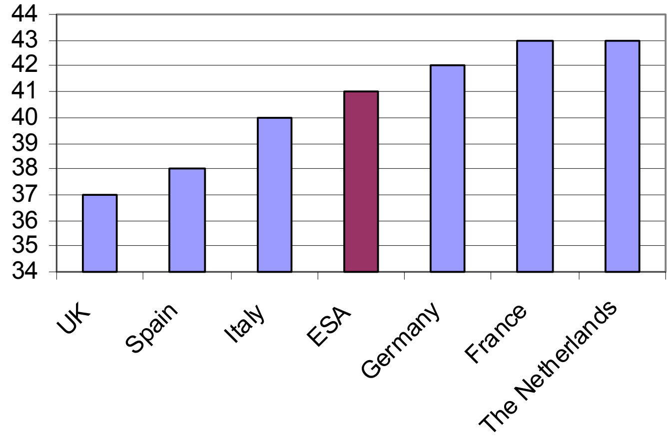
Graph 29: Short Term/Renewable Positions: Age Distribution Based on Institutions' Answers (Source: [2.19])

Age differences are more important when looking at the age distribution as a function of the type of work contract, as shown in graphs 28 and 29. These age distributions clearly show a "short-term contracts for younger / permanent position for elders" situation. Only 20% of permanent post holders are under 36, this share grows to 65% for short-term contract holders. On the other side, only 8% of short-term contracts holders are over 46, against 44% for permanent positions. This results in more than a 10 year-difference between the two populations' mean age: the mean age of short-term contract holders is 34; for permanent positions, it grows to 45.

2.2.5) Mean Age and Age Distribution - National Considerations

In this part are presented the mean age and age distribution among ESA Member States with sufficient representativeness.

At first, and concerning mean age, Graph 30 shows the mean age for UK, Spain, Italy, Germany, France and the Netherlands.



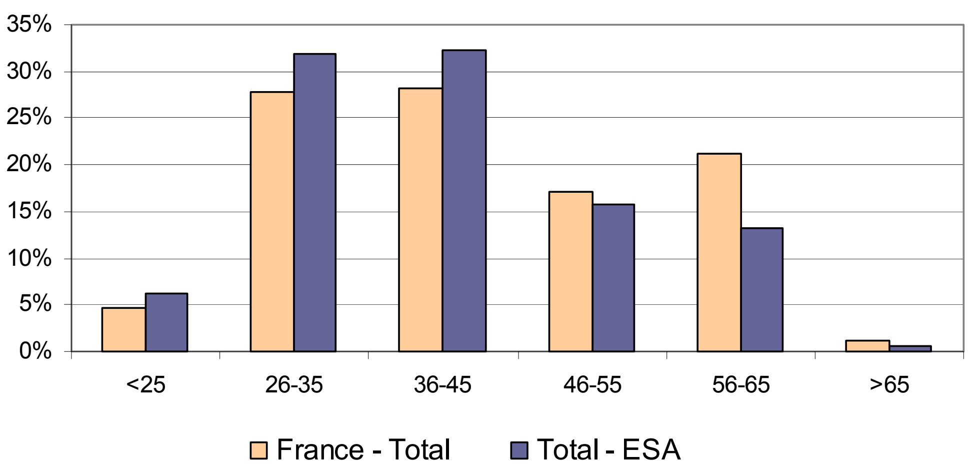
Graph 30: Some ESA Member States Space Science Workforce Mean Age.

Mean age varies very significantly among these countries, the French and Dutch workforce are the oldest with a mean age of 43; British and Spanish workforce, being below 40, are the youngest.

2.2.5.1) National Considerations - France

- **Global**

With a mean age of 43, France is, with The Netherlands, the country considered in the survey where the workforce involved in space science is the oldest. This can be illustrated by the age distribution presented in graph 31.

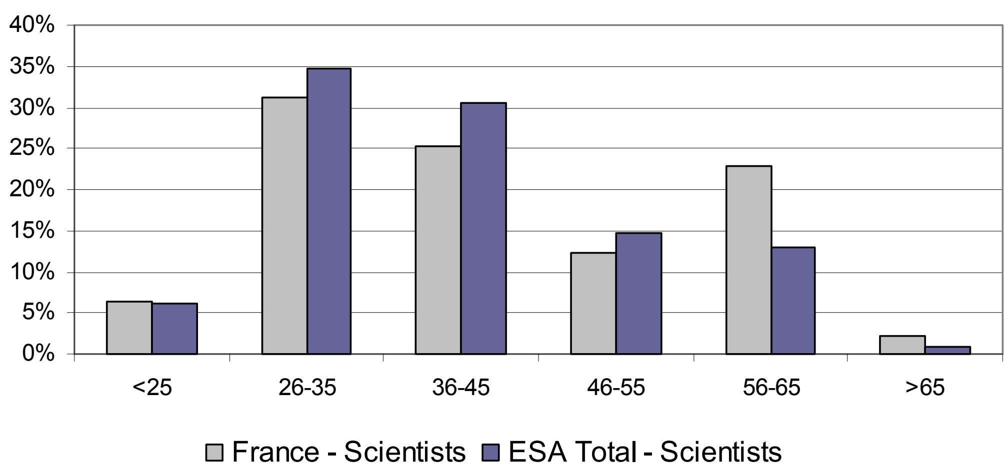


Graph 31: France Global Age Distribution Based on Institutions' Answers (Source: [2.20])

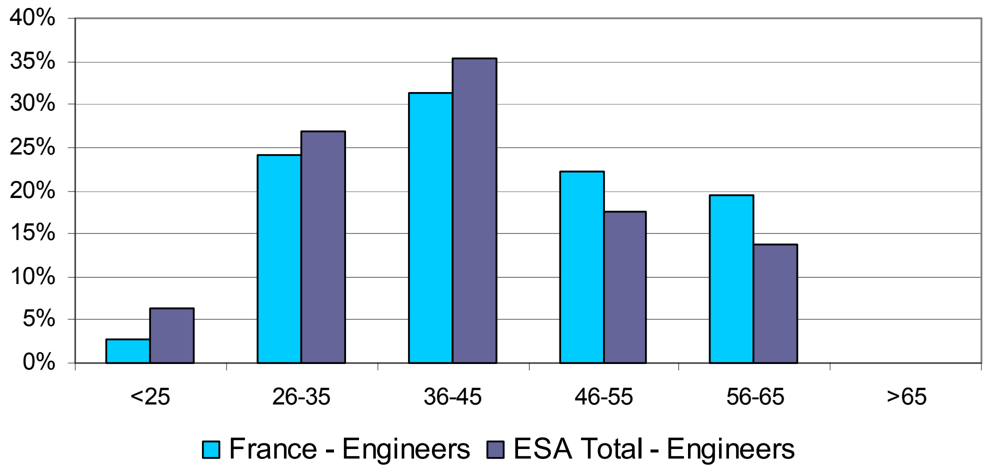
Only 33% of the workforce is under 36 (against 38% at the European level) and 39% are over 46 (38% at the European level). Unlike the age distribution at the European level, the French situation presents a bimodal distribution: there are more people in the range 56 to 65 (21%) than in the range 46 to 55 (17%).

- **Scientific/Engineering Workforce**

French engineers are older than scientists on average and both categories are older than the European average, and even the oldest of the countries considered: the engineers' mean age is 44 (40 at the European level) against 43 for scientists (40 at the European level). Graphs 32 and 33 present the age distribution of both categories.



Graph 32: French Scientific Workforce: Age Distribution Based on Institutions' Answers (Source: [2.20])



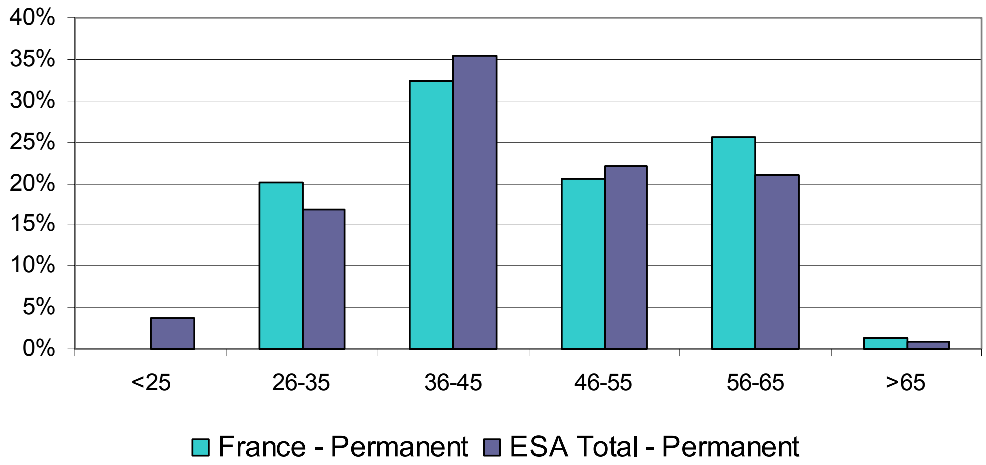
Graph 33: French Engineering Workforce: Age Distribution Based on Institutions' Answers (Source: [2.20])

The bimodal distribution does not appear on the engineering side and, thus, it is more salient for the scientific workforce: there are roughly twice as many scientists with ages from 56 to 65 (23%) as with ages from 45 to 56 (12%). Furthermore, France relies more on older scientists: 25% of them are over 56, against 14% at the European Level.

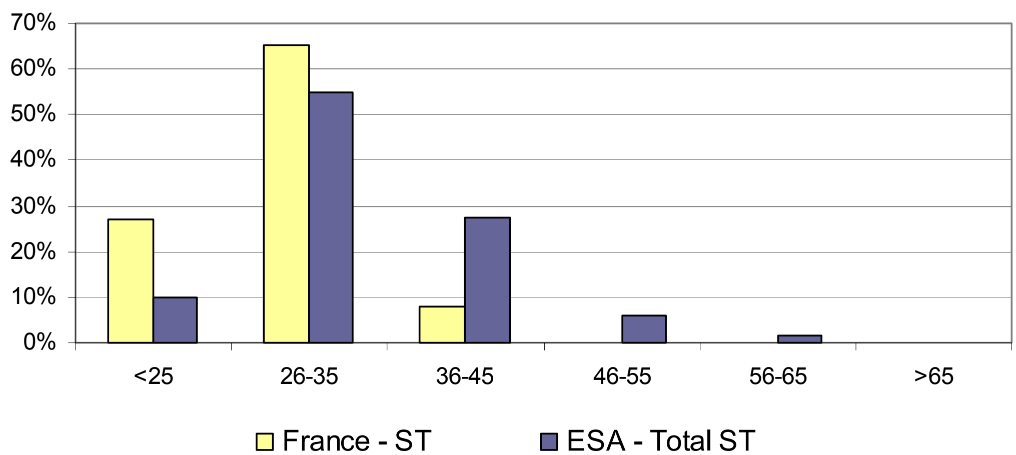
On the engineering side, and compared to the European level, there are less members of the workforce under 36 (27% against 33%) and many more over 46 (42% against 32%)

- **Permanent Posts/Short Term Contracts**

As at the European level, French short-term contract holders are younger than permanent position holders; but the age gap is even bigger: 17 years; French permanent post holders' mean age is higher than the European average (46 against 45) For short-term contract holders however, it is the opposite: their mean age is 29, against 34 for the European average. Graphs 34 and 35 present the age distribution of both categories.



Graph 34: French Permanent positions: Age Distribution Based on Institutions' Answers (Source: [2.20])



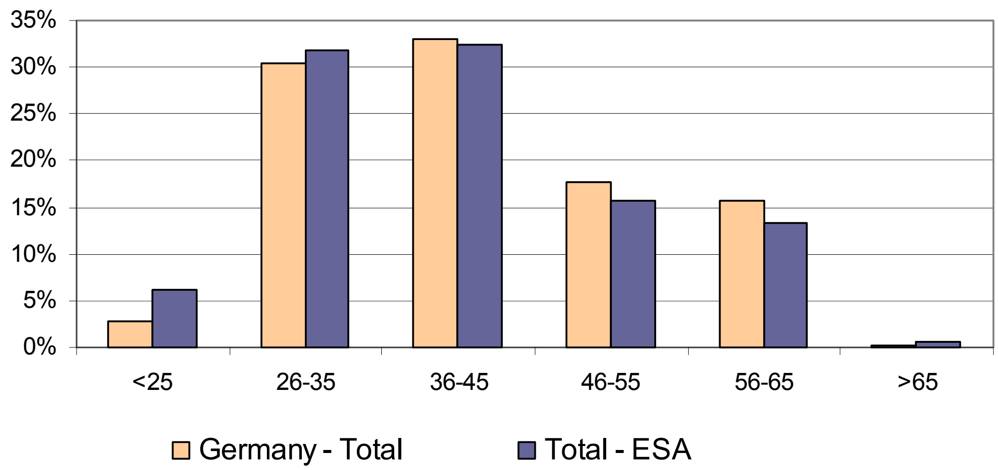
Graph 35: French Short Term positions: Age Distribution Based on Institutions' Answers (Source: [2.20])

As shown by the difference between the mean age of both populations, the split between "short-term contracts for younger" and "permanent positions for elder" is even more noticeable in France. Their age distributions lead to the same conclusion: there are no permanent post holders under 26 (4% at the European level) and of the 63 short-term contract holders represented, none is over 45 (8% at the European level).

2.2.5.2) National Considerations - Germany

- **Global**

The German workforce involved in space science is slightly older than the European average: its mean age is 42 against 41 at the European level. Graph 36 shows the German workforce age distribution.

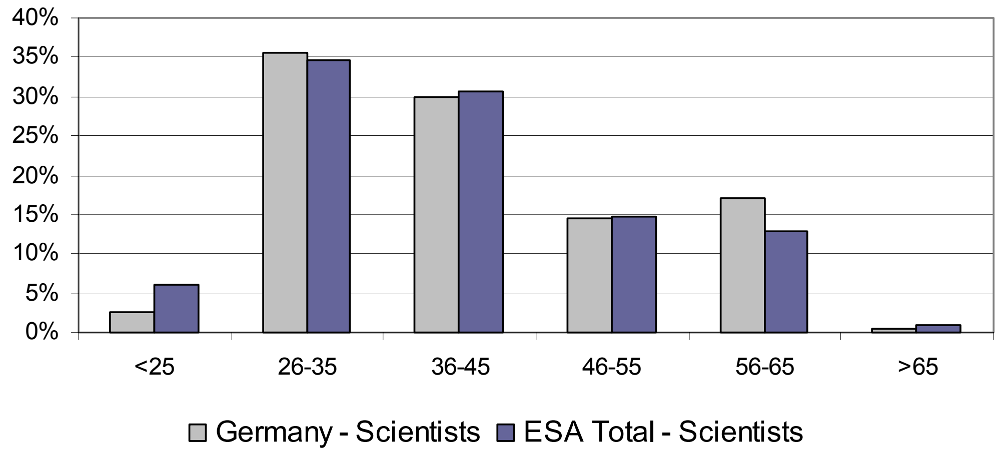


Graph 36: Germany Global Age Distribution Based on Institutions' Answers (Source: [2.21])

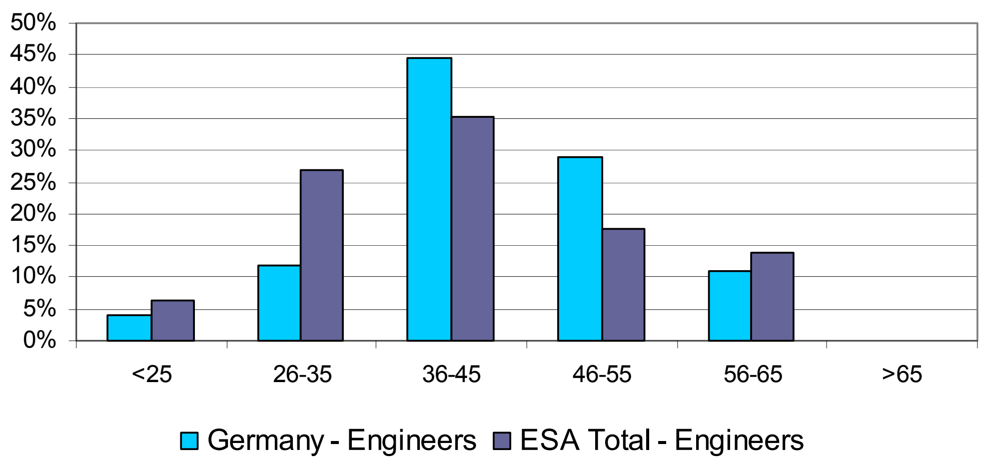
This distribution is quite different from the global European one : there are more members of the workforce over 46 (34% against 30%) and less members under 36 (33% against 38%).

- **Scientific/Engineering Workforce**

As for France and the mean European situation, German engineers are older than scientists on average, and both categories are older than the European average. But the age gap between the two categories is quite important: 3 years on average: the scientists mean age is 42 (40 for the European average) and for the engineers it is 45 (41 for the European average). Graphs 37 and 38 show the age distribution of both categories.



Graph 37: German Scientific Workforce: Age Distribution Based on Institutions' Answers (Source: [2.21]).



Graph 38: German Engineering Workforce: Age Distribution Based on Institutions' Answers (Source: [2.21]).

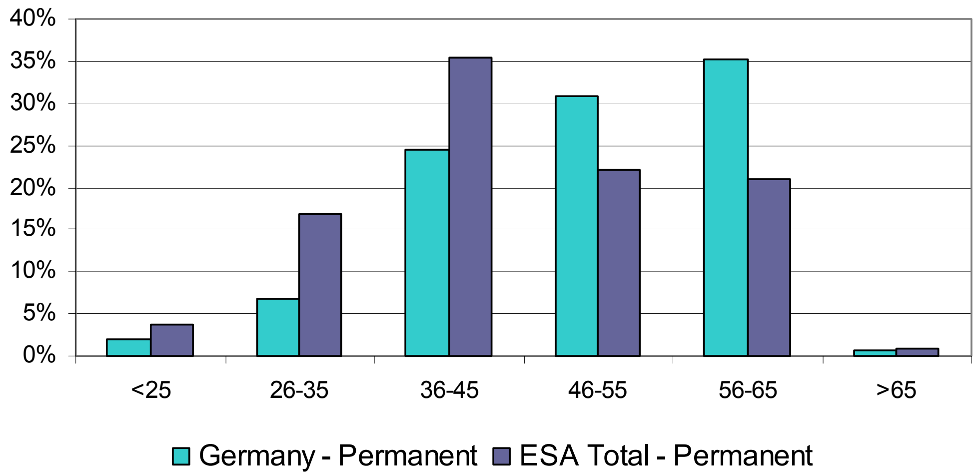
When separating scientists and engineers, a slight bimodal distribution appears on the scientific side; apart from that, this distribution is quite similar to the European situation: 38% of the German scientists are under 36, against 41% at the European level, 32% of them are over 46, against 29% at the European level.

On the engineering side, the distribution is much more different compared to the European situation: 40% of the 76 engineers represented are over 46, against 32% at the European level. But above all, it is the German young engineers' situation that differs a lot from the global tendency: there are more than twice as many engineers under 36 at the European level (33%) than in

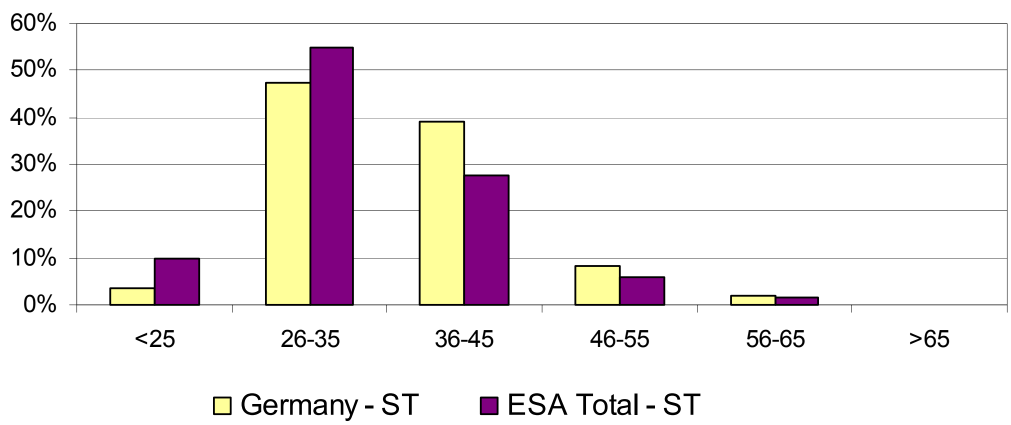
Germany (16%). This situation could cause major concern when the 36-45 population, that represents almost 45% of the German engineering workforce, is eligible for retirement.

- **Permanent Posts/Short-Term Contracts**

As for France, in Germany, permanent positions seem to be devoted to older members while short-term contracts are mainly held by younger members of the workforce. The gap between the two populations' mean age exceeds 10 years: 50 for permanent positions (45 at the European level) and 37 for short-term contract holders (34 at the European level). Graphs 39 and 40 present the age distribution of both populations.



Graph 39: German Permanent positions: Age Distribution Based on Institutions' Answers (Source: [2.21]).



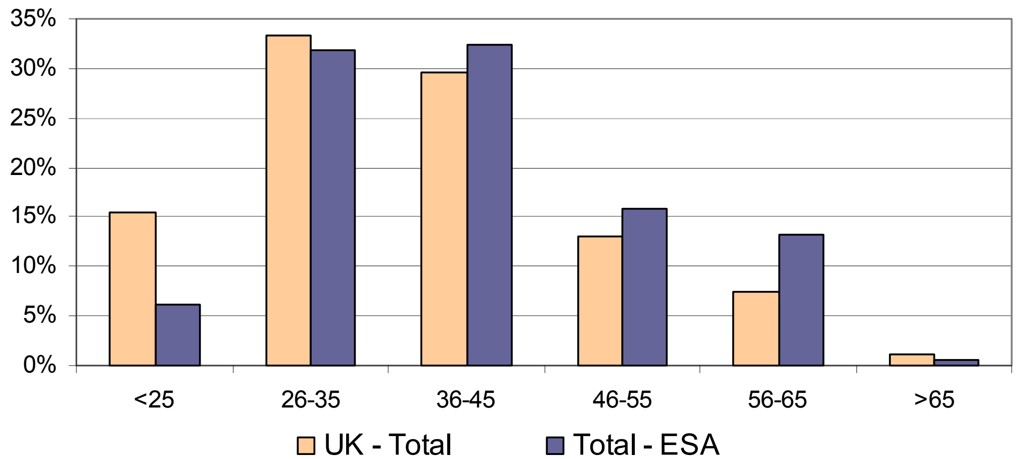
Graph 40: German Short Term positions: Age Distribution Based on Institutions' Answers (Source: [2.21]).

Two-thirds (67%) of the permanent positions are held by people over 46 (against 44% at the European level); for people under 36, the German situation shows a share that is less than half the European one: 9% against 20%. Regarding short-term contract holders, the German situation seems to be more balanced than the European one: there are less people holding such a contract under 36 (51% against 65%) and slightly more people over 46 (10% against 8%).

2.2.5.3) National Considerations - United Kingdom

- **Global**

In UK, the age situation is significantly different from the French or German one. First, the British workforce is the youngest of the considered countries: its mean age is 37 while it is 41 at the European level. Graph 41 shows the age distribution of the British workforce involved in space science.

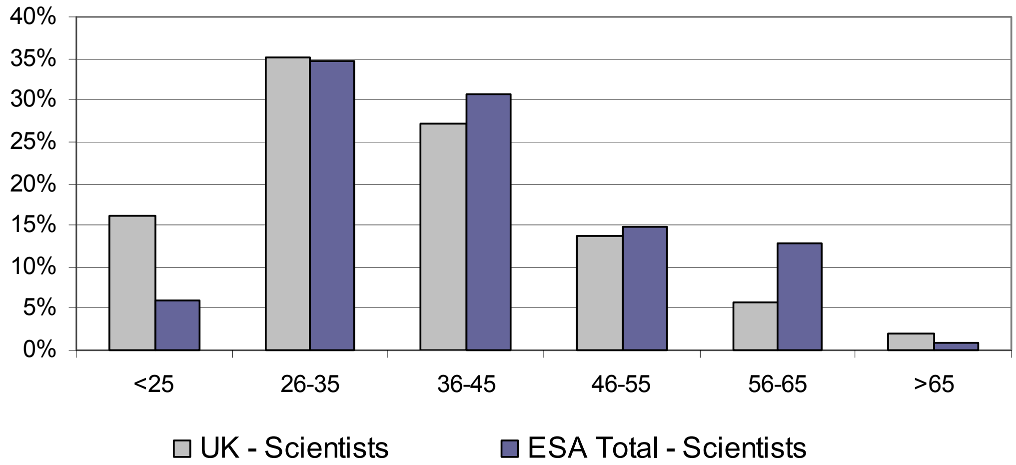


Graph 41: UK Global Age Distribution Based on Institutions' Answers (Source: [2.22]).

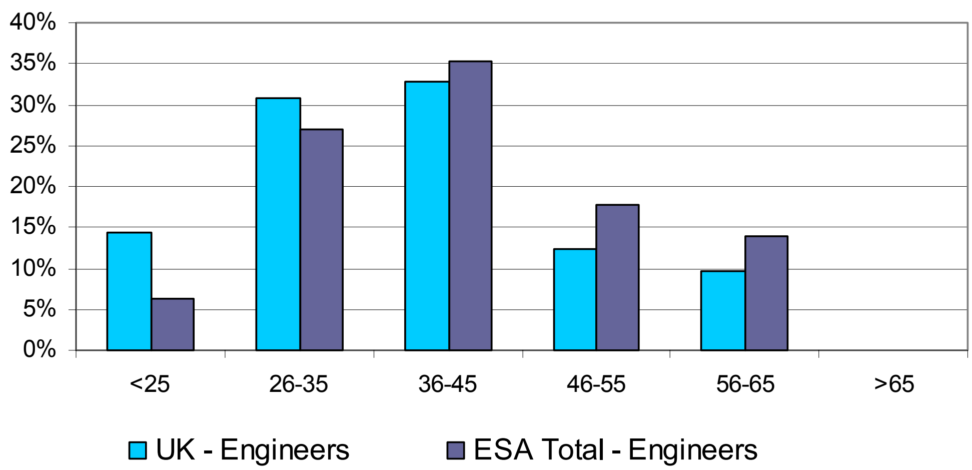
Beside a lower share of people over 46 in the UK than at the European level (22% against 30%), and based on the participating institutions inputs, the main British specific feature is the high involvement of young members of the workforce: almost half (49%) of the British workforce is under 36, against 38% at the European level. This difference mainly comes from the share of the workforce under 25 that is the highest of the considered countries: 15% (6% at the European level). This high share is mainly due to the fact that British students graduate or complete their PhDs relatively earlier than in the rest of European.

- **Scientific/Engineering Workforce**

As for the countries already considered, British engineers are older on average than scientists, but the gap between their mean ages is only one year. Both populations are respectively the youngest of the considered countries: the scientists mean age is 37 (40 for the European average) and the engineers' is 38 (41 for the European average). Graphs 42 and 43 show the age distribution of both categories.



Graph 42: UK Scientific Workforce: Age Distribution Based on Institutions' Answers (Source: [2.22]).

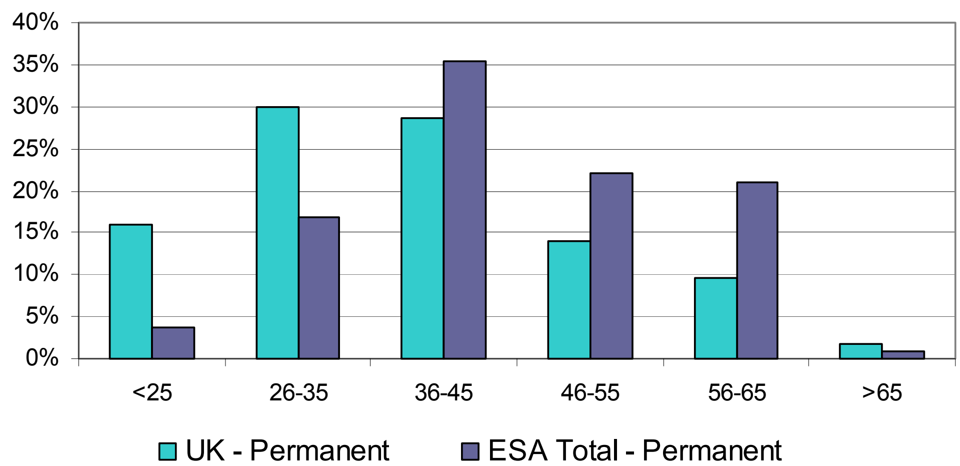


Graph 43: UK Engineering Workforce: Age Distribution Based on Institutions' Answers (Source: [2.22])

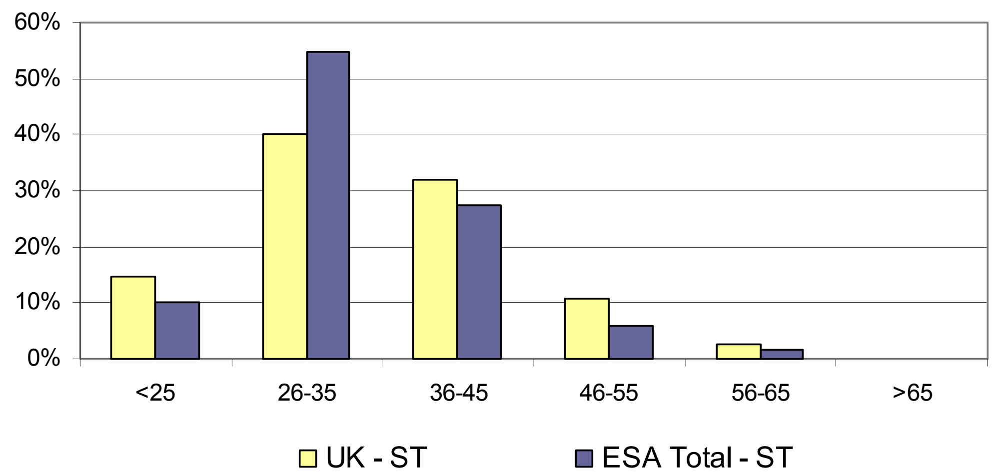
Unlike France and Germany, the UK situation of scientists does not feature a bimodal distribution. This distribution shows a high Involvement of young scientists: more than half (51%) of the scientific workforce is under 36, against 41% at the European level. At the other end, only 21% of them are over 46, against 29% at the European level. Even if the British scientists are the youngest of the considered countries, a part of it (2%) is over 65. Looking at the engineering side, the distribution also shows a high involvement of the young part of the workforce: 45% of British engineers are under 36 (33% for Europe) and 22% of them are over 46 when this share grows to 32% at the European level.

- **Permanent Posts/Short-Term Contracts**

Here again, the mean age of permanent position holders is higher than the one of short-term contracts holders, but the gap between the two is much less than what was seen before. Thus permanent positions holders are younger than the European average (mean age: 39 against 45 at the European level) and short-term contracts holders are older than the European average (mean age 35 against 34 for Europe). Graphs 44 and 45 present the age distribution of both populations.



Graph 44: UK Permanent Positions: Age Distribution Based on Institutions' Answers (Source: [2.22])



Graph 45: UK Short Term Positions: Age Distribution Based on Institutions' Answers (Source: [2.22])

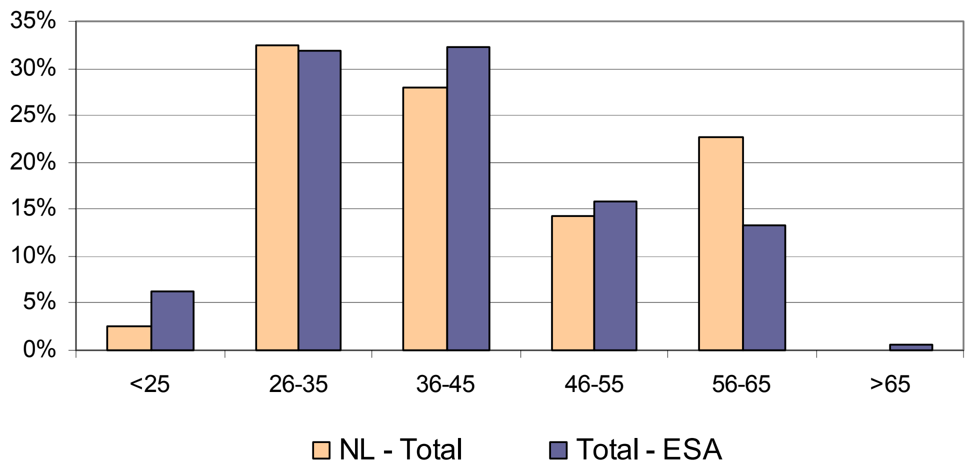
These age distributions are much more balanced than the French and German ones, they do not reflect the "permanent positions for elder – short term contracts for younger" situation that exists in both countries and at the

European level. Compared to the European situation, there are many more permanent post holders under 36 in the UK (46% against 20%) and more short-term contracts holders are over 46 (14% against 8%).

2.2.5.4) National Considerations - Netherlands

- **Global**

The Netherlands is, like France, the country where the workforce is the oldest: its mean age is 43, against 41 at the European level. Graph 46 shows the Dutch workforce age distribution.

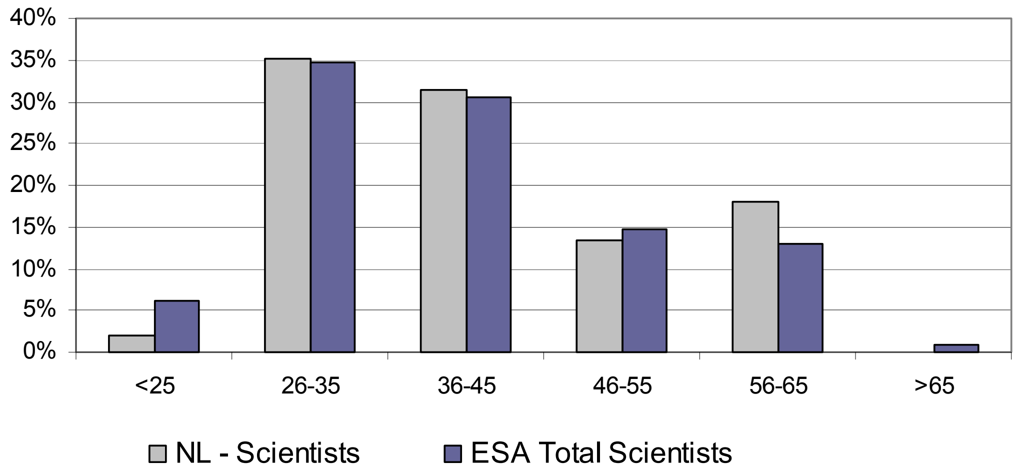


Graph 46: NL Global Age Distribution Based on Institutions' Answers (Source: [2.23])

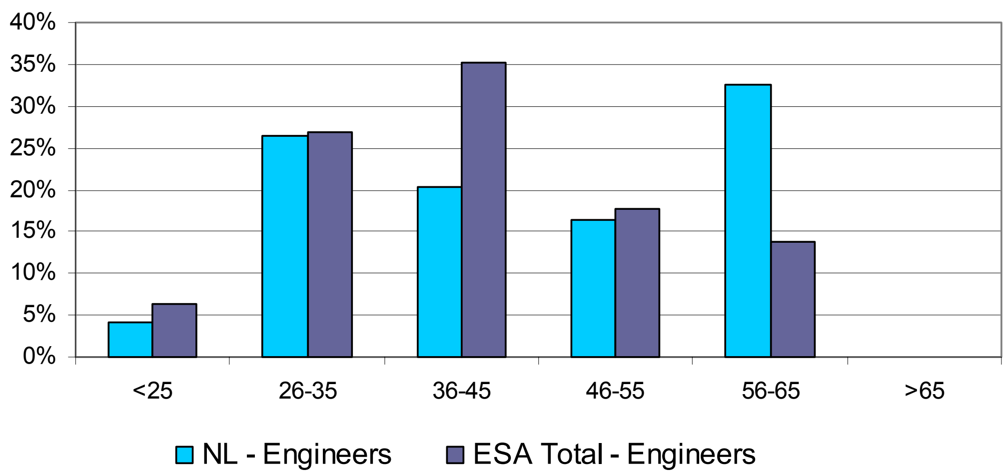
The Dutch situation presents a bimodal distribution: there are more members of the workforce with ages from 56 to 65 (23%) than with ages from 46 to 55 (14%). There are less people under 36 than the European average (35% against 38%), this is mainly due to the poor involvement of members of the workforce under 26 (3% against 6% at the European level). On the other side, there are more members over 46 (37% against 30%), mainly due to the high share of the 56-65 population (23% against 13%)

- **Scientific/Engineering Workforce**

The low level of representativity of the Dutch workforce in the questionnaires data does not allow us to calculate the mean age of both the scientific and engineering workforce. Graphs 47 and 48 present the age distribution of both populations.



Graph 47: NL Scientific Workforce: Age Distribution Based on Institutions' Answers (Source: [2.23])



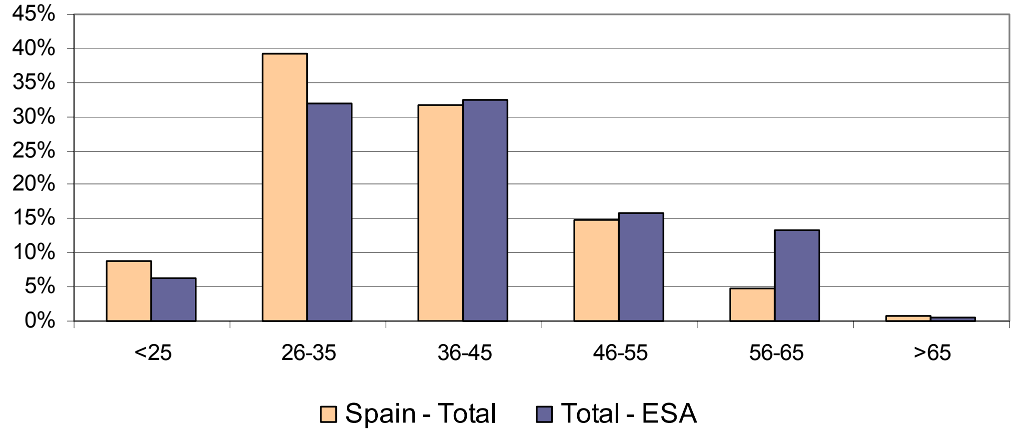
Graph 48: NL Engineering Workforce: Age Distribution Based on Institutions' Answers (Source: [2.23])

On the scientific side, 31% of the workforce is over 46 (29% for Europe) and 37% is under 36 (41% for Europe). Looking at engineers, the distribution of the 49 members of the workforce represented is significantly different from the European situation: about half (49%) of it is over 46, against 32% at the European level. Both the scientists and engineers populations present a bimodal age distribution, but it is much more noticeable on the engineering side: there are twice as many engineers with ages from 56 to 65 (33%) than with ages from 46 to 55 (16%).

2.2.5.5) National Considerations - Spain

- **Global**

Spanish workforce mean age is below the European average: it is 38 (41 for Europe). Graph 49 present the Spanish workforce age distribution.

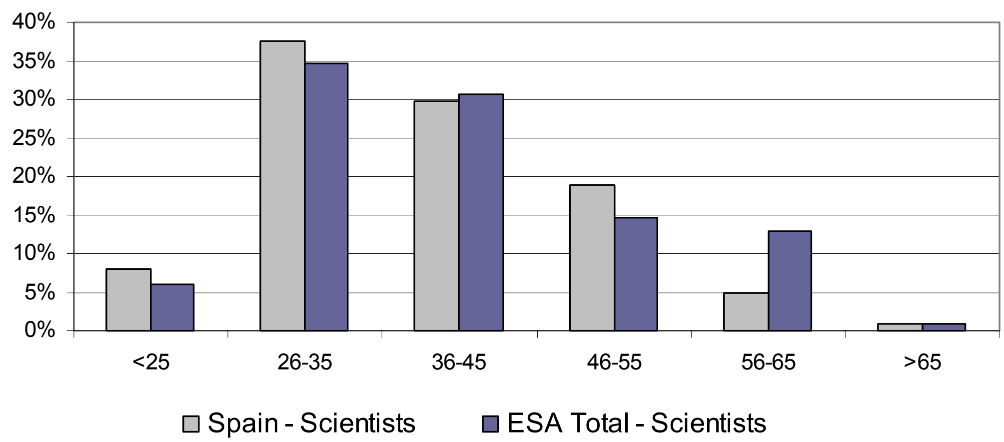


Graph 49: Spanish Global Age Distribution Based on Institutions' Answers (Source: [2.24])

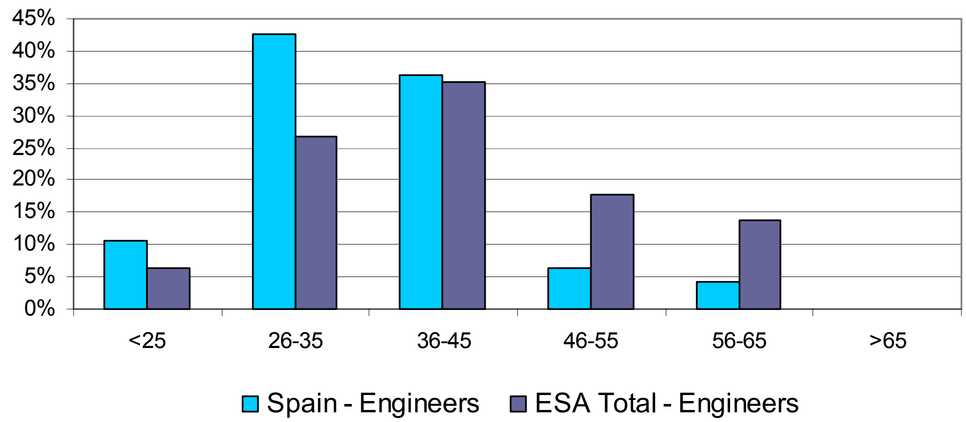
Spain presents a higher involvement of the young workforce: almost half (48%) of them are under 36, against 38% at the European level. At the other end, the involvement of the older workforce is less marked: 22% of them are over 46 against 30% at the European level.

- **Scientific/Engineering Workforce**

The low level of representativity of the Spanish workforce in the data obtained does not allow us to calculate the mean age of both the scientific and engineering workforce. Graphs 50 and 51 present the age distribution of both populations.



Graph 50: Spanish Scientific Workforce: Age Distribution Based on Institutions' Answers (Source: [2.24])



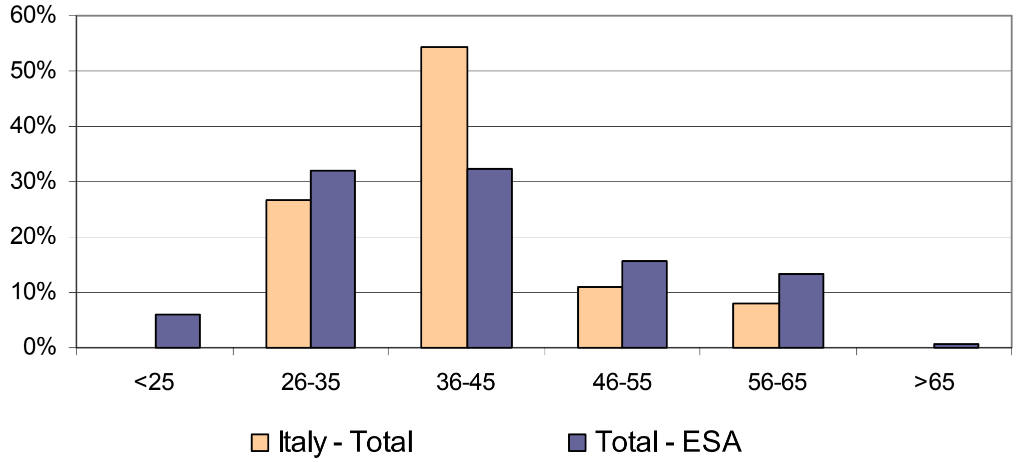
Graph 51: Spanish Engineering Workforce: Age Distribution Based on Institutions' Answers (Source: [2.24])

Age distributions of both categories present a younger workforce than the European average: 41% of the 101 scientists represented are under 36, against 29% at the European level, and only 25% of them are over 46 (41% for Europe). On the engineering side, there is a similar situation: of the 49 Spanish engineers represented, 27 of them (54%) are under 36 (32% at the European level) and 5 of them (10%) are over 46 (33% for Europe).

2.2.5.6) National Considerations - Italy.

- **Global**

The mean age of the Italian workforce involved in space science is in the same range as the European one: 40 against 41. Graph 52 presents the Italian workforce age distribution.

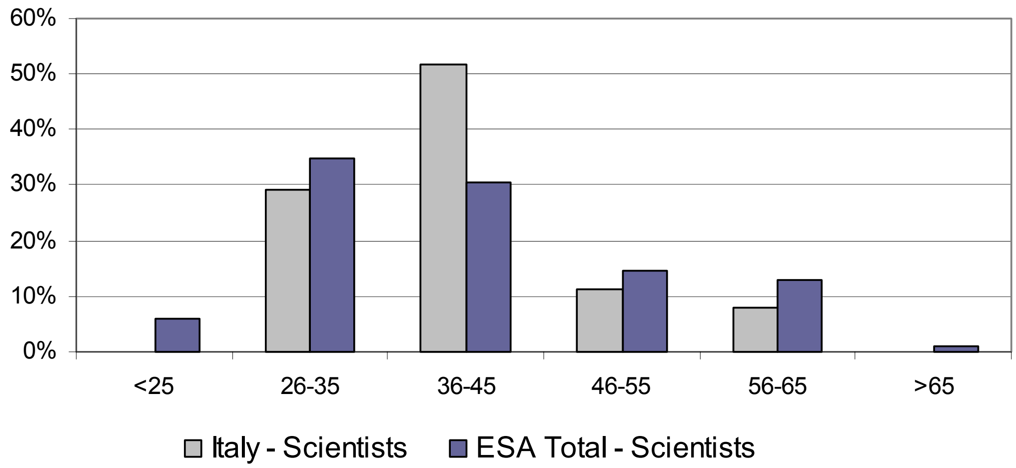


Graph 52: Italian Global Age Distribution Based on Institutions' Answers (Source: [2.25])

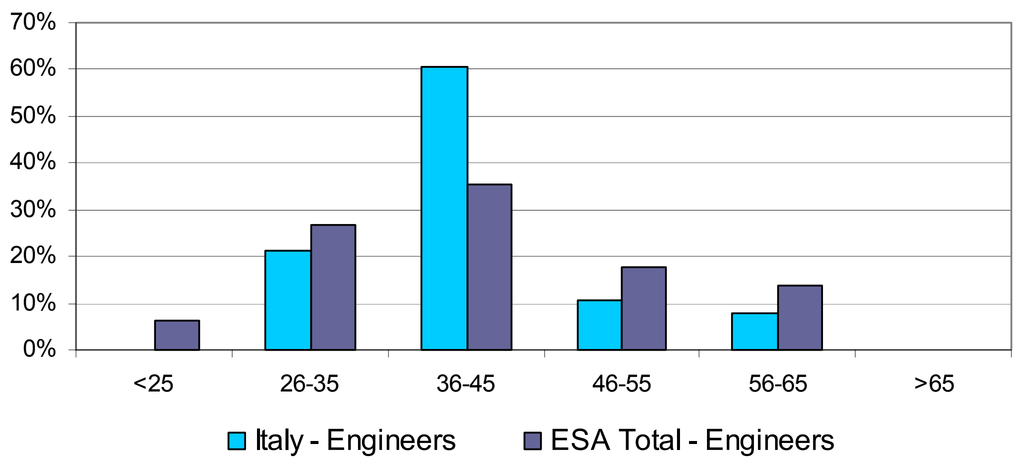
The Italian workforce seems to be much more concentrated in the 36 to 45 y.o. range, which includes more than half of it (54% against 32% for Europe). Thus, both the under 36 y.o. and over 46 y.o. share of the workforce is below the European average (respectively 27% against 38% and 19% against 30%).

- **Scientific/Engineering Workforce**

The low level of representativity of the Italian workforce in the data obtained does not allow us to calculate the mean age of both the scientific and engineering workforce. Graphs 53 and 54 present the age distribution of both populations.



Graph 53: Italian Scientific Workforce: Age Distribution Based on Institutions' Answers (Source: [2.25])

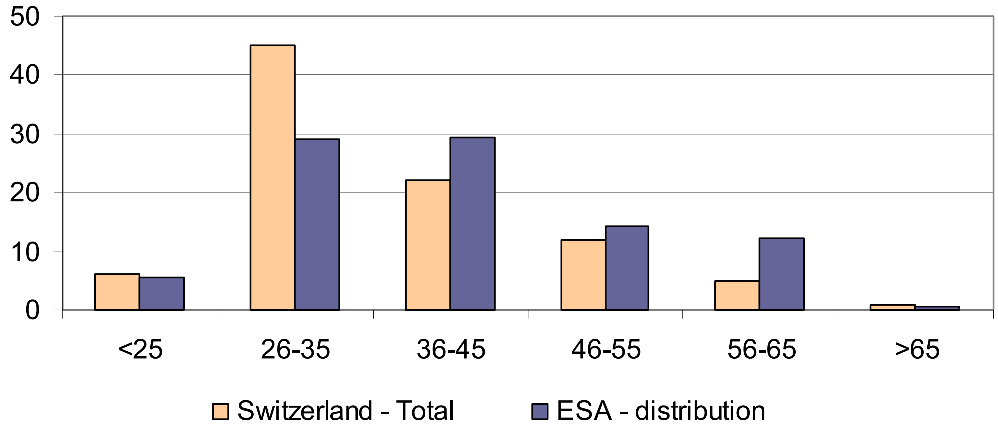


Graph 54: Italian Engineering Workforce: Age Distribution Based on Institutions' Answers (Source: [2.25])

These age distributions confirm the concentration of the workforce around the 36 to 45 population for both categories. It represents 52% of the 89 scientific workforce represented (against 31% for Europe) and 61% of the 38 engineering workforce represented (against 35% for Europe).

2.2.5.7) National Considerations – Switzerland.

The Swiss institutions that answered the questionnaire represent a workforce of 91. Due to a low level of participation to the individual questionnaire, the Swiss workforce's mean age calculation is only based on the institutional questionnaire, i.e. the age distribution presented on graph 55.

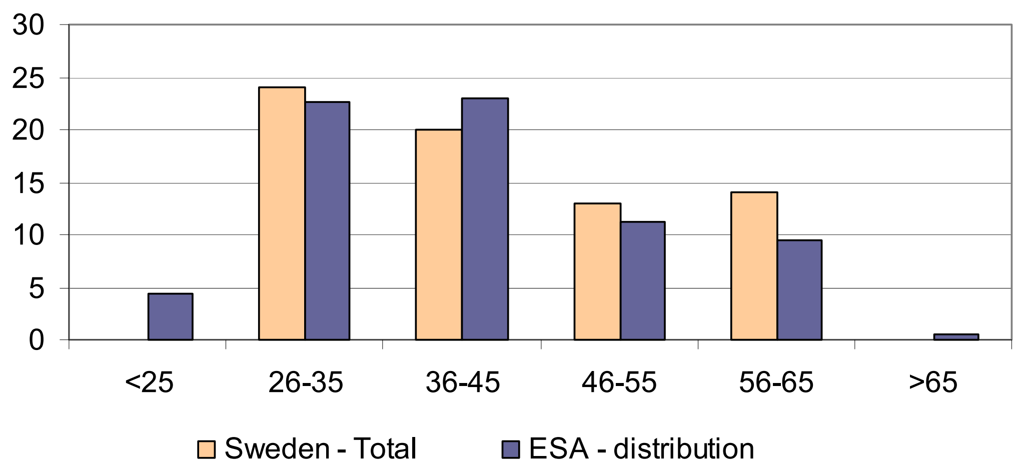


Graph 55: Swiss Global Age Distribution Based on Institutions' Answers (Number of Workforce per Category, Source: [2.26])

The Swiss workforce's mean age extrapolated from this distribution is 38. This workforce seems to be youngest than the global population. More than half of it (51 out of 91) is under 36, this young population is concentrated in the 26-35 category, which gathers almost half of the workforce (45 out of 91). The population over 46 represents about 1/5 of the Swiss workforce, against 30% at the global level.

2.2.5.8) National Considerations – Sweden.

The Swedish institutions that answered the questionnaire represent a workforce of 71. As for Switzerland, the Swedish workforce's mean age calculation is only based on the institutional questionnaire, i.e. the age distribution presented on graph 56.

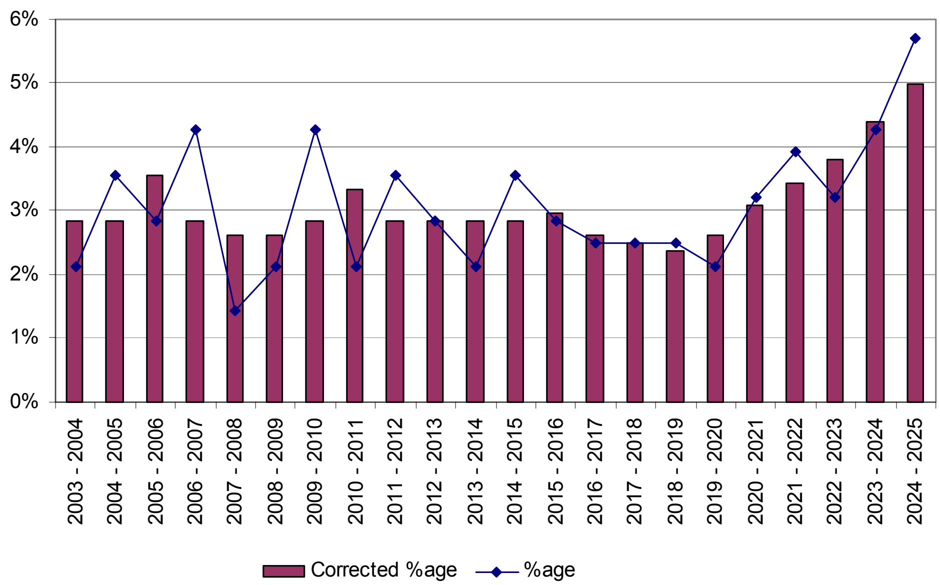


Graph 56: Swedish Global Age Distribution Based on Institutions' Answers (Number of Workforce per Category, Source: [2.27])

The Swedish workforce's mean age extrapolated from this distribution is 43. This relatively high mean age can be explained by its age distribution: roughly 1/3 of this workforce is under 36 against 38% at the global level. The population over 46 represents about 2/5 of the Swedish workforce, against 30% of the global population.

2.2.6) Retirement Issues.

Concerning retirement, respondents to the individual questionnaires that hold a permanent position were asked in which year they expected to retire. These data have been processed at the European level. Of the 281 respondents, about one third (32,4%) expect to retire after 2025; for the remaining 68%, graph 57 presents the share of the workforce that expects to retire over the 2003-2025 time frame, by 2 year intervals. To draw a synthetic view, two sets of data are presented: actual data and corrected data (sliding 3 year average).



Graph 57: Participating Permanent Position Holders Expected Retirement Year (Source: [2.28])

Over the 2003-2015 period, the distribution is quite flat around a yearly retirement rate of slightly less than 3% (of the current workforce). Two peaks can nevertheless be noted: a first one between 2004 and 2007, when 10,7% of the current workforce expects to retire during this period; a second one between 2009 and 2012, with 10% of retirement. Between 2016 and 2019, retirement rates are expected to decrease, and then grow sharply to reach about 6% in the 2024-2025 period. 22% of the current workforce expects to retire in the 2019-2025 period.

The mean expected retirement age is 63 y.o.. Engineers expect to retire at 62 and scientists at 64.

2.3) The Case of Instrument Designers and builders

In this part, we have focussed on the workforce that is more specifically involved in the instrument design and building. This population concerns the active workforce that achieved ten years ago, or is currently achieving, the following tasks:

- Project manager
- Principal Investigator
- Payload Conception
- Instrument design
- Software/Data Processing design,

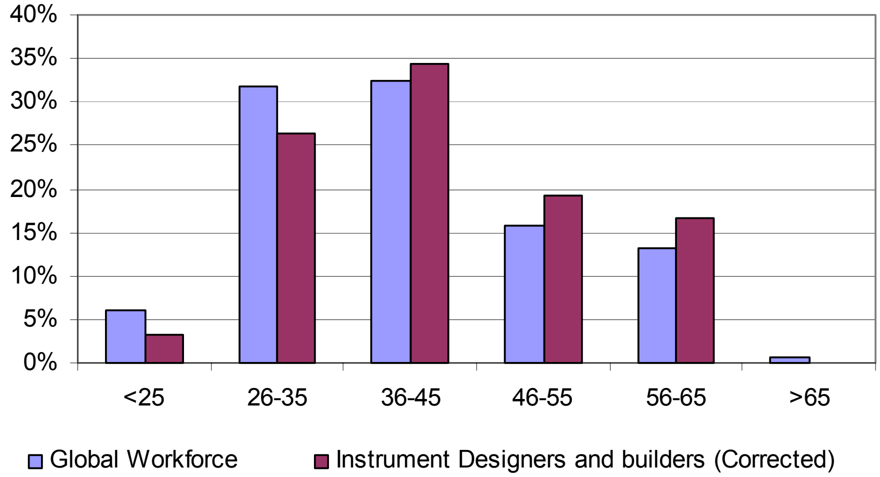
as well as the population which is currently using the following competencies:

- On Board Data Handling
- Sensor/detector technology
- Proposition and project/mission design
- Instrument system design

This population represents 331 people, that is, about ¾ of the global population. A more narrowed focus is presented concerning the workforce that achieved ten years ago, or is currently achieving, the task of Principal Investigator. This sub population represents 40 people, i.e. about 9% of the global population.

The data presented for the instrument designers and builders are based on the individual questionnaire inputs. Since the comparison between individual and institutional inputs shows a bias (the population that answered the individual questionnaire seems to constitute the oldest part of the workforce), and as the instrument designers and builders population is an important part of the population (around 75%), age distribution and mean age of this workforce have been corrected using the inputs from the institutional questionnaires. The population of PIs being highly specific and representing only 40 people, no correction was made on their age distribution and mean age.

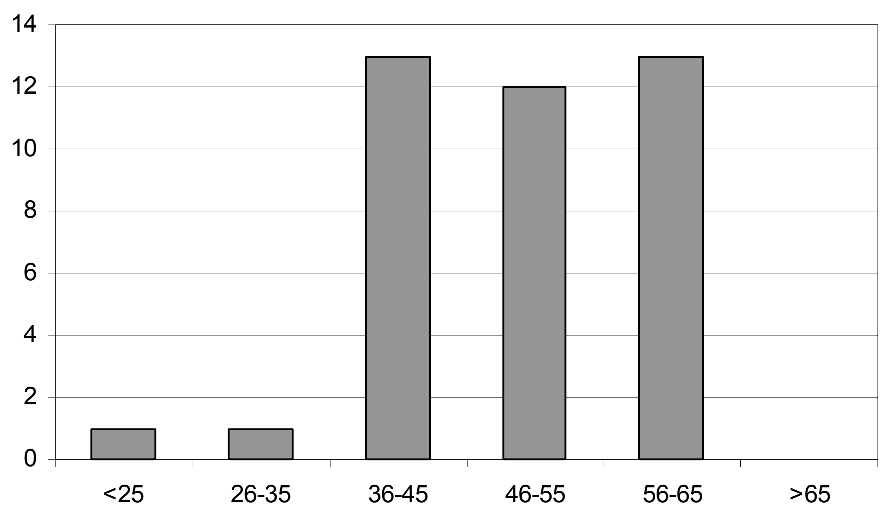
The instrument designers and builders' corrected mean age is 42; this figure is higher than the one of the global population (40.6). Graph 58 presents the age distribution of the Instruments designers and builders, and the one of the global workforce.



Graph 58: Instrument Designers and Builders Age Distribution (Source: [2.29])

As seen above, the designers and builders are older than the global population involved in space science; this age difference is illustrated by the age distribution of this workforce: 30% of them are under 35, against 38% for the global workforce. At the other end, the >46 population share is higher: 36% against 30% for the global workforce.

Looking more specifically at the population of PIs, one can see that this population is much older than the global workforce: its mean age is 49 against 40.6. Graph 59 presents the age distribution of PIs.



Graph 59: Principal Investigators' Age Distribution (Source: [2.30])

As this population is quite limited (40 PIs), the distribution is shown with the number of individuals, rather than a percentage. PIs are older and the pattern of their distribution is very different from that of the global population: almost this entire workforce (38 out of 40) is over 36; only 5% of PIs are below 36, while it represents 38% of the global population. Looking at the oldest part of the population, the >46 share is twice as large for PIs, than for the global population (a bit more than 60% (25 out of 40), against 30% of the global population).

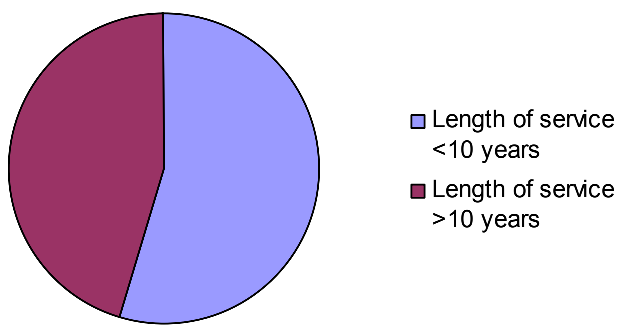
2.4) Qualitative Approach: Past and Current Space Science Research Activities

2.4.1) Professional Experience

The professional experience is assessed through two sets of data:

- The length of service of the workforce
- The number of space science flown instruments in which the workforce was involved (at the global European level).

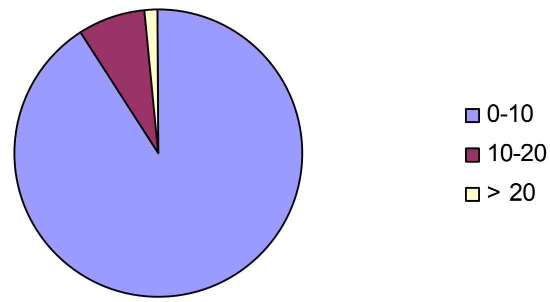
- **Professional Experience - Global**



Graph 60: Total Workforce Distribution Regarding Length of Service (Source: [2.31])

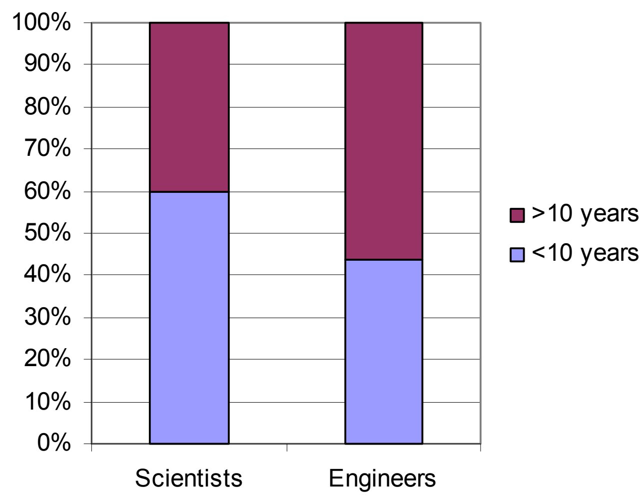
As shown on graph 60, the majority (54%) of the European workforce involved in space science has a length of service below 10 years. Surprisingly, 9.7% of the workforce that holds a short-term contract has more than 10 years of service; this share grows to 14.5% for engineers, against 8.2% for scientists

Looking at the number of flown instruments, shown on graph 61, the major part of the European workforce (91%) has been involved in less than 10 instruments. A marginal part of this workforce (between 1% and 2%) has been involved in more than 20 flown instruments.



Graph 61: Total Workforce Distribution Regarding the Number of Flown Instrument (Source: [2.32])

- **Professional Experience – Scientists Vs. Engineers**

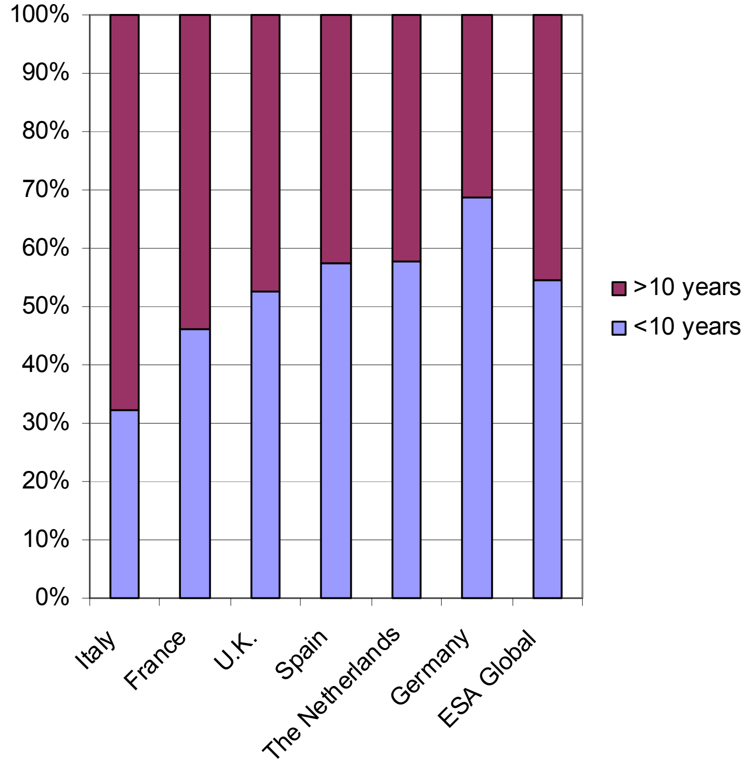


Graph 62: Scientific and Engineering Workforce Distribution Regarding Length of Service (Source: [2.31])

As shown on graph 62, unlike the general situation, and the situation of scientist (40% of them has a length of service below ten years), the majority (56%) of the engineers has been involved in space science for less than ten years. The distribution regarding the number of flown instruments does not present significant differences between scientists and engineers.

- **Professional Experience – National Considerations**

Looking at the professional experience at the national level, some large differences appear among countries. Graph 63 present national distributions regarding length of service (only the countries with significant workforce level have been considered).



Graph 63: Workforce Distribution Regarding Length of Service at the National Level (Source: [2.33]).

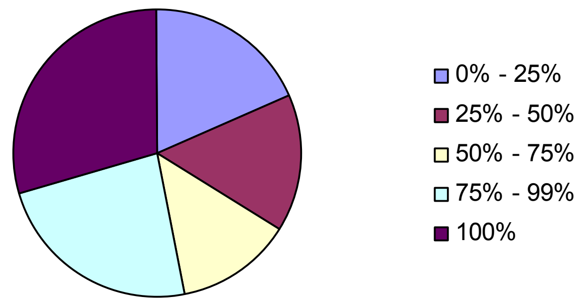
Unlike the general European situation, in France and especially in Italy, the majority of the workforce has been involved in space science for more than 10 years. The considered country with the highest share of workforce involved for less than ten years is Germany with 69% of its workforce in this category; this share is more than twice that of Italy.

2.4.2) Current Activity: Concentration and Intensity.

To describe the current activity related to space science, two sets of data have been considered:

- The share of space science in the global research activity at the individual level; this shows how the research effort is concentrated among the workforce,

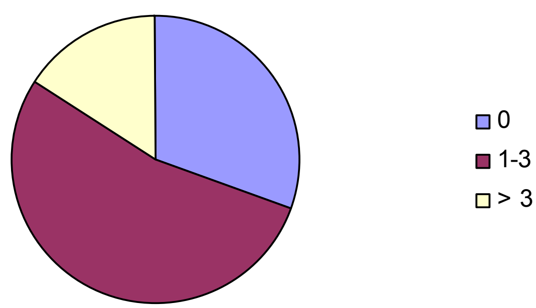
- The number of current scientific space instrument projects in which the workforce is currently involved; this shows the "intensity" of the research.



Graph 64: Distribution of the Workforce Regarding the Share of Space in Total Research Activity (Source: [2.34])

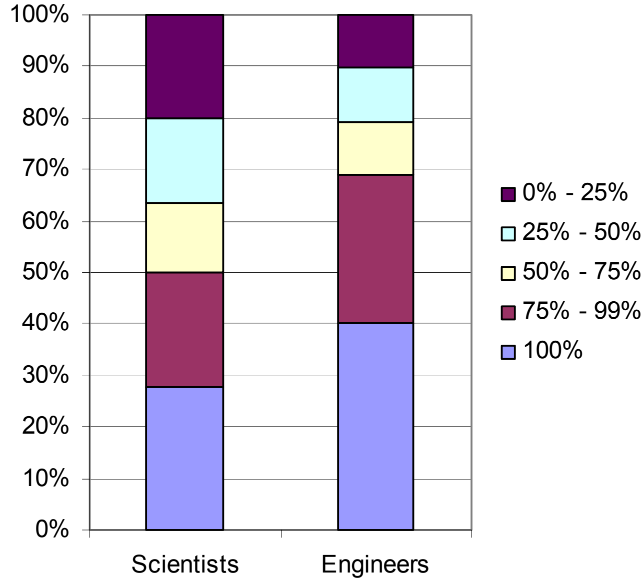
At the European level, 30% of the workforce devotes all its research effort to space science, 66% devotes more than half of it. 19% of the workforce devotes less than 25% of its research to space science.

As shown on graph 65, 69% of the workforce is currently involved in at least one space science project, 16% in more than three such projects. The remaining 31% are currently not involved in any space science project.



Graph 65: Workforce Distribution Regarding the Number of Current Space Projects (Source: [2.35])

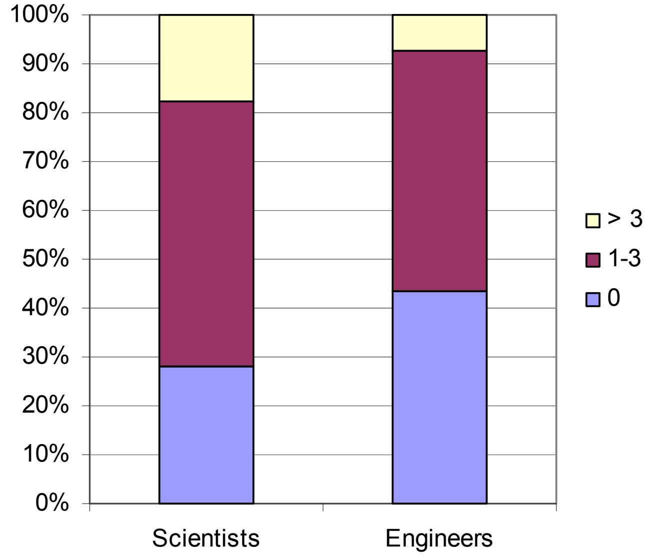
- **Current Concentration and Intensity – Scientists Vs. Engineers**



Graph 66: Distribution of the Workforce Regarding the Share of Space in Total Research Activity for Scientists and Engineers (Source: [2.34])

Looking at the differences between scientists and engineers regarding the share of space science in their activity, it seems that the engineering workforce is more "space specialised" than scientists: 2/5 of the 77 responding engineers devote all their activity to space science projects against 28% of the scientific workforce. 1/5 of engineers devote less than half of their activities to space science, against 36% on the scientific side.

As shown on graph 67, it seems that the share of workforce currently involved in at least one space project is lower on the engineering side than on the scientific side, however the limited number of answers does not allow us to present detailed figures.



Graph 67: Workforce Distribution Regarding the Number of Current Space Projects for Scientists and Engineers (Source: [2.35])

2.5) Space Science Related Competencies Use and Transfer

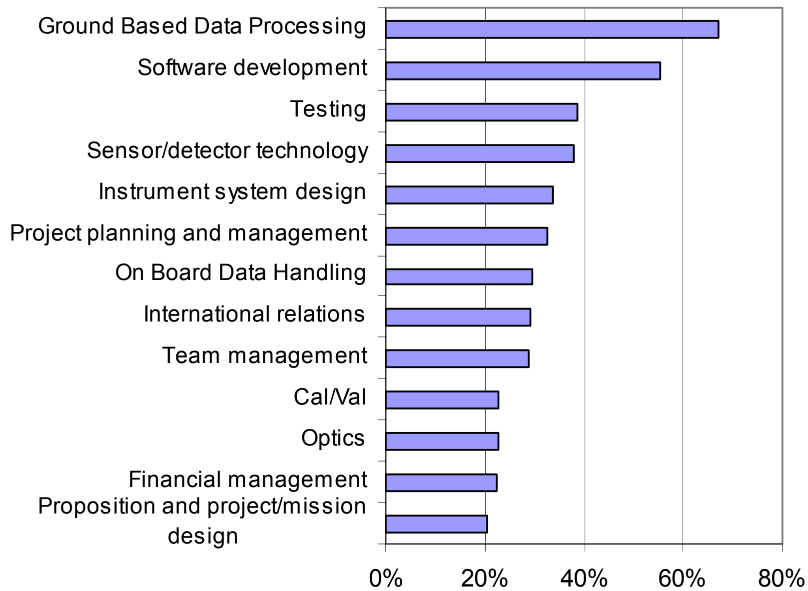
The information presented below is based on a list of 26 competencies related to space science instrument design (presented with the individual questionnaire in annex A); participants to the individual questionnaire were asked which competencies they were using, and which one they were transferring and how.

2.5.3) Competencies Use Distribution

As the work of scientists and engineers is not similar, these two populations have been considered separately.

- **Scientific Workforce**

Graph 68 shows the most used competencies on the scientific side. Only the competencies used by more than 20% of the workforce have been considered.



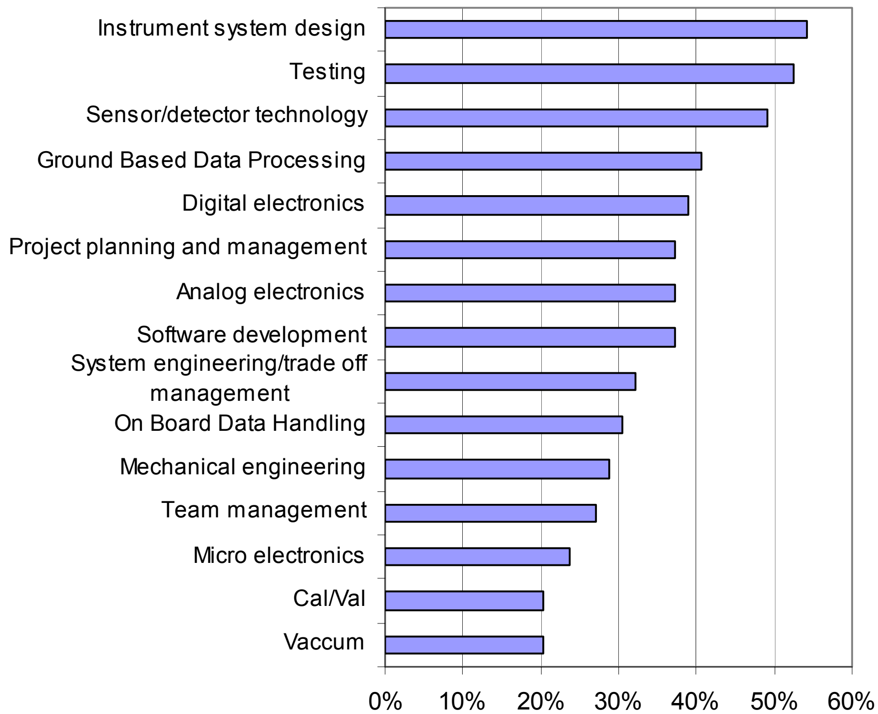
Graph 68: Competencies Mostly Used by the Scientific Workforce (Source: [2.36])

The competencies mostly used by the scientists are, by far: Ground Based Data Processing and Software development. More than half of this population uses them.

Of the 13 most used competencies, 5 refer to overall project management: "project planning and management", "international relations", "team management", "financial management" and "proposition and project/mission design". Of the six competencies related to project management, only the "project monitoring during the industrial phases" is below 20%.

- **Engineering Workforce**

As for scientists, only the competencies used by more than 1/5 of the 69 respondent have been considered, Graph 69 shows the most used competencies on the engineering side.



Graph 69: Competencies Mostly Used by the Engineering Workforce (Source: [2.37])

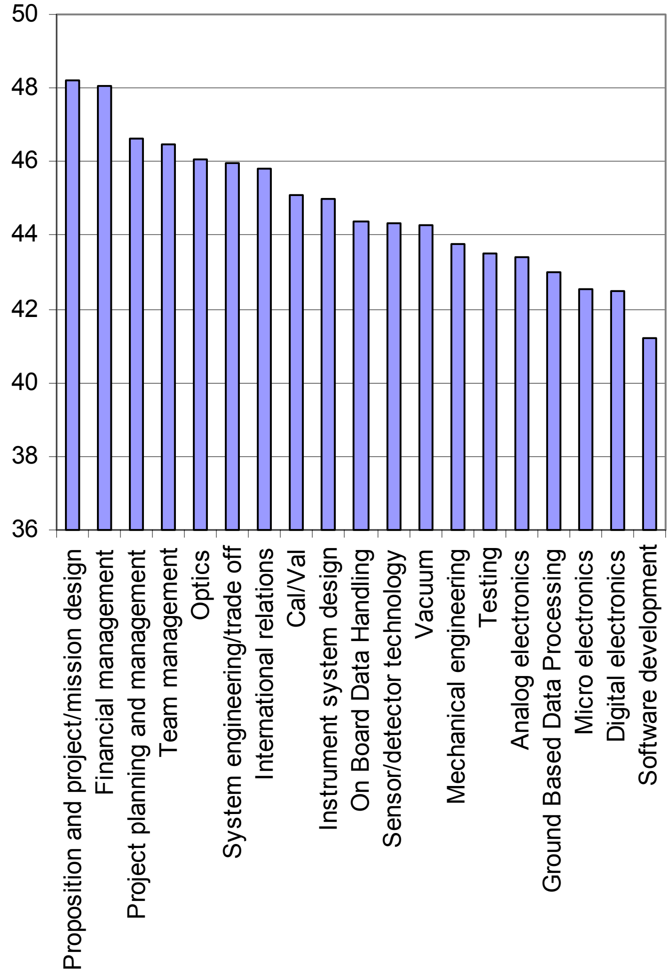
The competencies mostly used by the engineers are, by far: "instrument system design", "testing" (more than half of the workforce) and "sensor/detector technology" (almost half of it).

Only two management competencies are used by more than 1/5 of the engineers: "team management" and "project planning and management". All of the three proposed electronics-related competencies show up in the mostly used competencies for engineers, while none of them were used by more than 20% of scientists.

At the global level, about 2/3 of the mostly used competencies are common to scientists and engineers, the remainder are mainly project management skills for scientists and electronics for engineers.

2.5.4) Age Issues per Competency

The mean age of the workforce varies considerably among the users of the 19 competencies presented above; graph 70 presents these competencies regarding the mean age of their users.

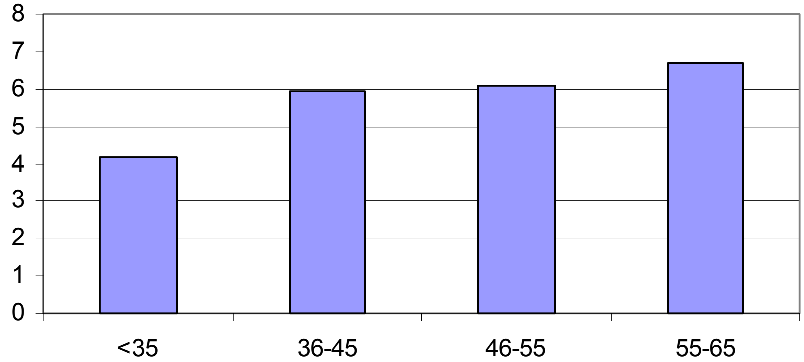


Graph 70: Mean Age per Competency Use (Source: [2.38])

"Proposition and project/mission design", as well as "financial management" are the two competencies for which the users' mean age is the highest: both are above 48. In general, the management competencies are used by older members of the community.

The software development competency users' mean age is by far the lowest: 41. In general, electronics-related, software and data processing competencies are used by younger members.

- **Mean Number of Competencies Used per Age Period.**



Graph 71: Average Number of K&S Used by age Period (Source: [2.39])

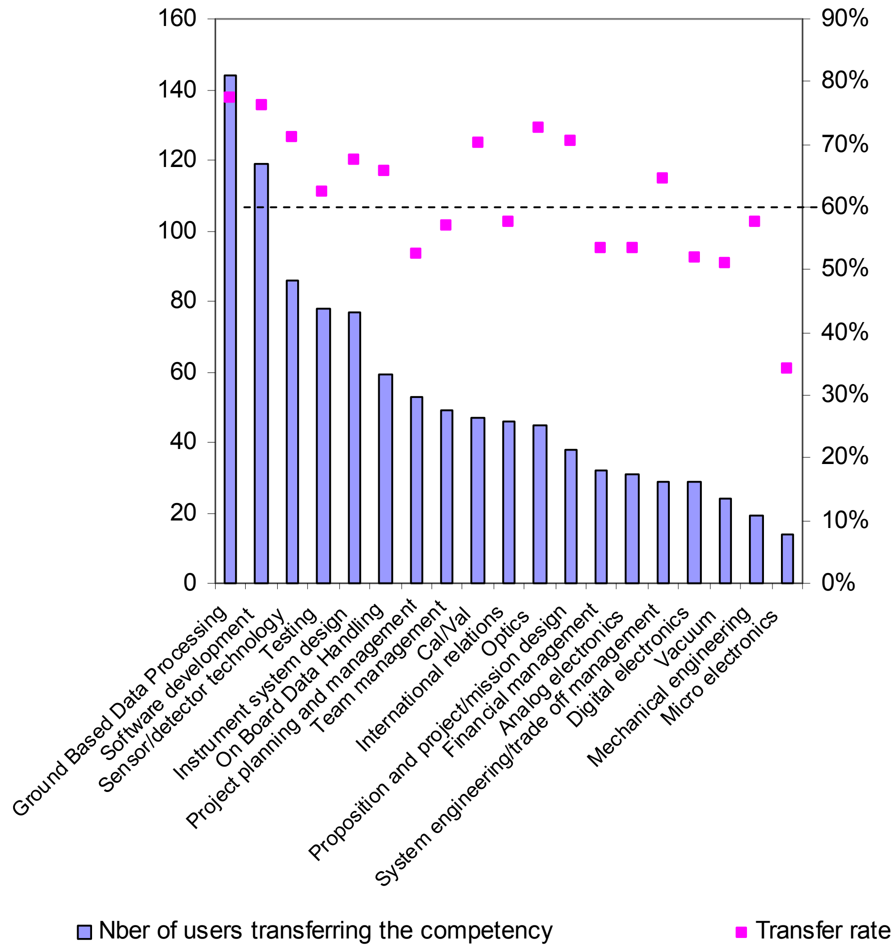
As shown on graph 71, the average number of used competencies increases with age. There is quite a big difference in the use of almost two competencies between the <35 population (4.2 competencies used) and the >35 (5.9 to 6.7 competencies).

2.5.5) Competency Transmission

Beside the use of competencies, it is important to assess if these are transferred and how. Graph 72 presents the most transferred competencies and their transfer rate (number of users/number of transfers).

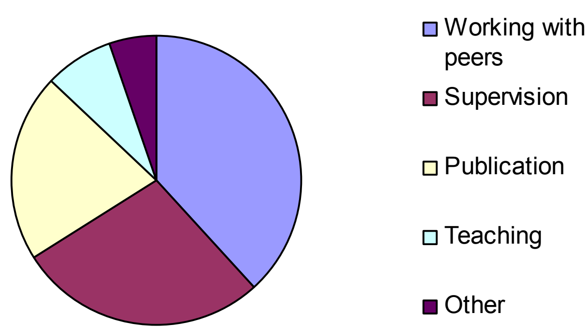
The most used competencies are also the most transferred; this is particularly true for Ground Based Data Processing and software development. Moreover, these two competencies have the highest transfer rate, that is the highest part of users transferring it. Among the seven most transferred competencies, are the six competencies that are mostly used by the scientific workforce, and the four mostly used by engineers.

About half of the considered competencies are transferred by more than 3/5 of their users. Looking at competencies that have the lowest transfer rate: of the 9 competencies transferred by less than 3/5 of their users, there are four management competencies: “project planning and management”, “team management”, “international relations” and “financial management”. Also included here are the three electronics-related competencies: “analogue electronics”, “digital electronics” and “micro-electronics”. These facts lead us to consider that the most specific competencies (management for scientists and electronics for engineers) are also the hardest to transfer, either because they are very tacit, or because their holders do not have time to devote to this.



Graph 72: Number of Users Transferring Competencies and Transfer Rate (Source [2.40])

Of the four transfer means proposed (working with peers, supervision, publication and teaching), graph 72 shows the preferred ones.



Graph 73: Competency Transfer: Means Distribution (Source: [2.41])

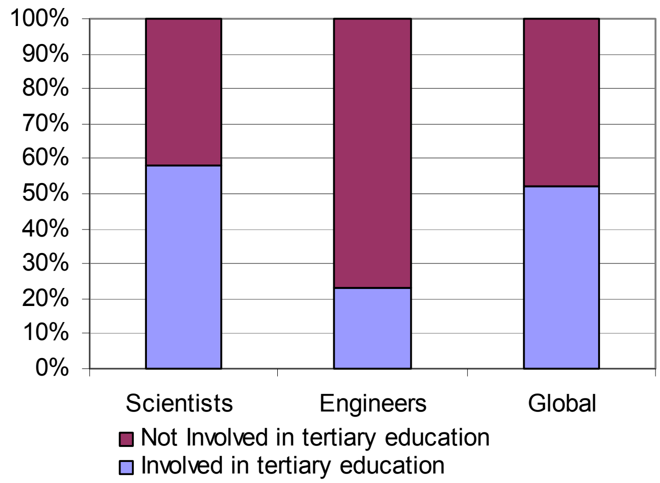
"On-the-job training means" (working with peers and supervision) are the most used ones (66%), with a preference for "working with peers" (38%), then come "formal transfer": "publication" (21%) and "teaching" (8%). On the job training seems to be the more natural way to transfer competencies, but without formal evaluation means, it is hard to assess its efficiency.

2.5.6) Formal Competency Transfer: Tertiary Education

In this part tertiary education is considered; these activities cover graduate course teaching, mentoring and PhD supervising.

- **Who is Involved in Tertiary Education?**

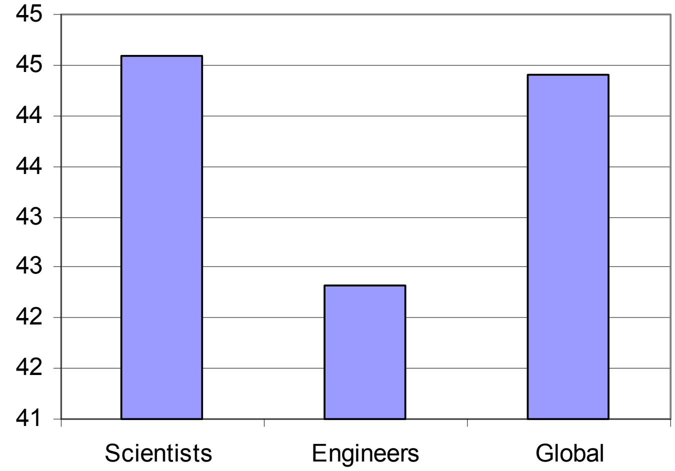
At the global level, more than half of the European workforce is involved in tertiary education (52%); graph 73 shows the differences in this involvement that appear between scientists and engineers.



Graph 74: Share of Workforce Involved in Tertiary Education (Source: [2.42])

From this graph, it can be assessed that scientists are much more involved in tertiary education than engineers: slightly less than 1/4 of the 70 respondent engineers are involved in such activities against 58% of the scientific workforce.

At the global level, the mean age of the workforce involved in tertiary education is 44.4 y.o. Graph 75 shows the mean age of this workforce at the global, scientific and engineering levels.

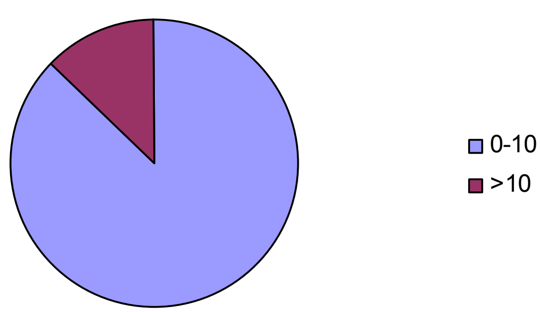


Graph 75: Mean Age of the Workforce Involved in Tertiary Education (Source: [2.43])

Unlike the general situation where scientists are younger than engineers, the mean age of the scientific workforce involved in tertiary education is higher than the comparable figure for engineers (44.6 against 42.3).

It seems also that education activities are carried out more by older members: the mean age of the engineering workforce involved in tertiary education is 42.3 against 41.5 for the global engineering population. The age gap is more important on the scientific side: scientists involved in tertiary education have a mean age of 44.6 against 40.4 for the global scientific population.

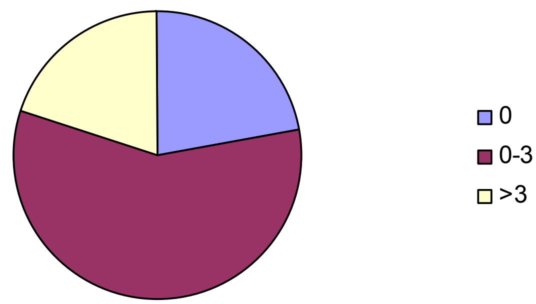
- **Tertiary Education – Experience and Current Activity of the Workforce Involved**



Graph 76: Number of Flown Instrument by the Workforce Involved in Tertiary Education (Source: [2.44])

As shown in graph 76, scientists and engineers that are involved in tertiary education seem to be more experienced than the average: 13% of them have been involved in more than 10 flown instruments against 9% for the global population.

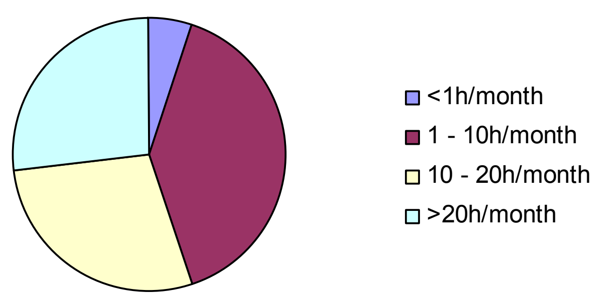
Beside this professional experience aspect, and as shown in graph 77, the workforce committed to tertiary education is currently involved in more space projects than the average: 79% of them are involved in at least one project against 69% for the global population. 20% of them are even involved in more than three projects, against 16% for the global workforce.



Graph 77: Number of Current Space Projects of the Workforce Involved in Tertiary Education (Source: [2.45])

- **Tertiary Education – What is the Importance of the Involvement?**

Beside the share of workforce involved in tertiary education, its experience and current activities, the importance of this involvement has to be assessed. Graph 78 presents the distribution of the workforce involved in tertiary education regarding the monthly time they dedicate to students.



Graph 78: Monthly Involvement in Tertiary Education (Source: [2.46])

Only 5% of the workforce involved in tertiary education devotes less than one hour to such activity, 55% devotes more than 10 hours, of which about half devotes more than 20 hours.

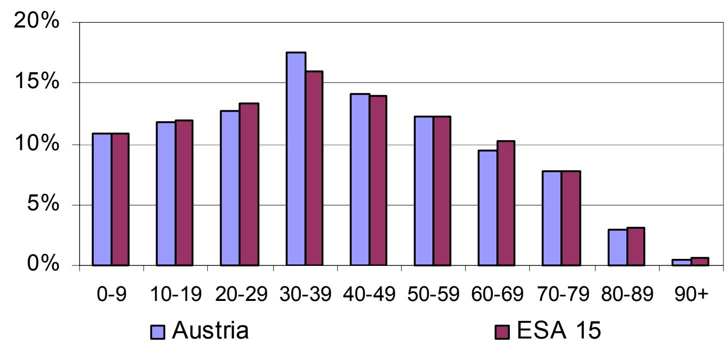
3) NATIONAL LEVEL INFORMATION

AUSTRIA

ENVIRONMENT

NATIONAL		ESA MS
Total population (Millions)	8.01	377
As %age of ESA Member states	2.1%	
Mean Age (2000)	39.7	39.9

AGE DISTRIBUTION



EDUCATION		
Graduates (as share of 20-24 y.o. pop.)	4.1%	8.4% (1)
Of which Science and Technology focus	32.2%	37% (1)
PhDs (as share of 25-29 y.o. pop.)	0.32	0.23% (1)
Of which Science and Technology focus	39.2	70% (1)
R&D FUNDING		
R&D expenditure/GDP	1.83%	1.92% (1)
Domestic R&D funding source: Government	39.7%	34.2% (2)
Industry	40.1%	56.3% (2)
Other (mainly cross national investment)	20.2%	9.49% (2)
R&D FUNDING EVOLUTION		
Govern't R&D mean annual growth (95-00)	-0.33%	0.61% (1)
Industry R&D mean annual growth (95-00)	2.96%	4.86% (1)
National Space programme budget mean annual growth (94-99)	-0.86%	0.18%
ESA science programme participation mean annual growth (95-00)	2.48%	-0.88%

(1): EU-15
(2): Switzerland Ireland and Norway excepted
N/A: Not Available

SPACE SCIENCE WORKFORCE

NATIONAL			ESA MS
Workforce volume evolution (87/92 – 97-02)		N/A	58%
COMPOSITION			
Scientists		N/A	64%
Engineers		N/A	36%
Permanent position holders		N/A	40%
Short term contract holders		N/A	60%
Length of service <10 years		N/A	54%
Length of service >10 years		N/A	46%
MEAN AGE AND AGE DISTRIBUTION			
Global workforce	Mean age (y.o.)	N/A	40.6

N/A

Scientific workforce	Mean age (y.o.)	**N/A**	**40.3**

N/A

Engineering workforce	Mean age (y.o.)	**N/A**	**41.4**

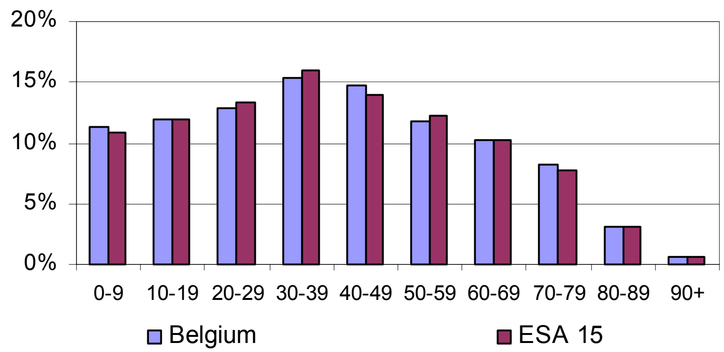
N/A

BELGIUM

ENVIRONMENT

NATIONAL		ESA MS
Total population (Millions)	10.2	377
As %age of ESA Member states	2.7%	
Mean Age (2000)	40	39.9

AGE DISTRIBUTION



EDUCATION		
Graduates (as share of 20-24 y.o. pop.)	10.6%	8.4% (1)
Of which Science and Technology focus	29.4%	37% (1)
PhDs (as share of 25-29 y.o. pop.)	0.14%	0.23% (1)
Of which Science and Technology focus	68.3	70% (1)
R&D FUNDING		
R&D expenditure/GDP	1.98%	1.92% (1)
Domestic R&D funding source: Government	23.2%	34.2% (2)
Industry	66.2%	56.3% (2)
Other (mainly cross national investment)	10.4%	9.49% (2)
R&D FUNDING EVOLUTION		
Govern't R&D mean annual growth (95-00)	5.5%	0.61% (1)
Industry R&D mean annual growth (95-00)	5.7%	4.86% (1)
National Space programme budget mean annual growth (94-99)	22.1%	0.18%
ESA science programme participation mean annual growth (95-00)	2.1%	-0.88%

(1): EU-15
(2): Switzerland Ireland and Norway excepted
N/A: Not Available

SPACE SCIENCE WORKFORCE

NATIONAL		ESA MS
Workforce volume evolution (87/92 – 97-02)	N/A	58%
COMPOSITION		
Scientists	N/A	64%
Engineers	N/A	36%
Permanent position holders	N/A	40%
Short term contract holders	N/A	60%
Length of service <10 years	N/A	54%
Length of service >10 years	N/A	46%
MEAN AGE AND AGE DISTRIBUTION		
Global workforce Mean age (y.o.)	N/A	40.6

N/A

Scientific workforce Mean age (y.o.)	N/A	40.3

N/A

Engineering workforce Mean age (y.o.)	N/A	41.4

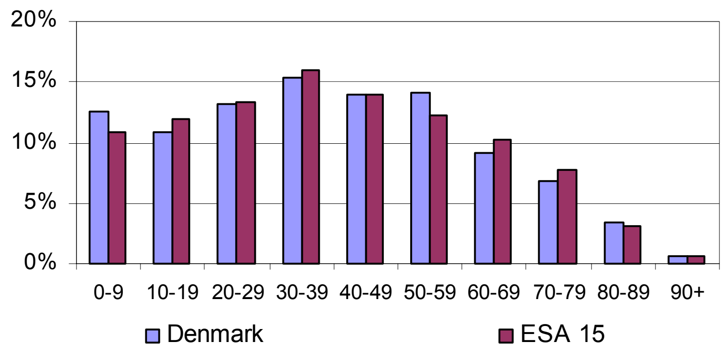
N/A

DENMARK

ENVIRONMENT

NATIONAL		ESA MS
Total population (Millions)	5.3	377
As %age of ESA Member states	1.4%	
Mean Age (2000)	39.4	39.9

AGE DISTRIBUTION



EDUCATION

Graduates (as share of 20-24 y.o. pop.)	8.3%	8.4% (1)
Of which Science and Technology focus	31%	37% (1)
PhDs (as share of 25-29 y.o. pop.)	0.09%	0.23% (1)
Of which Science and Technology focus	74%	70% (1)

R&D FUNDING

R&D expenditure/GDP	2%	1.92% (1)
Domestic R&D funding source: Government	32.6%	34.2% (2)
Industry	57.9%	56.3% (2)
Other (mainly cross national investment)	9.5%	9.5% (2)

R&D FUNDING EVOLUTION

Govern't R&D mean annual growth (95-00)	1.8%	0.61% (1)
Industry R&D mean annual growth (95-00)	12.5%	4.86% (1)
National Space programme budget mean annual growth (94-99)	-2%	0.18%
ESA science programme participation mean annual growth (95-00)	0.7%	-0.88%

(1): EU-15
(2): Switzerland Ireland and Norway excepted
N/A: Not Available

SPACE SCIENCE WORKFORCE

NATIONAL		ESA MS
Workforce volume evolution (87/92 – 97-02)	N/A	58%
COMPOSITION		
Scientists	N/A	64%
Engineers	N/A	36%
Permanent position holders	N/A	40%
Short term contract holders	N/A	60%
Length of service <10 years	N/A	54%
Length of service >10 years	N/A	46%

MEAN AGE AND AGE DISTRIBUTION

Global workforce	Mean age (y.o.)	N/A	40.6

N/A

Scientific workforce	Mean age (y.o.)	N/A	40.3

N/A

Engineering workforce	Mean age (y.o.)	N/A	41.4

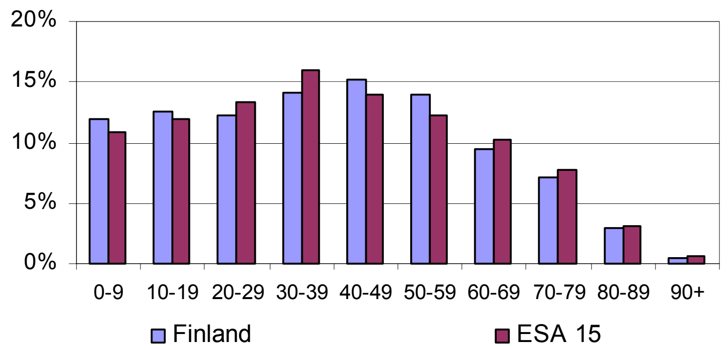
N/A

FINLAND

ENVIRONMENT

NATIONAL		ESA MS
Total population (Millions)	5.2	377
As %age of ESA Member states	1.4%	
Mean Age (2000)	39.4	39.9

AGE DISTRIBUTION



EDUCATION		
Graduates (as share of 20-24 y.o. pop.)	9.2%	8.4% (1)
Of which Science and Technology focus	67.1%	37% (1)
PhDs (as share of 25-29 y.o. pop.)	0.43	0.23% (1)
Of which Science and Technology focus	67.1%	70% (1)
R&D FUNDING		
R&D expenditure/GDP	3.2%	1.92% (1)
Domestic R&D funding source: Government	29.2%	34.2% (2)
Industry	66.9%	56.3% (2)
Other (mainly cross national investment)	3.9%	9.49% (2)
R&D FUNDING EVOLUTION		
Govern't R&D mean annual growth (95-00)	5%	0.61% (1)
Industry R&D mean annual growth (95-00)	17.5%	4.86% (1)
National Space programme budget mean annual growth (94-99)	-8.1%	0.18%
ESA science programme participation mean annual growth (95-00)	-5.37%	-0.88%

(1): EU-15
(2): Switzerland Ireland and Norway excepted
N/A: Not Available

SPACE SCIENCE WORKFORCE

NATIONAL		ESA MS
Workforce volume evolution (87/92 – 97-02)	N/A	58%
COMPOSITION		
Scientists	N/A	64%
Engineers	N/A	36%
Permanent position holders	N/A	40%
Short term contract holders	N/A	60%
Length of service <10 years	N/A	54%
Length of service >10 years	N/A	46%
MEAN AGE AND AGE DISTRIBUTION		
Global workforce Mean age (y.o.)	N/A	40.6

N/A

Scientific workforce Mean age (y.o.)	N/A	40.3

N/A

Engineering workforce Mean age (y.o.)	N/A	41.4

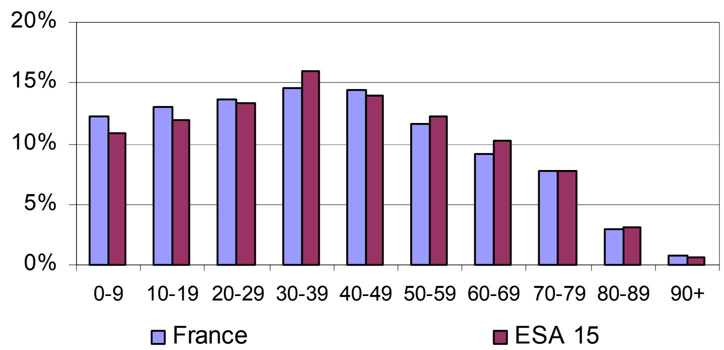
N/A

FRANCE

ENVIRONMENT

NATIONAL		ESA MS
Total population (Millions)	59.2	377
As %age of ESA Member states	15.7%	
Mean Age (2000)	38.8	39.9

AGE DISTRIBUTION



EDUCATION

Graduates (as share of 20-24 y.o. pop.)	13.7%	8.4% (1)
Of which Science and Technology focus	31%	37% (1)
PhDs (as share of 25-29 y.o. pop.)	0.25%	0.23% (1)
Of which Science and Technology focus	65.6%	70% (1)

R&D FUNDING

R&D expenditure/GDP		2.2%	1.92% (1)
Domestic R&D funding source:	Government	36.9%	34.2% (2)
	Industry	54.1%	56.3% (2)
	Other (mainly cross national investment)	9%	9.49% (2)

R&D FUNDING EVOLUTION

Govern't R&D mean annual growth (95-00)	-1.52%	0.61% (1)
Industry R&D mean annual growth (95-00)	3.48%	4.86% (1)
National Space programme budget mean annual growth (94-99)	2.12%	0.18%
ESA science programme participation mean annual growth (95-00)	0.64%	-0.88%

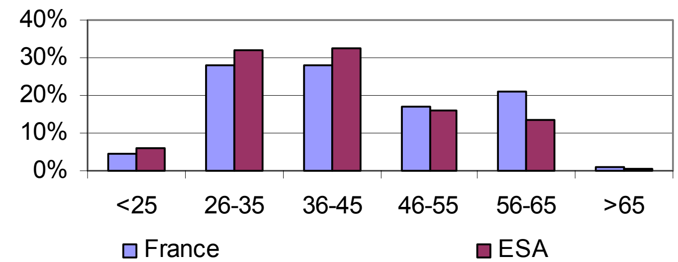
(1): EU-15
(2): Switzerland Ireland and Norway excepted
N/A: Not Available

SPACE SCIENCE WORKFORCE

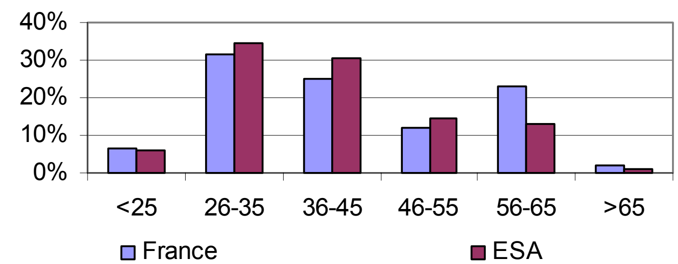
NATIONAL		ESA MS
Workforce volume evolution (87/92 – 97-02)	47%	58%
COMPOSITION		
Scientists	52%	64%
Engineers	48%	36%
Permanent position holders	83%	40%
Short term contract holders	17%	60%
Length of service <10 years	46%	54%
Length of service >10 years	54%	46%

MEAN AGE AND AGE DISTRIBUTION

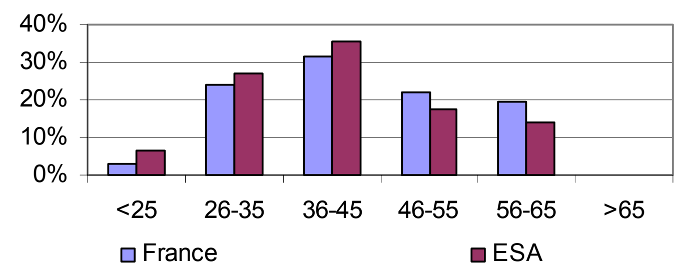
Global workforce	Mean age (y.o.)	43	40.6



Scientific workforce	Mean age (y.o.)	43	40.3



Engineering workforce	Mean age (y.o.)	44	41.4

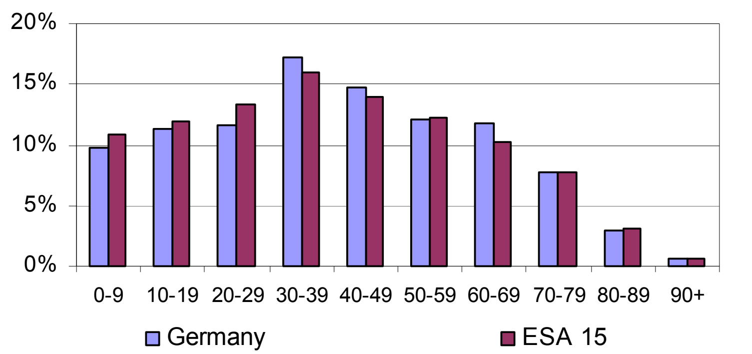


GERMANY

ENVIRONMENT

NATIONAL		ESA MS
Total population (Millions)	82	377
As %age of ESA Member states	21.7%	
Mean Age (2000)	41	39.9

AGE DISTRIBUTION



EDUCATION

Graduates (as share of 20-24 y.o. pop.)	7.1%	8.4% (1)
Of which Science and Technology focus	45.6%	37% (1)
PhDs (as share of 25-29 y.o. pop.)	0.34%	0.23% (1)
Of which Science and Technology focus	71.7%	70% (1)

R&D FUNDING

R&D expenditure/GDP	2.44%	1.92% (1)
Domestic R&D funding source: Government	32.5%	34.2% (2)
Industry	65%	56.3% (2)
Other (mainly cross national investment)	2.5%	9.49% (2)

R&D FUNDING EVOLUTION

Govern't R&D mean annual growth (95-00)	-0.52%	0.61% (1)
Industry R&D mean annual growth (95-00)	4.78%	4.86% (1)
National Space programme budget mean annual growth (94-99)	-15.68%	0.18%
ESA science programme participation mean annual growth (95-00)	0.76%	-0.88%

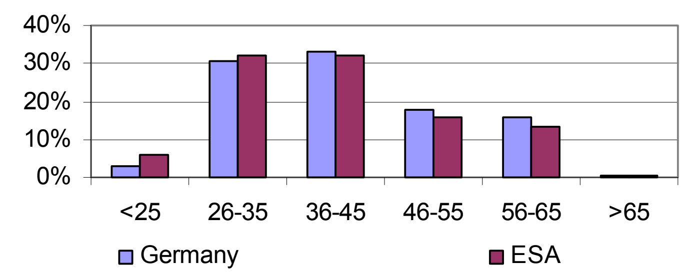
(1): EU-15
(2): Switzerland Ireland and Norway excepted
N/A: Not Available

SPACE SCIENCE WORKFORCE

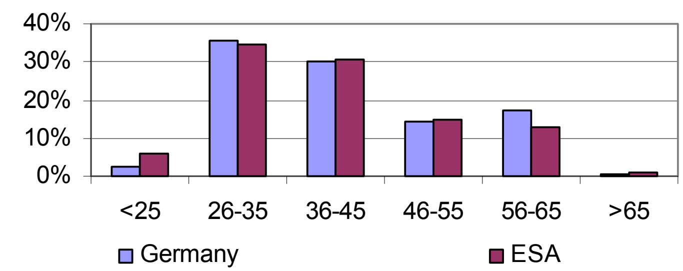
NATIONAL		ESA MS
Workforce volume evolution (87/92 – 97-02)	67%	58%
COMPOSITION		
Scientists	78%	64%
Engineers	22%	36%
Permanent position holders	42%	40%
Short term contract holders	58%	60%
Length of service <10 years	69%	54%
Length of service >10 years	31%	46%

MEAN AGE AND AGE DISTRIBUTION

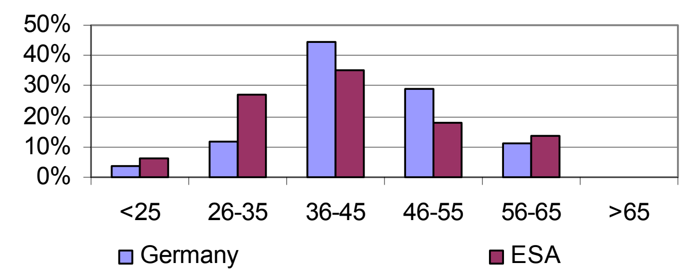
Global workforce	Mean age (y.o.)	42	40.6



Scientific workforce	Mean age (y.o.)	42	40.3



Engineering workforce	Mean age (y.o.)	45	41.4

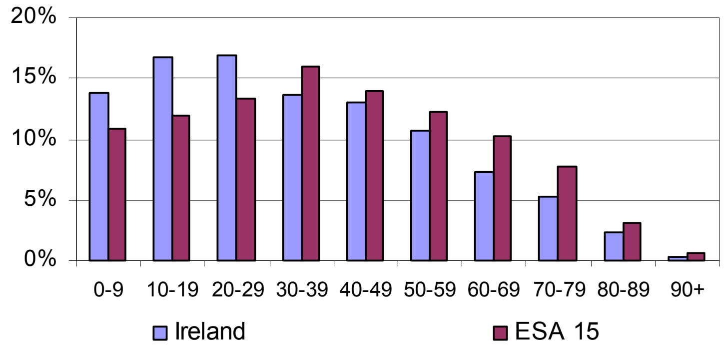


IRELAND

ENVIRONMENT

NATIONAL		ESA MS
Total population (Millions)	3.8	377
As %age of ESA Member states	1%	
Mean Age (2000)	34.8	39.9

AGE DISTRIBUTION



EDUCATION		
Graduates (as share of 20-24 y.o. pop.)	11.9%	8.4% (1)
Of which Science and Technology focus	35%	37% (1)
PhDs (as share of 25-29 y.o. pop.)	0.16%	0.23% (1)
Of which Science and Technology focus	76.6%	70% (1)
R&D FUNDING		
R&D expenditure/GDP	1.39%	1.92% (1)
Domestic R&D funding source: Government	N/A	34.2% (2)
Industry	N/A	56.3% (2)
Other (mainly cross national investment)	N/A	9.49% (2)
R&D FUNDING EVOLUTION		
Govern't R&D mean annual growth (95-00)	2.69%	0.61% (1)
Industry R&D mean annual growth (95-00)	11.29%	4.86% (1)
National Space programme budget mean annual growth (94-99)	-2.65%	0.18%
ESA science programme participation mean annual growth (95-00)	4.5%	-0.88%

(1): EU-15
(2): Switzerland Ireland and Norway excepted
N/A: Not Available

SPACE SCIENCE WORKFORCE

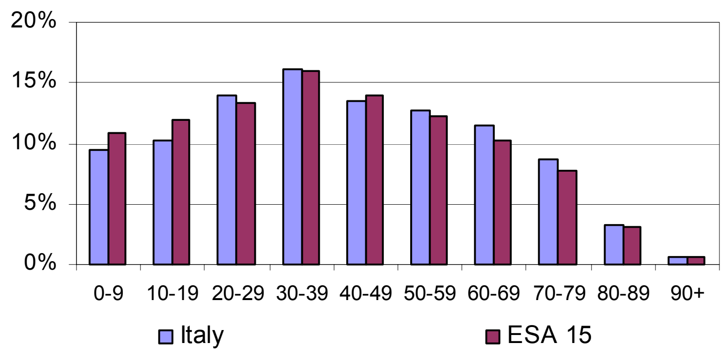
NATIONAL			ESA MS
Workforce volume evolution (87/92 – 97-02)		N/A	58%
COMPOSITION			
Scientists		N/A	64%
Engineers		N/A	36%
Permanent position holders		N/A	40%
Short term contract holders		N/A	60%
Length of service <10 years		N/A	54%
Length of service >10 years		N/A	46%
MEAN AGE AND AGE DISTRIBUTION			
Global workforce	Mean age (y.o.)	N/A	40.6
N/A			
Scientific workforce	Mean age (y.o.)	N/A	40.3
N/A			
Engineering workforce	Mean age (y.o.)	N/A	41.4
N/A			

ITALY

ENVIRONMENT

NATIONAL		ESA MS
Total population (Millions)	57.6	377
As %age of ESA Member states	15.3%	
Mean Age (2000)	41.5	39.9

AGE DISTRIBUTION



EDUCATION		
Graduates (as share of 20-24 y.o. pop.)	4.1%	8.4% (1)
Of which Science and Technology focus	28.4%	37% (1)
PhDs (as share of 25-29 y.o. pop.)	0.08%	0.23% (1)
Of which Science and Technology focus	58.6%	70% (1)
R&D FUNDING		
R&D expenditure/GDP	1.04%	1.92% (1)
Domestic R&D funding source: Government	51.3%	34.2% (2)
Industry	44%	56.3% (2)
Other (mainly cross national investment)	4.7%	9.49% (2)
R&D FUNDING EVOLUTION-0.08%		
Govern't R&D mean annual growth (95-00)	-0.08%	0.61% (1)
Industry R&D mean annual growth (95-00)	3.84%	4.86% (1)
National Space programme budget mean annual growth (94-99)	13.92%	0.18%
ESA science programme participation mean annual growth (95-00)	5.15%	-0.88%

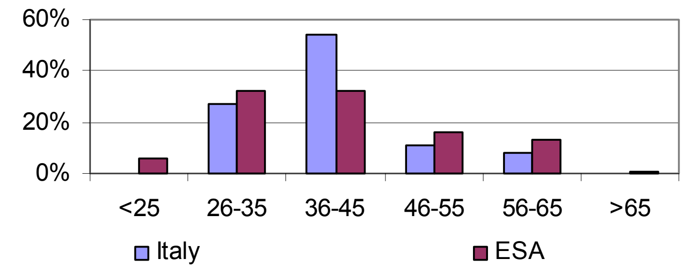
(1): EU-15
(2): Switzerland Ireland and Norway excepted
N/A: Not Available

SPACE SCIENCE WORKFORCE

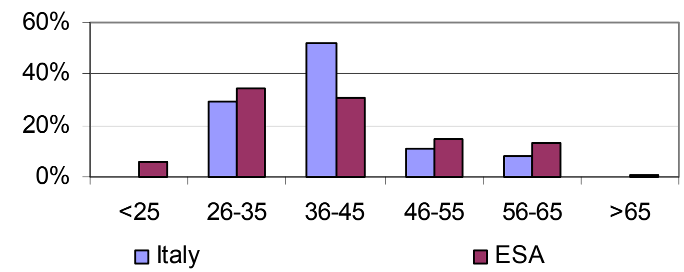
NATIONAL		ESA MS
Workforce volume evolution (87/92 – 97-02)	83%	58%
COMPOSITION		
Scientists	70%	64%
Engineers	30%	36%
Permanent position holders	75%	40%
Short term contract holders	25%	60%
Length of service <10 years	32%	54%
Length of service >10 years	68%	46%

MEAN AGE AND AGE DISTRIBUTION

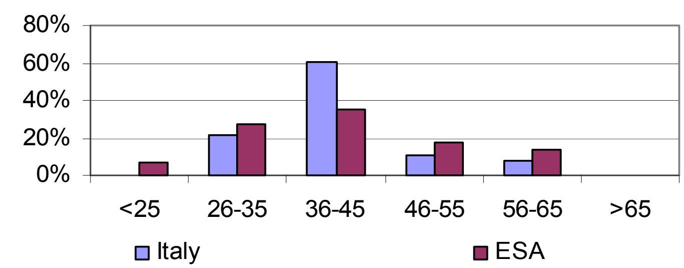
Global workforce Mean age (y.o.)	40	40.6



Scientific workforce Mean age (y.o.)	N/A	40.3



Engineering workforce Mean age (y.o.)	N/A	41.4

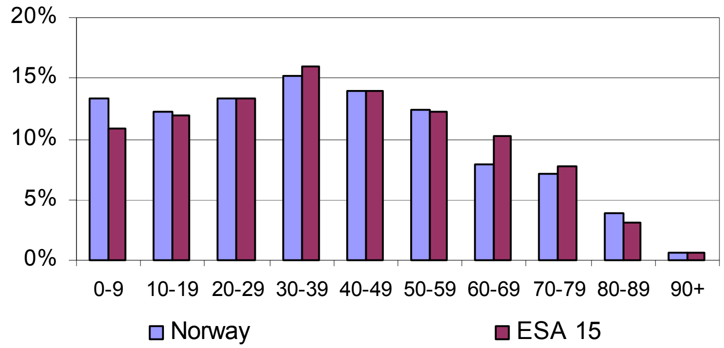


NORWAY

ENVIRONMENT

NATIONAL		ESA MS
Total population (Millions)	4.5	377
As %age of ESA Member states	1.2%	
Mean Age (2000)	38.6	39.9

AGE DISTRIBUTION



EDUCATION

Graduates (as share of 20-24 y.o. pop.)	N/A	8.4% (1)
Of which Science and Technology focus	N/A	37% (1)
PhDs (as share of 25-29 y.o. pop.)	N/A	0.23% (1)
Of which Science and Technology focus	N/A	70% (1)

R&D FUNDING

R&D expenditure/GDP	1.7%	1.92% (1)
Domestic R&D funding source: Government	N/A	34.2% (2)
Industry	N/A	56.3% (2)
Other (mainly cross national investment)	N/A	9.49% (2)

R&D FUNDING EVOLUTION

Govern't R&D mean annual growth (95-00)	N/A	0.61% (1)
Industry R&D mean annual growth (95-00)	N/A	4.86% (1)
National Space programme budget mean annual growth (94-99)	-1.81%	0.18%
ESA science programme participation mean annual growth (95-00)	2.3%	-0.88%

(1): EU-15
(2): Switzerland Ireland and Norway excepted
N/A: Not Available

SPACE SCIENCE WORKFORCE

NATIONAL		ESA MS
Workforce volume evolution (87/92 – 97-02)	N/A	58%
COMPOSITION		
Scientists	N/A	64%
Engineers	N/A	36%
Permanent position holders	N/A	40%
Short term contract holders	N/A	60%
Length of service <10 years	N/A	54%
Length of service >10 years	N/A	46%
MEAN AGE AND AGE DISTRIBUTION		
Global workforce Mean age (y.o.)	N/A	40.6

N/A

Scientific workforce Mean age (y.o.)	N/A	40.3

N/A

Engineering workforce Mean age (y.o.)	N/A	41.4

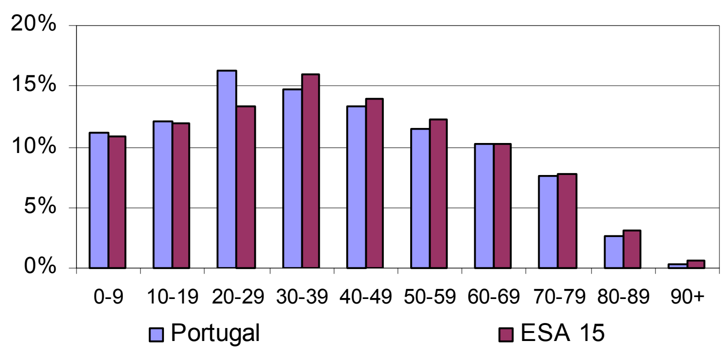
N/A

PORTUGAL

ENVIRONMENT

NATIONAL		ESA MS
Total population (Millions)	10	377
As %age of ESA Member states	2.7%	
Mean Age (2000)	38.8	39.9

AGE DISTRIBUTION



EDUCATION		
Graduates (as share of 20-24 y.o. pop.)	5%	8.4% (1)
Of which Science and Technology focus	26.8%	37% (1)
PhDs (as share of 25-29 y.o. pop.)	N/A	0.23% (1)
Of which Science and Technology focus	N/A	70% (1)
R&D FUNDING		
R&D expenditure/GDP	0.76%	1.92% (1)
Domestic R&D funding source: Government	69.7%	34.2% (2)
Industry	21.3%	56.3% (2)
Other (mainly cross national investment)	9%	9.49% (2)
R&D FUNDING EVOLUTION		
Govern't R&D mean annual growth (95-00)	10.85%	0.61% (1)
Industry R&D mean annual growth (95-00)	12.18%	4.86% (1)
National Space programme budget mean annual growth (94-99)	N/A	0.18%
ESA science programme participation mean annual growth (95-00)	N/A	-0.88%

(1): EU-15
(2): Switzerland Ireland and Norway excepted
N/A: Not Available

SPACE SCIENCE WORKFORCE

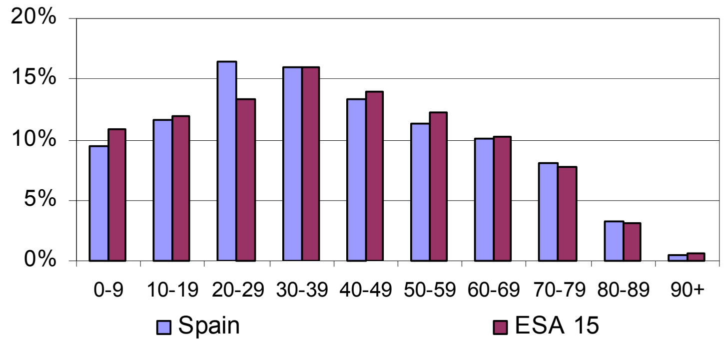
NATIONAL		ESA MS
Workforce volume evolution (87/92 – 97-02)	N/A	58%
COMPOSITION		
Scientists	N/A	64%
Engineers	N/A	36%
Permanent position holders	N/A	40%
Short term contract holders	N/A	60%
Length of service <10 years	N/A	54%
Length of service >10 years	N/A	46%
MEAN AGE AND AGE DISTRIBUTION		
Global workforce Mean age (y.o.)	N/A	40.6
N/A		
Scientific workforce Mean age (y.o.)	N/A	40.3
N/A		
Engineering workforce Mean age (y.o.)	N/A	41.4
N/A		

SPAIN

ENVIRONMENT

NATIONAL		ESA MS
Total population (Millions)	39.9	377
As %age of ESA Member states	10.6%	
Mean Age (2000)	39.9	39.9

AGE DISTRIBUTION



EDUCATION		
Graduates (as share of 20-24 y.o. pop.)	6.7%	8.4% (1)
Of which Science and Technology focus	30.5%	37% (1)
PhDs (as share of 25-29 y.o. pop.)	0.19%	0.23% (1)
Of which Science and Technology focus	60.7%	70% (1)
R&D FUNDING		
R&D expenditure/GDP	0.89%	1.92% (1)
Domestic R&D funding source: Government	40.8%	34.2% (2)
Industry	48.9%	56.3% (2)
Other (mainly cross national investment)	10.3%	9.49% (2)
R&D FUNDING EVOLUTION		
Govern't R&D mean annual growth (95-00)	12.72%	0.61% (1)
Industry R&D mean annual growth (95-00)	8.52%	4.86% (1)
National Space programme budget mean annual growth (94-99)	-2.6%	0.18%
ESA science programme participation mean annual growth (95-00)	-3.38%	-0.88%

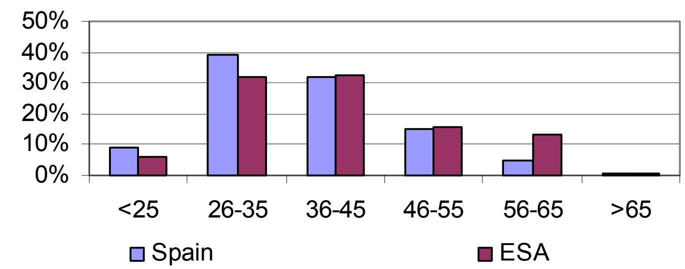
(1): EU-15
(2): Switzerland Ireland and Norway excepted
N/A: Not Available

SPACE SCIENCE WORKFORCE

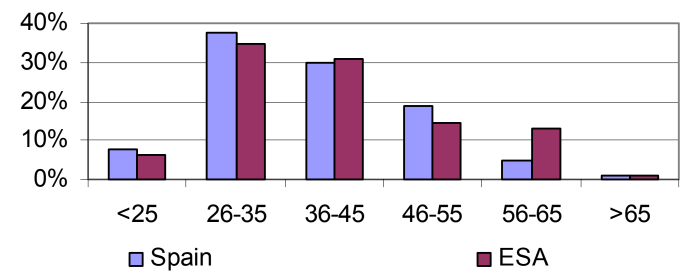
NATIONAL		ESA MS
Workforce volume evolution (87/92 – 97-02)	N/A	58%
COMPOSITION		
Scientists	68%	64%
Engineers	32%	36%
Permanent position holders	42%	40%
Short term contract holders	58%	60%
Length of service <10 years	59%	54%
Length of service >10 years	41%	46%

MEAN AGE AND AGE DISTRIBUTION

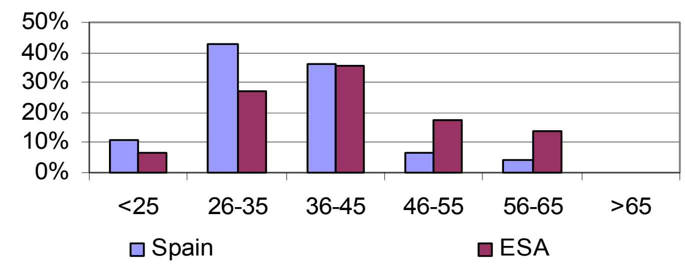
	Mean age (y.o.)	National	ESA MS
Global workforce	Mean age (y.o.)	38	40.6



	Mean age (y.o.)	National	ESA MS
Scientific workforce	Mean age (y.o.)	N/A	40.3



	Mean age (y.o.)	National	ESA MS
Engineering workforce	Mean age (y.o.)	N/A	41.4

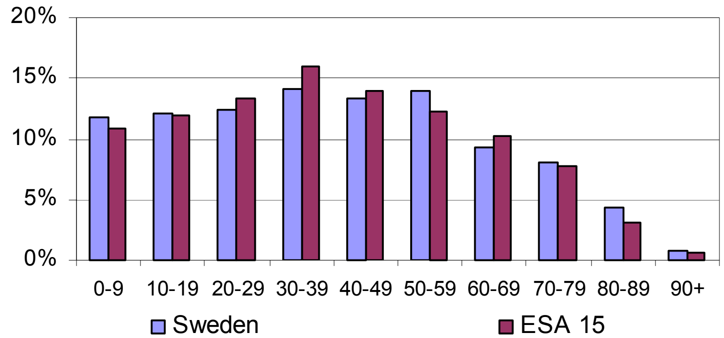


SWEDEN

ENVIRONMENT

NATIONAL		ESA MS
Total population (Millions)	8.8	377
As %age of ESA Member states	2.3%	
Mean Age (2000)	40.5	39.9

AGE DISTRIBUTION



EDUCATION

Graduates (as share of 20-24 y.o. pop.)	6.2%	8.4% (1)
Of which Science and Technology focus	46.2%	37% (1)
PhDs (as share of 25-29 y.o. pop.)	0.42%	0.23% (1)
Of which Science and Technology focus	76.1%	70% (1)

R&D FUNDING

R&D expenditure/GDP	3.8%	1.92% (1)
Domestic R&D funding source: Government	24.5%	34.2% (2)
Industry	67.8%	56.3% (2)
Other (mainly cross national investment)	7.7%	9.49% (2)

R&D FUNDING EVOLUTION

Govern't R&D mean annual growth (95-00)	-5.28%	0.61% (1)
Industry R&D mean annual growth (95-00)	6.37%	4.86% (1)
National Space programme budget mean annual growth (94-99)	-4.23%	0.18%
ESA science programme participation mean annual growth (95-00)	4.09%	-0.88%

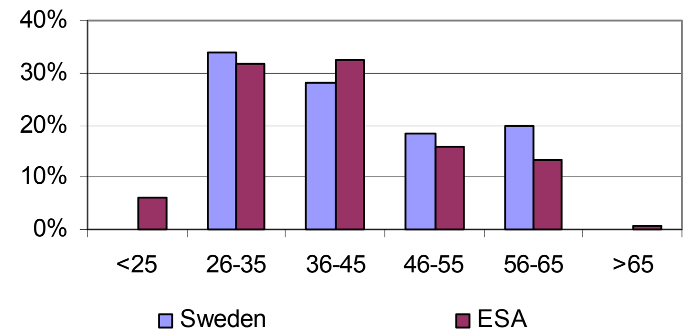
(1): EU-15
(2): Switzerland Ireland and Norway excepted
N/A: Not Available

SPACE SCIENCE WORKFORCE

NATIONAL		ESA MS
Workforce volume evolution (87/92 – 97-02)	N/A	58%
COMPOSITION		
Scientists	N/A	64%
Engineers	N/A	36%
Permanent position holders	N/A	40%
Short term contract holders	N/A	60%
Length of service <10 years	N/A	54%
Length of service >10 years	N/A	46%

MEAN AGE AND AGE DISTRIBUTION

Global work	Extrapolated Mean age (y.o.)	43	--



Scientific workforce	Extrapolated Mean age (y.o.)	N/A	40.3

N/A

Engineering workforce	Mean age (y.o.)	N/A	41.4

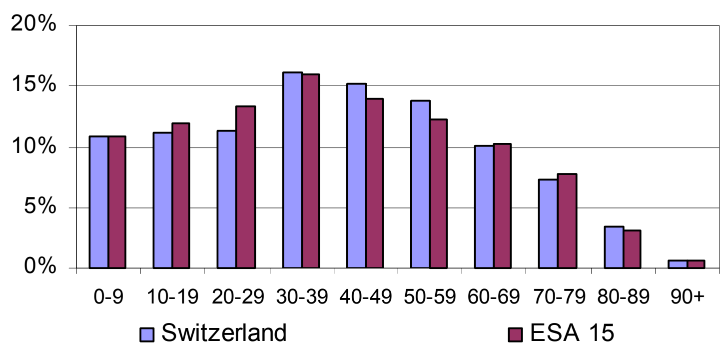
N/A

SWITZERLAND

ENVIRONMENT

NATIONAL		ESA MS
Total population (Millions)	7.2	377
As %age of ESA Member states	1.9%	
Mean Age (2000)	40.6	39.9

AGE DISTRIBUTION



EDUCATION

Graduates (as share of 20-24 y.o. pop.)	N/A	8.4% (1)
Of which Science and Technology focus	N/A	37% (1)
PhDs (as share of 25-29 y.o. pop.)	N/A	0.23% (1)
Of which Science and Technology focus	N/A	70% (1)

R&D FUNDING

R&D expenditure/GDP	N/A	1.92% (1)
Domestic R&D funding source: Government	N/A	34.2% (2)
Industry	N/A	56.3% (2)
Other (mainly cross national investment)	N/A	9.49% (2)

R&D FUNDING EVOLUTION

Govern't R&D mean annual growth (95-00)	N/A	0.61% (1)
Industry R&D mean annual growth (95-00)	N/A	4.86% (1)
National Space programme budget mean annual growth (94-99)	-1.74%	0.18%
ESA science programme participation mean annual growth (95-00)	-1.24%	-0.88%

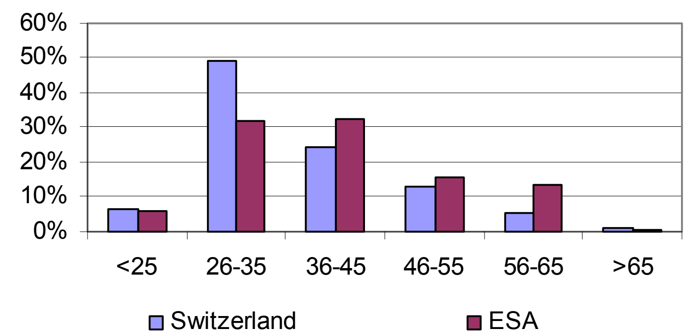
(1): EU-15
(2): Switzerland Ireland and Norway excepted
N/A: Not Available

SPACE SCIENCE WORKFORCE

NATIONAL		ESA MS
Workforce volume evolution (87/92 – 97-02)	N/A	58%
COMPOSITION		
Scientists	N/A	64%
Engineers	N/A	36%
Permanent position holders	N/A	40%
Short term contract holders	N/A	60%
Length of service <10 years	N/A	54%
Length of service >10 years	N/A	46%

MEAN AGE AND AGE DISTRIBUTION

Global workforce	Extrapolated Mean age (y.o.)	38	--



Scientific workforce	Mean age (y.o.)	N/A	40.3

N/A

Engineering workforce	Mean age (y.o.)	N/A	41.4

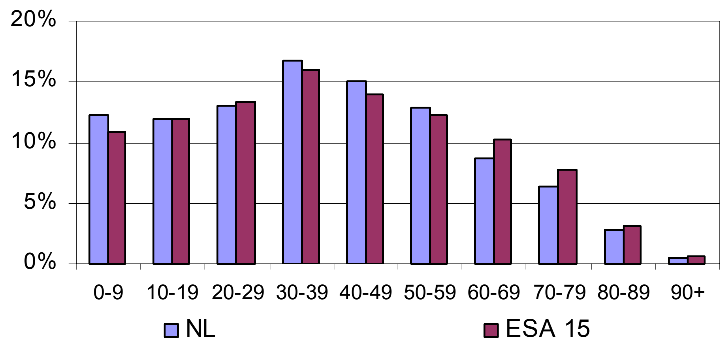
N/A

THE NETHERLANDS

ENVIRONMENT

NATIONAL		ESA MS
Total population (Millions)	15.9	377
As %age of ESA Member states	4.2%	
Mean Age (2000)	38.5	39.9

AGE DISTRIBUTION

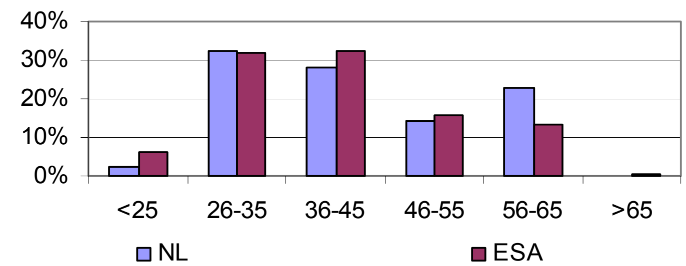


EDUCATION		
Graduates (as share of 20-24 y.o. pop.)	8.1%	8.4% (1)
Of which Science and Technology focus	30.1%	37% (1)
PhDs (as share of 25-29 y.o. pop.)	0.39%	0.23% (1)
Of which Science and Technology focus	66.8%	70% (1)
R&D FUNDING		
R&D expenditure/GDP	1.94%	1.92% (1)
Domestic R&D funding source: Government	35.7%	34.2% (2)
Industry	49.7%	56.3% (2)
Other (mainly cross national investment)	14.6%	9.49% (2)
R&D FUNDING EVOLUTION		
Govern't R&D mean annual growth (95-00)	2.68%	0.61% (1)
Industry R&D mean annual growth (95-00)	4.73%	4.86% (1)
National Space programme budget mean annual growth (94-99)	13.19%	0.18%
ESA science programme participation mean annual growth (95-00)	1.28%	-0.88%

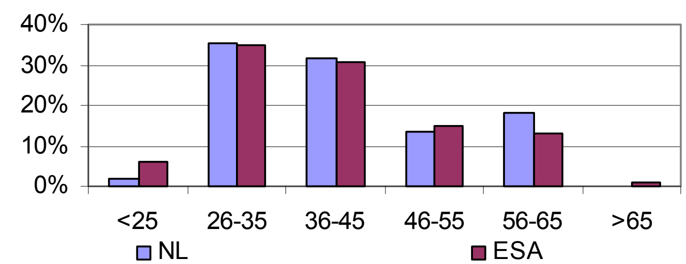
(1): EU-15
(2): Switzerland Ireland and Norway excepted N/A: Not Available

SPACE SCIENCE WORKFORCE

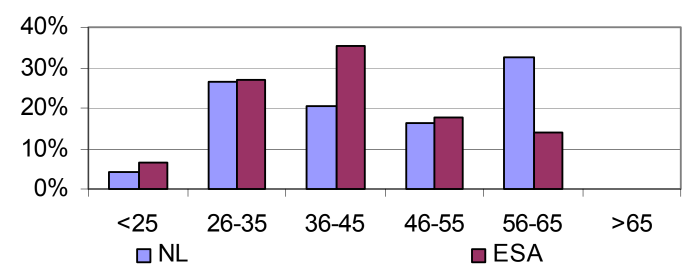
NATIONAL		ESA MS
Workforce volume evolution (87/92 – 97-02)	37%	58%
COMPOSITION		
Scientists	68.2%	64%
Engineers	31.8%	36%
Permanent position holders	53.9%	40%
Short term contract holders	46.1%	60%
Length of service <10 years	57.8%	54%
Length of service >10 years	42.2%	46%
MEAN AGE AND AGE DISTRIBUTION		
Global workforce Mean age (y.o.)	N/A	40.6



Scientific workforce Mean age (y.o.)	N/A	40.3



Engineering workforce Mean age (y.o.)	N/A	41.4

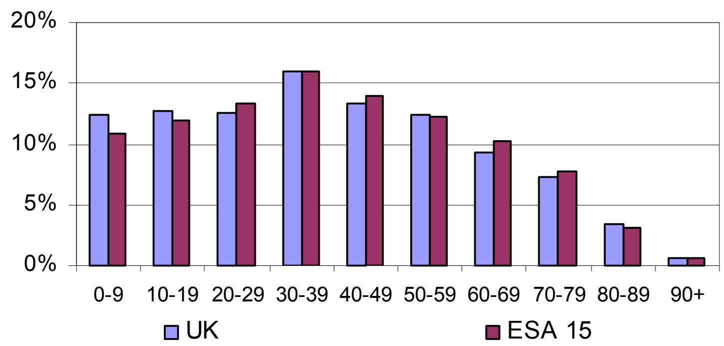


UNITED KINGDOM

ENVIRONMENT

NATIONAL		ESA MS
Total population (Millions)	59.4	377
As %age of ESA Member states	15.8%	
Mean Age (2000)	39	39.9

AGE DISTRIBUTION



EDUCATION

Graduates (as share of 20-24 y.o. pop.)	12.3%	8.4% (1)
Of which Science and Technology focus	36.7%	37% (1)
PhDs (as share of 25-29 y.o. pop.)	0.23%	0.23% (1)
Of which Science and Technology focus	68.6%	70% (1)

R&D FUNDING

R&D expenditure/GDP	1.87%	1.92% (1)
Domestic R&D funding source: Government	27.9%	34.2% (2)
Industry	49.4%	56.3% (2)
Other (mainly cross national investment)	22.7%	9.49% (2)

R&D FUNDING EVOLUTION

Govern't R&D mean annual growth (95-00)	0.27%	0.61% (1)
Industry R&D mean annual growth (95-00)	1.99%	4.86% (1)
National Space programme budget mean annual growth (94-99)	3.36%	0.18%
ESA science programme participation mean annual growth (95-00)	0.45%	-0.88%

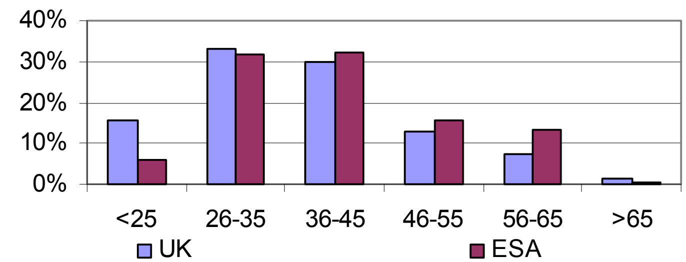
(1): EU-15
(2): Switzerland Ireland and Norway excepted
N/A: Not Available

SPACE SCIENCE WORKFORCE

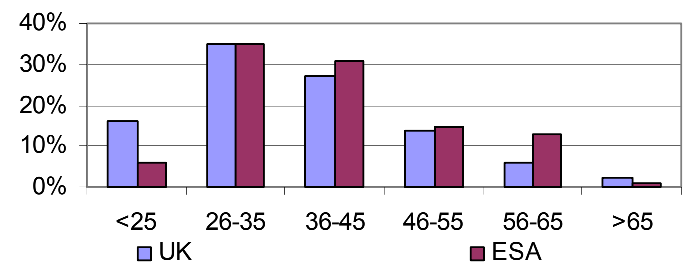
NATIONAL		ESA MS
Workforce volume evolution (87/92 – 97-02)	58%	58%
COMPOSITION		
Scientists	57%	64%
Engineers	43%	36%
Permanent position holders	67%	40%
Short term contract holders	33%	60%
Length of service <10 years	52%	54%
Length of service >10 years	48%	46%

MEAN AGE AND AGE DISTRIBUTION

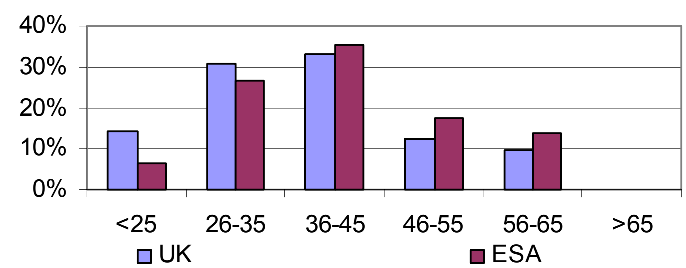
Global workforce	Mean age (y.o.)	37	40.6



Scientific workforce	Mean age (y.o.)	37	40.3



Engineering workforce	Mean age (y.o.)	38	41.4



Sources

[1.1]: UN population division – World population prospect - http://esa.un.org/unpp/

[1.2]: Towards a European Research Area Key Figures 2000 - http://europa.eu.int/comm/research/pdf/keyfiguresihp.pdf

[1.3]: Les jeunes et les études scientifiques : les raisons de la "désaffection", un plan d'action Maurice Porchet- Mars 2002
http://www.education.gouv.fr/rapport/default.htm

[1.4]: Higher Education Statistic Agency - http://www.hesa.ac.uk

[1.5]: Towards a European Research Area - Key figures 2001 - Special edition - Indicators for benchmarking of national research policies - published on the 17th July 2001 - http://europa.eu.int/comm/research/era/pdf/benchmarking2001.pdf

[1.6]: European space directory 2000 – Sevig Press - 2000

[1.7]: ESA science programme budgets – Provided by ESA

[1.8]: European Union - Eurostats for inflation rates -
http://europa.eu.int/comm/eurostat/Public/datashop/print-product/EN?catalogue=Eurostat&product=1-eb040-EN&mode=download

[1.9]: European Union - Eurostats
http://europa.eu.int/comm/eurostat/Public/datashop/print-product/EN?catalogue=Eurostat&product=9-t9050pc-EN&mode=download

[1.10] : Ministère de l'éducation nationale - La R&D en Europe et dans les principaux pays de l'OCDE
http://cisad.adc.education.fr/reperes/public/chiffres/internat/default.htm

[1.11] European Union - Europeans, science and technology – December 2001
http://europa.eu.int/comm/research/press/2001/pr0612en.html

[1.12] Space Marketing A European Perspective Walter A.R. Peeters - Kluwer Academic publishers, 2000

[1.13]: European Union - http://europa.eu.int/comm/eurostat/Public/datashop/print-product/EN?catalogue=Eurostat&product=KS-NS-01-006-__-I-EN&mode=download

[2.1]

	Population	%age
Female	72	16,4%
Male	368	83,6%
Grand Total	**440**	**100,0%**

(Data from IQ "gender")

[2.2]

	Permanent	ST/Renewable	Population
Total Population	60,4%	39,6%	1769,1

(Data from lab Q WF age distribution)

[2.3]

Duration (years)	Population	%age
1	49	30,4%
2	40	24,8%
3	40	24,8%
4	11	6,8%
5	11	6,8%
>5	10	6,2%
Grand Total	**161**	**100,0%**

(Data from Individual questionnaire "ST contract expected duration")

[2.4]

	Scientists	Engineers	Population
Total Population	63,5%	36,5%	1769

(Data from lab Q "Workforce Age Distribution")

[2.5]

	Science		Engineering	
	Population	**%age**	**Population**	**%age**
Female	61	16,9%	10	13,0%
Male	299	83,1%	67	87,0%
Grand Total	**360**	**100,0%**	**77**	**100,0%**

(Data from Individual Questionnaire "Field" and "Gender")

[2.6]

	Permanent	ST/Renewable	Population
Scientists	52,9%	47,1%	**1123,1**
Engineers	73,4%	26,6%	**646,0**

(Data from lab Q WF Age distrib)

[2.7]

	Scientists involved
High energy	21,7%
IR + sub mm	19,4%
UV + Optical	7,3%
Total Astro	**48,4%**
Space physics	18,4%
Fundamental physics	11,0%
Solar physics	9,9%
Total Physics	**39,3%**
Planetary exploration	**12,3%**
Total	**1094**

(Data from the Lab Questionnaire "Distribution of workforce" - Only the scientific Workforce has been considered.)

[2.8]

Period	TOTAL
87-92	1157,5
92-97	1453
97-02	1825,7
Increase over the period	**58%**

(Data from the Lab Questionnaire – "WF level by 5-years increment")

[2.9]

Period	Permanent post	Short Term/ Renewable
87-92	815,5	342
92-97	915	538
97-02	1087,6	738,1
Increase over the period	**33,4%**	**115,8%**

(Data from the Lab Questionnaire – "WF level by 5-years increment")

[2.10]

	Science			Engineering			
Period	**Permanent post**	**Short Term/ Renewable**	**Total Science**	**Permanent post**	**Short Term/ Renewable**	**Total Engineering**	**TOTAL**
87-92	390	260	**650**	425,5	82	**507,5**	**1158**
92-97	468	410	**878**	447	128	**575**	**1453**
97-02	605,55	541,1	**1146,65**	482	197	**679**	**1826**
Increase over the period	**55%**	**108%**	**76%**	**13%**	**140%**	**34%**	**58%**

(Data from lab Q "distribution of Workforce")

[2.11]

	87-92	92-97	97-02	
High energy	242	304	336	**38,80%**
IR	46	74	110	**139,10%**
UV	22	26	27	**22,70%**
Total Astronomy	**310**	**404**	**473**	**52,60%**
Space physics	139	173	230	**65,50%**
Solar physics	1	53	68	**NA**
Fundamental	0	10	31	**NA**
Total Physics	**140**	**236**	**329**	**135,00%**
Planetary	**38**	**47**	**63**	**65,80%**

(Data from the Lab Questionnaire "main research area" - Only the scientific Workforce has been considered.)

[2.12]

	Population	%age
France	364	20,6%
Germany	352	19,9%
UK	337	19,0%
The Netherlands	154	8,7%
Spain	148	8,4%
Italy	127	7,2%
Switzerland	91,05	5,1%
Sweden	71	4,0%
Other countries	125,05	7,1%
Total	**1769,1**	**100%**

(Data from the Lab Questionnaire "WF age distribution")

[2.13]

	Scientists	Engineers	Population
France	51,8%	48,2%	364
Germany	78,3%	21,7%	352
UK	56,7%	43,3%	337
The Netherlands	68,2%	31,8%	154
Spain	68,2%	31,8%	148
Italy	70,1%	29,9%	127
Switzerland	60,5%	39,5%	91,05
ESA countries	63,5%	36,5%	1769

(Data from lab Q WF distribution per RA)

[2.14]

	Permanent	Short Term/Renewable	Population
France	82,7%	17,3%	364
Italy	74,8%	25,2%	127
UK	67,4%	32,6%	337
The Netherlands	53,9%	46,1%	154
Spain	41,9%	58,1%	148
Germany	41,6%	58,4%	352
Switzerland	27,5%	72,5%	91,05
ESA Countries	60,4%	39,6%	1769,05

(Data from lab Q WF distribution per RA)

[2.15]

Country	87-92	92-97	97-02	Evolution
Spain	79	109	170	**115,2%**
Italy	60	85	110	**83,3%**
Germany	210	271,5	350,5	**66,9%**
UK	204	277	323	**58,3%**
France	307	354	453	**47,6%**
The Netherlands	96	114	132	**37,5%**

(Data from the Lab Questionnaire – "WF level by 5-years increment" – only countries with significant WF representation have been considered)

[2.16]

	<25	26-35	36-45	46-55	56-65	>65	
Total ESA	**6%**	**32%**	**32%**	**16%**	**13%**	**1%**	**1769,05**

(Data from the Lab Questionnaire – "Age Distribution")

[2.17]

	<25	26-35	36-45	46-55	56-65	>65	
Total Science	6,1%	34,7%	30,6%	14,7%	12,9%	1,0%	**1123,05**
Total Engineering	6,3%	26,9%	35,3%	17,6%	13,9%	0,0%	**646**

(Data from the Lab Questionnaire – "Age Distribution")

[2.18]

	Population	IQ based Mean Age	Correction	Corrected Mean Age
Hi energy	84	41,4	0,95	**39,4**
IR + sub mm	57	42,5	0,95	**40,4**
UV + Optical	33	42,0	0,95	**39,9**
Astro		**41,9**	0,95	**39,8**
Space physics	56	44,0	0,95	**41,8**
Solar physics	34	46,1	0,95	**43,8**
Fundamental physics	34	42,4	0,95	**40,3**
Physics		**44,1**	0,95	**41,9**
Planetary exploration	**52**	41,2	0,95	**39,1**

(Data from the Individual Questionnaire "Age" and "Main Research domain and from the scientists mean age 2.2)1.2 only the scientific workforce has been considered)

[2.19]

	<25	26-35	36-45	46-55	56-65	>65	Population
Total Permanent	4%	17%	36%	22%	21%	1%	**1068,55**
Total ST	10%	55%	27%	6%	2%	0%	**700,5**

(Data from the Lab Questionnaire – "Age Distribution")

[2.20]

	<25	26-35	36-45	46-55	56-65	>65	Total
France - Scientists	6%	31%	25%	12%	23%	2%	188,5
France - Engineers	3%	24%	31%	22%	19%	0%	175,5
France - Permanent	0%	20%	32%	21%	26%	1%	301
France - ST	27%	65%	8%	0%	0%	0%	63
France - Total	5%	28%	28%	17%	21%	1%	364

(Data from the lab questionnaire "age distribution")

[2.21]

	<25	26-35	36-45	46-55	56-65	>65	Total
Germany - Scientists	3%	36%	30%	15%	17%	0%	**275,5**
Germany - Engineers	4%	12%	44%	29%	11%	0%	**76,5**
Germany - Permanent	2%	7%	25%	31%	35%	1%	**146,5**
Germany - ST	3%	47%	39%	8%	2%	0%	**205,5**
Germany - Total	3%	30%	33%	18%	16%	0%	**352**

(Data from the lab questionnaire "age distribution")

[2.22]

	<25	26-35	36-45	46-55	56-65	>65	Total
UK - Scientists	16%	35%	27%	14%	6%	2%	191
UK - Engineers	14%	31%	33%	12%	10%	0%	146
UK - Permanent	16%	30%	29%	14%	10%	2%	227
UK - ST	15%	40%	32%	11%	3%	0%	110
UK - Total	15%	33%	30%	13%	7%	1%	337

(Data from the lab questionnaire "age distribution")

[2.23]

	<25	26-35	36-45	46-55	56-65	>65	Total
NL - Scientists	2%	35%	31%	13%	18%	0%	105
NL - Engineers	4%	27%	20%	16%	33%	0%	49
NL - Permanent	0%	6%	30%	23%	41%	0%	83
NL - ST	6%	63%	25%	4%	1%	0%	71
NL - Total	3%	32%	28%	14%	23%	0%	154

(Data from the lab questionnaire "age distribution")

[2.24]

	<25	26-35	36-45	46-55	56-65	>65	Total
Spain - Scientists	8%	38%	30%	19%	5%	1%	101
Spain - Engineers	11%	43%	36%	6%	4%	0%	47
Spain - Permanent	0%	15%	50%	27%	8%	0%	62
Spain - ST	15%	57%	19%	6%	2%	1%	86
Spain - Total	9%	39%	32%	15%	5%	1%	148

(Data from the lab questionnaire "age distribution")

[2.25]

	<25	26-35	36-45	46-55	56-65	>65	Total
Italy - Scientists	0%	29%	52%	11%	8%	0%	89
Italy - Engineers	0%	21%	61%	11%	8%	0%	38
Italy - Permanent	0%	4%	71%	15%	11%	0%	95
Italy - ST	0%	94%	6%	0%	0%	0%	32
Italy - Total	0%	27%	54%	11%	8%	0%	127

(Data from the lab questionnaire "age distribution")

[2.26]

	<25	26-35	36-45	46-55	56-65	>65	Total
Switzerland - Total	6	45	22	12	5	1	91

(Data from the lab questionnaire "age distribution")

[2.27]

	<25	26-35	36-45	46-55	56-65	>65	Total
Sweden- Total	0	24	20	13	14	0	71

(Data from the lab questionnaire "age distribution")

[2.28]

Period	Share
2003 - 2004	2,1%
2004 - 2005	3,6%
2005 - 2006	2,8%
2006 - 2007	4,3%
2007 - 2008	1,4%
2008 - 2009	2,1%
2009 - 2010	4,3%
2010 - 2011	2,1%
2011 - 2012	3,6%
2012 - 2013	2,8%
2013 - 2014	2,1%
2014 - 2015	3,6%

Period	Share
2015 - 2016	2,8%
2016 - 2017	2,5%
2017 - 2018	2,5%
2018 - 2019	2,5%
2019 - 2020	2,1%
2020 - 2021	3,2%
2021 - 2022	3,9%
2022 - 2023	3,2%
2023 - 2024	4,3%
2024 - 2025	5,7%
>2025	32,4%
Population	**281**

(Data from Individual Questionnaire "expected retirement year")

[2.29]

	<25	26-35	36-45	46-55	56-65	>65	Population
Global Workforce (Individual questionnaire-based) = X	**3%**	**27%**	**33%**	**20%**	**16%**	**1%**	**416**
Global Workforce (Institutional questionnaire-based) = Y	**6%**	**32%**	**32%**	**16%**	**13%**	**1%**	**1769**
Correction Factor = Y/X	**2,08**	**1,17**	**0,98**	**0,79**	**0,82**	**0,91**	
Instrument Designers and builders population (Individual questionnaire-based)	**5**	**71**	**110**	**77**	**64**	**0**	**327**
Instrument Designers and builders - Corrected population	**10**	**83**	**108**	**60**	**52**	**0**	**315**
Instrument Designers and builders - Corrected Distribution	**3%**	**26%**	**34%**	**19%**	**17%**	**0%**	

(Data from Individual Questionnaire "age", "Task achieved ten years ago", "tasks currently achieved" and competencies used" and from lab questionnaire "age distribution")

[2.30]

	<25	26-35	36-45	46-55	56-65	>65
PIs	1	1	13	12	13	0

(Data from Individual Questionnaire "age", "Task achieved ten years ago", "tasks currently achieved")

[2.31]

	Length of service <10 years	Length of service >10 years	Population
Global	54%	46%	**1812**
Science	59,9%	40,1%	**1146**
Engineering	43,9%	56,1%	**666**

(Data from lab Q distribution of WF according to seniority)

[2.32]

Number of flown instruments	Global
0-10	90,9%
10-20	7,6%
> 20	1,5%
Population	**407**

(Data from Individual Q ''number of flown instrument'')

[2.33]

	<10 years	>10 years	Population
France	45,6%	54,4%	**425**
Germany	68,7%	31,3%	**358**
UK	52,5%	47,5%	**341**
The Netherlands	57,8%	42,2%	**154**
Spain	58,5%	41,5%	**147**
Italy	32,3%	67,7%	**127**
ESA Global	**54,0%**	**46,0%**	**1812**

(Data from lab Q "Country" and "distribution of WF according to seniority")

[2.34]

Share of space in total Research Activity	**Global**	**Scientists**	**Engineers**
100%	**18,7%**	27,6%	40,3%
75% - 99%	**15,3%**	22,3%	28,6%
50% - 75%	**13,0%**	13,6%	10,4%
25% - 50%	**23,2%**	16,4%	10,4%
0% - 25%	**29,8%**	20,1%	10,4%
Population	**439**	**359**	**77**

(Data from Individual Q share of space related activity)

[2.35]

Number of current space projects	**Global**	**Scientists**	**Engineers**
0	30,6%	28,2%	43,3%
1-3	53,4%	54,1%	49,3%
> 3	15,9%	17,7%	7,5%
Population	**421**	**351**	**67**

(Data from IndividualQ nber of space projects currently involved in)

[2.36]

	Science	
	Population	**%age**
Ground Based Data Processing	162	66,9%
Software development	134	55,4%
Testing	94	38,8%
Sensor/detector technology	92	38,0%
Instrument system design	82	33,9%
Project planning and management	79	32,6%
On Board Data Handling	72	29,8%
International relations	71	29,3%
Team management	70	28,9%
Cal/Val	55	22,7%
Optics	55	22,7%
Financial management	54	22,3%
Proposition and project/mission design	50	20,7%
Total Population	**242**	

(Data from Individual questionnaire “field” and “K&S” use)

[2.37]

	Engineering	
	Population	%age
Instrument system design	32	54,2%
Testing	31	52,5%
Sensor/detector technology	29	49,2%
Ground Based Data Processing	24	40,7%
Digital electronics	23	39,0%
Software development	22	37,3%
Analog electronics	22	37,3%
Project planning and management	22	37,3%
System engineering/trade off management	19	32,2%
On Board Data Handling	18	30,5%
Mechanical engineering	17	28,8%
Team management	16	27,1%
Micro electronics	14	23,7%
Vacuum	12	20,3%
Cal/Val	12	20,3%
Total Population	**59**	

(Data from Individual questionnaire "field" and "K&S use")

[2.38]

	Population	Mean Age
Proposition and project/mission design	52	48,2
Financial management	58	48,1
Project planning and management	98	46,6
Team management	84	46,5
Optics	61	46,1
System engineering/trade off management	45	46,0
International relations	78	45,8
Cal/Val	65	45,1
Instrument system design	111	45,0
On Board Data Handling	90	44,4
Sensor/detector technology	118	44,3
Vacuum	47	44,3
Mechanical engineering	32	43,8
Testing	123	43,5
Analog electronics	56	43,4
Ground Based Data Processing	187	43,0
Micro electronics	31	42,5
Digital electronics	55	42,5
Software development	157	41,2

(Data from Individual questionnaire "Age" and "K&S use")

[2.39]

Age	Number of K&S used	Population
<35	4,2	75
36-45	5,9	110
46-55	6,1	61
55-65	6,7	48

(Data from Individual Questionnaire "Age" and "K&S use")

[2.40]

	Nber User	Nber Transfer	Transfer rate
Ground Based Data Processing	186	144	77,4%
Software development	156	119	76,3%
Sensor/detector technology	121	86	71,1%
Testing	125	78	62,4%
Instrument system design	114	77	67,5%
On Board Data Handling	90	59	65,6%
Project planning and management	101	53	52,5%
Team management	86	49	57,0%
Cal/Val	67	47	70,1%
International relations	80	46	57,5%
Optics	62	45	72,6%
Proposition and project/mission design	54	38	70,4%
Financial management	60	32	53,3%
Analog electronics	58	31	53,4%
System engineering/trade off management	45	29	64,4%
Digital electronics	56	29	51,8%
Vacuum	47	24	51,1%
Mechanical engineering	33	19	57,6%
Micro electronics	41	14	34,1%

(Data from Individual questionnaire "K&S use" and "K&S transfer")

[2.41]

Tranfer Mean	Total
Working with peers	725
Supervision	526
Publication	395
Teaching	149
Other	101

(Data from individual questionnaire "transmission mean"

[2.42]

Tertiary Education Teaching	Share	Total Population
Global	**52,02%**	**396**
Scientists	58,28%	326
Engineers	22,86%	70

(Data from Individual questionnaire "teaching")

[2.43]

	Mean age of the workforce involved in tertiary education
Scientists	44,6
Engineers	42,3
Global	**44,4**

(Data from Individual questionnaire "teaching")

[2.44]

Number of flown instruments	**Share of workforce involved in tertiary education**
0-10	87,1%
10-20	10,8%
>20	2,1%
Population	**194**

(Data from Individual Questionnaire "number of flown instrument" and "involvement in tertiary education"

[2.45]

Number of current space projects	**Share**
0	22,1%
0-3	57,8%
>3	20,1%
Population	**199**

(Data from Individual Questionnaire "number of current space project" and "involvement in tertiary education"

[2.46]

Monthly involvement	**Share**
<1h/month	5,2%
1 - 10h/month	39,6%
10 - 20h/month	28,1%
>20h/month	27,1%
Population	**192**

(Data from the individual questionnaire "contact hours")

ANNEX

Annex A: Individual questionnaire and number of inputs for each question

Annex B: Institutional questionnaire and number of inputs for each question

Annex C: List of institutions that participated to the institutional questionnaire

Annex D: Terms of reference of the study

Annex E: List of ESSC members (April 2003)

ANNEX A. INDIVIDUAL QUESTIONNAIRE

1- Personal Information

Who are you?

	Number of Valid Answers
Organisation	**442**
Country	**442**
Age	**438**
Gender	**440**

What is your academic qualification?

Number of Valid Answers: **440**

LIST
Doctor
Ph. D student
Graduate (Five Year University diploma)
Undergraduate (Up to 4 Year University diploma)

In which field?

Number of Valid Answers: **439**

LIST
Science - Astronomy
Science - Physics
Science - Other
Engineering - Mechanics
Engineering - Electronics
Engineering - Software
Engineering - System
Engineering - Other

2- Professional Information

What is the share of space-related projects (scientific payload/instrument) in your total research time?

Number of Valid Answers: **439**

LIST
0% - 25 %
25% - 50%
50% - 75%
75% - 99%
100%

Please indicate in how many approved space sciences payload you have been involved in, as Principal Investigator or Co-Investigator.

Number of Valid Answers: **407**

LIST
<10
10-20
20-30
30-40
>40

Please indicate in how many on-study space sciences payload projects you are currently involved in, as Principal Investigator or Co-Investigator.

Number of Valid Answers: **421**

LIST
0
<3
3-5
>5

What is your space research area?

Number of Valid Answers – Main area: **420**

		Main Area (Tick one box)	**Secondary area(s) (Tick one or several boxes)**
Astronomy	High energy (Including cosmic rays)		
	UV + Optical		
	IR + sub mm (including radio astronomy)		
Solar System	Space physics		
	Solar physics		
	Planetary exploration		
Fundamental physics	Fundamental physics in space		

Are you, or were you, involved in other space science area(s) (e.g. Earth observation, life science,…)?

Number of Valid Answers: **412**

LIST
yes
No

If yes, please specify

What position are you holding?

Number of Valid Answers: **439**

LIST
Permanent post
Short term contract/Third party
Retired

If you hold a permanent post, in what period do you expect to retire?

Number of Valid Answers: **281**

LIST
2003-2004
2004-2005
2005-2006
…
>2025

If you hold a short term contract, what is its expected duration?

Number of Valid Answers: **161**

LIST
1
2
3
…
>8

If you are retired, are you still active?

Number of Valid Answers: **6**

LIST
Yes
No

Regarding to payload/instrument projects, which task were you doing ten years ago (if relevant), and which task are you doing today?

Number of Valid Answers – Task 10 Years ago: **237**
Number of Valid Answers – Task assumed today: **170**

	Task assumed 10 years ago (tick one box)	**Task(s) assumed today (tick one or several box(es))**
Project Manager Principal Investigator		
Payload conception Instrument design Software/data processing design Testing/validation		

3- Formal teaching activities.

Are you involved in formal educational activities (Graduate level teaching, mentoring, Ph D supervising)?

Number of Valid Answers: **398**

LIST
yes
No

If yes, please specify:

Discipline	**Institution**	**Contact hours**
		LIST *<1h/month* *1 - 10h/month* *10 – 20h/month* *>20h/month*

4- Comments

What are, in your opinion, the main obstacles regarding career evolution in the space science arena? (Optional)

In your opinion, what are the best ways of maintaining instrument builders' competences? (Optional)

5- Optional questions related to knowledge.

Some competences and skills have been listed in this part of the questionnaire, please indicate the ones that are necessary to assume your position, and how you are transferring these to the next generation.

Number of Valid Answers: **304**

	Tick the box if you use and apply knowledge in that area.	Are you transferring this knowledge	If yes, please indicate how (tick one or several box(es)	If "Other", please specify how.
On board Data handling		LIST: *yes* / *No*	*Supervising* / *Formal teaching* / *Publications* / *Working with peers* / *Other*	TEXT
Ground Based Data Processing		Id.	Id.	Id.
Software development		Id.	Id.	Id.
Analogical electronics		Id.	Id.	Id.
Digital electronics		Id.	Id.	Id.
Micro electronics		Id.	Id.	Id.
Sensor/detector technology		Id.	Id.	Id.
RF design		Id.	Id.	Id.
Optics		Id.	Id.	Id.
Power management		Id.	Id.	Id.
Control engineering		Id.	Id.	Id.
Propulsion		Id.	Id.	Id.
Micro mechanics		Id.	Id.	Id.
Mechanical engineering		Id.	Id.	Id.
Orbital Mechanics		Id.	Id.	Id.
Scientific operations design		Id.	Id.	Id.
Thermal engineering		Id.	Id.	Id.
Cryo engineering		Id.	Id.	Id.
Vacuum		Id.	Id.	Id.
Proposition and project/mission design		Id.	Id.	Id.
CalVal		Id.	Id.	Id.
Instrument system		Id.	Id.	Id.

design				
System engineering/trade off management		Id.	Id.	Id.
Testing		Id.	Id.	Id.
Project planning and management		Id.	Id.	Id.
Team Management		Id.	Id.	Id.
Financial management		Id.	Id.	Id.
Project monitoring (indus phases)		Id.	Id.	Id.
International relations		Id.	Id.	Id.
Other 1		Id.	Id.	Id.
Other 2		Id.	Id.	Id.
Other 3		Id.	Id.	Id.

ANNEX B. INSTITUTIONAL QUESTIONNAIRE

1- Basic Information

	Number of Valid Answers
Laboratory denomination	**67**
Country	**67**

Please indicate in how many approved space sciences payload your research unit/labortory has been involved in, at the Principal Investigator level, in the last 15 years.

Number of Valid Answers: **64**

LIST
<10
10-30
30-50
50-70
>70

Please indicate in how many space sciences payload projects your research unit/labortory is currently involved in, at the Principal Investigator or Co-Investigator levels.

Number of Valid Answers: **67**

LIST
0
<3
3-6
6-9
>9

2- Space science workforce

What is the share of space-related projects (scientific payload/instrument) in the total research effort of your research unit/labortory?

Number of Valid Answers: **67**

LIST
0% - 25 %
25% - 50%
50% - 75%
75% - 99%
100%

Please estimate, to the best of your ability and separating the permanent posts from the short term/renewable contracts, the average workforce that were or had been involved in payload/instrument design (inc. software and testing) for the proposed 5-year increments.

Number of Valid Answers: **66**

Period	Scientific workforce (Dr., post doc, PhD student, research assistant,…)		Technical workforce (engineers)	
	Permanent	Short term/renewable	Permanent	Short term/renewable
1987-1992	Number	Number	Number	Number
1992-1997	Number	Number	Number	Number
1997-2002	Number	Number	Number	Number

Which, in the following propositions, is the main space research area in which your research unit/labortory is involved in? What is the distribution of the workforce regarding to space research areas? Please also indicate if your research unit/labortory holds a particular strength/best practice (a well established area of expertise, e.g. dust particle detectors, magnetometers,…)

Number of Valid Answers – Main area: **64**
Number of Valid Answers - Workforce: **58**

		Main space area (Tick one box)	Scientific workforce		Technical workforce		Particular strength/B practice
			Permanent	Short term/renewable	Permanent	Short term/renewable	
Astronomy	High energy (Including cosmic rays)		Number	Number	Number	Number	Text
	UV + Optical		Number	Number	Number	Number	Text
	IR + sub mm (inc. radio astronomy)		Number	Number	Number	Number	Text
Solar System	Space physics		Number	Number	Number	Number	Text
	Solar physics		Number	Number	Number	Number	Text
	Planetary exploration		Number	Number	Number	Number	Text
Fundamental physics	Fundamental physics in space		Number	Number	Number	Number	Text

Please indicate the distribution of the workforce currently involved in payload/instrument design (inc. software and testing) according to their age.

Number of Valid Answers: **64**

	Scientific workforce		**Technical workforce**	
	Permanent	**Short term/renewable**	**Permanent**	**Short term/renewable**
<25 y.o.	Number	Number	Number	Number
26 - 35 y.o.	Number	Number	Number	Number
36 - 45 y.o.	Number	Number	Number	Number
46 - 55 y.o.	Number	Number	Number	Number
56 -65 y.o.	Number	Number	Number	Number
>65 y.o.	Number	Number	Number	Number

Please indicate the distribution of the scientific and technical workforce according to their length of service.

Number of Valid Answers: **64**

	Scientific workforce		**Technical workforce**	
	Permanent	**Short term/renewable**	**Permanent**	**Short term/renewable**
<10 years.	Number	Number	Number	Number
>10 years.	Number	Number	Number	Number

3- Comments

What are, in your opinion, the main hurdles regarding career evolution in the space science arena?
(Optional)

In your opinion, what are the best ways of maintaining the instrument builders' competences?
(Optional)

ANNEX C. LIST OF PARTICIPATING INSTITUTIONS

Country	Institution	Town
Austria	Space Research Institute/AAS	Graz
Belgium	Laboratoire de Physique Atmosphérique et Planétaire	
Belgium	Centre Spatial de Liege	Angleur
Belgium	Vito	Mol
Denmark	Dept. Physics and Astronomy	Aarhus
Finland	Metsahovi Radio Observatory	Kylmala
Finland	MilliLab - Millimetre Wave Laboratory of Finland	Espoo
Finland	Observatory, University of Helsinki	Helsinki
Finland	University of Helsinki, Department of Physical Sciences	Helsinki
Finland	VTT	Espoo
France	Institut des Sciences Nucleaires	Grenoble
France	Centre d'Etude Spatiale des Rayonnements	Toulouse
France	Institut d'Astrophysique Spatiale	Orsay
France	Laboratoire de l'Accélérateur Linéaire	Orsay cedex
France	Centre de Spectrometrie Nucleaire et de Spectrometrie de Masse (CSNSM)	Orsay campus
France	Laboratoire de Planétologie de Grenoble	Grenoble
France	Institute for Radiation Protection and Nuclear Safety	Fontenay-aux-Roses
France	CEA/SERVICE D'ASTROPHYSIQUE	Gif sur yvette cedex
France	GEPI (UMR 8111 du CNRS)	Meudon
France	CNRS/IPSL/Service d'aéronomie	Verrières le buisson
Germany	Astrophysical Institute Potsdam	Potsdam
Germany	University of Hannover - Institut für Atom- und Molekülphysik	Hannover

Germany	University of Siegen, Dept. of Physics	Siegen
Germany	University of Wuppertal, Dept. of Physics	Wuppertal
Germany	Max-Planck-Institut für extraterrestrische Physik	Garching
Germany	Institute for Experimental Physics	Duesseldorf
Germany	Max-Planck-Institute for Aeronomy	Katlenburg-lindau
Germany	Max-Planck-Institute for Chemistry	Mainz
Germany	Institut für Astronomie und Astrophysik, Abt. Astronomie, Univers. Tübingen	Tübingen
Germany	Kiepenheuer-Institut fuer Sonnenphysik	Freiburg
Germany	Astrophysical Institute	Jena
Germany	I. Physikalisches Institut der RWTH B	Aachen
Germany	Dr. Remeis Observatory, Astronomical Institute University Erlangen-Nuernberg	Bamberg
Germany	Astronomisches Institut der Ruhr-Universität Bochum	Bochum
Germany	Institut fuer Planetologie	Muenster
Ireland	Dublin Institute for Advanced Studies	Dublin
Italy	G31 Observational Cosmology	Rome
Italy	Fisica dello Spazio Interplanetario	Roma
Italy	"Cosmic Physics Laboratory" at INAF - Osservatorio Astronomico di Capodimonte	Napoli
Italy	Osservatorio Astrofisico di Catania - INAF (Istituto Nazionale di Astrofisica)	Catania
Italy	laboratory for Infrared optics	Padova
Norway	Norwegian Defence Research Establishment (FFI)	Kjeller
Norway	Institute of Theoretical Astrophysics, University of Oslo	Oslo
Spain	CIEMAT	Madrid

Spain	Instituto Universitario de Microgravedad "Ignacio da Riva" (IDR/UPM)	Madrid
Spain	Departament of Astronomy and Meteorology. University of Barcelona	Barcelona
Spain	Institut d'Estudis Espacials de Catalunya	Barcelona
Spain	Space Sciencies & Electronics	Madrid
Spain	LAEFF - INTA	Madrid
Spain	Instituto de Astrofísica de Canarias	La laguna
Sweden	Stockholm Observatory	Stockholm
Sweden	Swedish Institute of Space Physics	Kiruna
Switzerland	INTEGRAL Science Data Centre	Versoix
Switzerland	Geneva Observatory	Sauverny
Switzerland	PMOD / WRC	Davos dorf
Switzerland	ETH Zurich, Isotope Geology	Zurich
Switzerland	Space Research and Planetology of University of Bern, Physikalisches Institut	Bern
The Netherlands	Leiden Observatory	Leiden
The Netherlands	SRON	Utrecht
UK	Rutherford Appleton Lab	Didcot
UK	University of Sussex, Space Science Centre	Brighton
UK	Mullard Space Science Laboratory, University College London	Dorking
UK	Space Physics Group	London
UK	Atmospheric, Oceanic and Planetary Physics	Oxford
UK	Astronomy INstrumentation Group	Cardiff
UK	Institute for Gravitational Research	Glasgow
UK	School for Physical Sciences	Canterbury

ANNEX D. TERMS OF REFERENCE OF THE STUDY

Summary

ESA's Directorate of the Science Programme (D/SCI) invited the ESSC-ESF to carry out a study on "Space science demography in Europe: status, perspectives, proposals". This invitation was originated by a letter to D/SCI from R. Bonnet, CNES Deputy Director General for Science, outlining his concerns regarding the situation of the space science community in France. Since then, the initiative was supported by ESA's Science Programme Committee delegations, which were asked to comment before the invitation was sent to ESSC-ESF. An interim perspective is requested by the end of September 2002.

Background

On 10 April 2002, ESA's Directorate of the Science Programme (D/SCI) invited the ESSC-ESF to carry out a study on "Space science demography in Europe: status, perspectives, proposals". This request was triggered by a letter from R. Bonnet to D. Southwood, raising the worrying situation of the space science community in France and, more specifically, to the ageing and retirement of a whole generation of scientists that was actively involved in the first 40 years of space research. CNES addressed the fact that the expertise and know-how this generation developed, in particular in terms of instrument design and development (role of PIs), seems not to have been transferred to the new generation of young scientists (several possible reasons were invoked).

Prior to sending an official invitation to ESSC-ESF, D/SCI presented the concept of this study to the delegations of ESA's Science Programme Committee (SPC), whose answers ranged from positive to enthusiastic; in the cases where discussion was required, evolution was consistently in the direction of more support to the initiative. Hence this exercise is expected to receive full support from ESA delegations, in particular in supplying the available national statistical elements required to conduct such a study.

A first meeting took place on 3 May, 2002 in Paris, ESA HQ, to discuss the details of the study. Attending this meeting were : G. Cavallo (ESA D/SCI); L. Culhane (ESSC-ESF); D. Southwood (ESA D/SCI); J.-C. Worms (ESSC-ESF). An interim perspective (i.e. modus operandi, general framework and first findings) is requested by D/SCI to be available by the end of September 2002.

Objectives

The ESA Director of Science has proposed the following guidelines for this exercise.

1. The study should start from a statistical analysis, Member State by Member State, of the age distribution of space scientists, broadly categorised by skills (ranging from academic level, project scientists and PIs, down to technician level). Although the global age distribution has value in itself, D/SCI's major concern is the age distribution of instrument builders. Once the age distributions have been assessed, their origins should be investigated country by country. It is especially for this part of the exercise that the support of the SPC delegations was asked for and obtained.
2. The analysis will most probably evidence the fact that we are facing in Europe a very diverse situation. Different countries might show wholly different problems. This

would lead us to conclude that there are different perspectives both in the short, medium and long term range. However, it is not excluded that a general picture for Europe will emerge, by properly weighting the various inputs.

3. Actions should then be proposed. These might be taken at national level, ESA level, European level; they might have an official and unofficial character; they might involve personnel engineering and/or technical support. As examples of the various available tools, one can list recommendations to Ministries of Research, improving staff mobility among Member States, creating knowledge bases for experimental know-how, transferring skills to industry and between institutes.

Modus operandi

- set up a steering group (SG) for the exploitation of the Member States statistics and the production of subsequent advice; the SG could comprise representatives from the relevant ESF standing committees
- set up a data analysis framework, based on the study requirements
- hire a part-time project assistant to (i) collect the data and put it in a form suitable for analysis, and (ii) conduct a bibliographic survey of existing –and recent – works related to the study topic
- collect relevant statistics from ESA Member States and, where appropriate, identify supplementary institutional targets for data collection
- invite ESSC members to carry out or support related inquiries at their national level
- organise meeting(s) of the SG to analyse the data and produce recommendations
- present an interim report on the status of development of this initiative to ESA D/SCI and to ESSC plenary meeting (September 2002)
- present a final report to ESA D/SCI during the first term of 2003

Steering Group

It is envisaged to hold two 1-day meetings of the SG. Preparation for those meetings, as well as the draft process for the final report, will make an extensive use of electronic mail. Furthermore, this SG can make use of existing meetings (e.g. ESSC plenary).

The SG's composition is:

- L. Culhane (ESSC, UK)
- I. Butterworth (Imperial College, UK, ESF PESC representative)
- P. Ehrenfreund (ESSC, Netherlands)
- J. Farrow (ISU)
- J.M. Mas-Hesse (LAEFF, Spain)
- S. Mehlert (ESF)
- J.L. Puget (ESSC, France)
- S. Vitale (ESSC, Italy)
- N. Walter (Project Assistant)
- J.-C. Worms (ESSC)
- J.C. Zarnecki (Open University, UK).

Schedule

ESSC-ESF will initiate this activity in August 2002. The first meeting of the planning group will take place no later than mid-September 2002.

It is expected that the overall duration of this project will not exceed 8 months. The report to ESA D/SCI could thus be made available in April 2003.

ANNEX E. LIST OF ESSC MEMBERS (APRIL 2003)

Gerhard Haerendel, IUB, Bremen, Germany (Chairman)

Daniel Beysens, CEA Pessac, France
Bernard Billia, L2MP-CNRS, Marseille,France
Peter Cargill, Blackett Laboratory, Imperial College, London, United Kingdom
Bruno Carli, IFAC-CNR, Firenze, Italy
Augusto Cogoli, Space Biology Group, ETH Zürich, Switzerland
Angioletta Coradini, IFSI-CNR, Roma, Italy
Pascale Ehrenfreund, Leiden Observatory, Leiden, Netherlands
Jean-Louis Fellous, IFREMER, Issy-les-Moulineaux, France
Monica Grady, Natural History Museum, London, United Kingdom
Eberhard Grün, MPI Kernphysik, Heidelberg, Germany
Christine King, BRGM-ARN, Orléans, France
Hannu Koskinen, University of Helsinki, Helsinki, Finland
Wolfgang Lucht, PIK, Potsdam, Germany
Niels Lund, Danish Space Research Institute, Copenhagen, Denmark
Peter Norsk, Division of Aviation Medicine, Copenhagen, Denmark
Jean-Loup Puget, IAS Orsay, France
Ian S.Robinson, University of Southampton, United Kingdom
Kai-Uwe Schrogl, DLR, Köln, Germany
Martin J.L.Turner, University of Leicester, United Kingdom
Stefano Vitale, Università di Trento, Italy

Roger M.Bonnet, Paris, France (ex officio as COSPAR President)

Jean-Claude Worms (Executive Scientific Secretary), Illkirch, France
Svenje Mehlert (ESF Scientific Secretary), Strasbourg, France