Research councils and emerging fields of science: the case of nanotechnology

A comparative pilot study of Germany, the United Kingdom, The Netherlands and Norway

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Summary

This paper presents results of a pilot study that is part of my PhD project on intermediary organizations dealing with science. The pilot focuses on research councils and this paper will present and compare results to initial answers to three questions. What actions did the research councils take towards science? How did research councils become involved with nanotechnology? Did they adapt their respective internal organization in order to deal with nanotechnology and if so, why? The results will be put into the perspective of the workshop's suggestion that emphasis has shifted from 'organic' change towards policy driven change. Although I agree that there has been such a change, this pilot shows that there is a twist to it where research councils are concerned.

Introduction

The central question driving this paper and the PhD project is: How do intermediary organizations respond to the emergence of a new field of science and what is the response's effect on both the new field and the intermediary organizations? When science is concerned, intermediary organizations are loosely described as those organizations that operate between a government and science (Meulen & Rip, 1994, p. 12; Meulen & Rip, 1998, p. 758). Examples include research councils, science funding organizations, and associations of universities or scientists. Such organizations often involve themselves or get involved when a new field of science emerges. An 'emerging field of science' here basically means an eventually large scale trend in science's content development as well as its institutional development. Examples of such fields are materials science, computer science, biotechnology and nanotechnology. The PhD project takes nanotechnology as its case. It is the most recent and still emerging field, hence offers an opportunity to catch the actions and non-actions of intermediary organizations in the act. Nanotechnology emerges in a context which differs in some ways from earlier decades that witnessed the rise of other fields. In two broad strokes: science has increasingly more been required to legitimate its funding requests in terms of gains to society. The end of the cold war era has shifted acceptable legitimation from military use towards social gains and in particular economic profit[1]. On the other hand nanotechnology also shows characteristics similar to earlier emerging fields. It is an interdisciplinary field of research and promises a wide range of applications.

The pilot presented in this paper is the start of first phase of the PhD project, which inventories a dozen countries. The pilot involved a document study of predominantly on-line source material. Websites of research councils, ministries, parliaments were explored, but also country reports from the European Network of Indicators Produces (a PRIME network) and the European Trend Chart on Innovation project. This method induces a disclaimer. There are

[1] See Sapolsky (1994), Guston(2000), Johnson (2004) and McCray(2005)

few on-line sources from the 1980s and roughly the first half of the 1990s. Some organizations have better on-line archives than others. The Research Council of Norway was revising its website which made parts of it unavailable. Due to the short period of time for this pilot, I was not able to retrieve other written sources to fill the gaps. Fortunately a number of sources provide some information about these early years of nanotechnology.

The four countries were selected to cover a broad range of national systems of research councils and science funding. Below follow country descriptions in terms of the organization of research councils and in terms of funding initiatives by these research councils as well as ministries. These sections answer the pilot's first question. The sections following the country descriptions will discuss the pilot's remaining two questions and this workshop's issues.

Norway

Norway currently has one research council, called the Norges forskningsråd (NFR; Research Council of Norway), which is the result of a merger of the five previously existing councils in 1993. After about eight years an international consortium evaluated its functioning, which lead to an internal reorganization in 2003. Currently, NFR's main task is funding of research. Next to that it has the task to provide policy advice on science and innovation, and the evaluation of Norwegian research[2]. Compared to the other four countries, NFR has a relatively strong position as an intermediary organization. One third of government spending on research runs through NFR or involves NFR for example as advisory body(DG Enterprise, 2004).

Norway has seen little explicit prioritized funding of nanotechnology. The only case is the launch of NFR's instrument of Large Scale Programs in 2003, when the program called Nanomat was one of the first of six funded programs. A Large Scale Program receives 100 M NOK (about 12,5 M euros) annually for a period of 5 to 10 years.

The Nanomat program not only seems to be NFR's first initiative in nanotechnology. It also seems to be the first time that nanotechnology was considered an interesting issue. I searched the archives of NFR's news magazine 'Forskning' which has an on line archive with issues dating back to 1993. Nanotechnology showed up for the first time in the first issue of 2002[3].

If the Nanomat program indeed is NFR's first action, then it is remarkable that it is a large scale program. The other five initial large scale programs cover territory that is quite familiar to Norway science and science funding practices: genomics, climate, clean energy, petroleum, aquaculture and computer science.

Germany

Germany has a rather complicated structure of science funding. It has a number of foundations and associations (Max Planck, Frauenhofer, Helmholz and Leibniz) that fund research institutes through basic funding only. Next to that, the Deutsche Forschungs Gesellschaft (DFG; German Research Foundation) provides grants through a number of instruments. In Germany freedom of scientific organization is anchored in its constitution (BMBF, 2005). This means that the DFG and the institute funding foundations are relatively free compared to other countries in spending their budgets. DFG's budget is provided by the

[2] See www.forskningsradet.no

[3] I used Google (10-3-2006) with the following searches:
nanoteknologi site:forskningsradet.ravn.no/bibliotek/forskning/
nanoteknologien site:forskningsradet.ravn.no/bibliotek/forskning/
NFR's international magazine was not on line available during data collection (beginning of March 2006)

Bundesministerium für Bildung und Forschung (BMBF; Federal Ministry of Education and Research). BMBF in addition has its own science funding instruments to achieve its targets in science policy. It may delegate management and administration to so called 'Projektträger', 'scientifically qualified' (BMBF, 2005, p. 25) project management agencies. These usually are existing organizations or departments within organizations. Finally, Germany is a federal nation in which each state can have its own Ministry and policies for science, education and innovation.

Germany is one of the well known early starters[4] in the field of nanotechnology. This is illustrated by the 1994 report of the Technologiezentrum of the Verein Deutscher Ingenieure (VDI-TZ; the Technology Association of German Engineers). Acting as a project management agency for BMBF, VDI-TZ produces a series of technology foresight reports and the 1994 report appeared in that series. In 1998 a follow-up report was written by the same author. (Bachmann, 1994, 1998)

Currently, DFG funds nanotechnology through a number of instruments. One salient action is the financing of three 'Subangström-Transmissions-Elektronenmikroskope' (SATEM), three high resolution Transmission Electron Microscopes (TEM) and two 'Rasterelektronenmikroskope' in 1998. (DFG, 1998) Although these tools are well known as tools for nanotechnology, DFG's press release did not mention that. It made clear that forty applications were backing these investments. As far as my sources go, this is typical for DFG in that it has never explicitly prioritized nanotechnology in a particular way but works primarily application driven.

This is different for BMBF which as of 1998 funded a number of Kompetenznetze (Networks of Competence) aimed at nanotechnology. Initially six networks for nanotechnology were launched (Bachmann, 1998, p. 125 - 127), later one other was added. At present, BMBF finances about 130 Networks of Competence.

United Kingdom

The United Kingdom currently has a system of eight[5] research councils plus the umbrella organization Research Councils UK (RCUK). In 1994 the then existing six research councils were reorganized into five councils and they were moved from the Department of Education and Skills to the Department of Trade and Industry (DTI)[6]. At the same time the post of Director General of the Research Councils and the Office of Science and Technology (OST) were established. OST was first located at the Cabinet office but later transferred to DTI (Hackmann, 2003, p. 80-82, 87). In due time following 1994, three new research councils were established and in 2002 RCUK was added. For this pilot I have restricted myself to the Engineering and Physical Sciences Research Council (EPSRC), since it is the biggest investing research council for nanotechnology. Still, the Biotechnology and Biological Sciences Research Council and the Medical Research Council also invest considerably compared to EPSRC (Science and Technology Committee, 2004, p. 39)

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[4] Other countries are Japan and the UK

[5] Arts and Humanities Research council (AHRC), Engineering and Physical Sciences Research Council (EPSRC), Particle Physics and Astronomy Research Council (PPARC), Biotechnology and Biological Sciences Research Council (BBSRC), Medical Research Council (MRC), Economic and Social Research Council (ESRC), Natural Environment Research Council (NERC), and the Council for the Central Laboratory of the Research Councils (CCLRC)

[6] The relocation of the research councils to DTI seems striking, compared to the other three countries where the research councils are the domain of the respective ministries for science. On the other hand, in these other three countries, innovation is a major topic for their ministries of science, whereas it is not in the UK.

The United Kingdom can be considered an early investor of nanotechnology because it had launched two programs by the end of the 1980s. In 1986 the National Physical Laboratory and DTI launched the National Initiative On Nanotechnology (NION). NION's aim was to promote awareness of nanotechnology. Its main parts were the Nanotechnology Forum and the Nanotechnology Strategy Committee. The former comprised 900 members from industry, academic institutes and government, and provided information on nanotechnology via conferences, mailings, a bi-annual newsletter and internet. Around 1991 DTI provided half a million pound to continue NION until March 1995. (PA Cambridge Economic Consultants & PA Technology, 1993; POST, 1996)

In 1988 DTI launched the LINK[7] Nanotechnology Programme (LNP). Initially, there was a budget of six million pounds over four years available to universities and public research institutes. One condition for funding was that matching private funds were found. In 1989 the then Science and Engineering research Council (SERC) joined the program and added one and a halve million pounds. One year later, the Defense Research Agency added 0.26 million pounds to one project. After the 1994 reorganization of the research councils SERC handed its participation over to EPSRC. When the last round of projects was funded in 1995/1996 the two councils had invested about five million pounds[8]. LNP's last projects were finished in 1999. (POST, 1996)

There was no follow up on the LNP and attention for nanotechnology seems to have faded until the UK Advisory Group on Nanotechnology Applications submitted its report to the Minister for Science and Innovation in 2002[9]. The report became known as the 'Taylor report' after the Advisory Group's chair and Director General of the Research Councils Dr. John Taylor. The Advisory Group notes:

> While the UK has excellent research credentials in nanoscience and nanotechnology, it lacks the coherent and coordinated national strategy for developing and applying the technology that characterises many of its leading industrial competitor nations. Partly as a result of this, much of UK industry has yet to respond to the challenge and to put in place its own R&D for nanotechnology.
> (2002, p. 6)

And of course, the report made several recommendations to change that situation.

One year later DTI launched the Micro and Nano Manufacturing Network (NMP), also called the MNT Manufacturing Initiative. Via this program DTI invests ninety million pounds over a period of six years. Fifty million for an applied research program and forty million for new and existing facilities, market development, access of industry to research and resources. Industrial applicants are required to provide fifty percent matching funding. DTI expects both the Regional Development Agencies and the research councils each to invest another 180 million pounds on nanotechnology over the period 2003-2009. (Science and Technology Committee, 2004)

In 2004 the parliamentary Standing Committee on Science and Technology criticizes especially DTI to have done 'too little, too late' as even its report's title makes clear. The Committee does not agree on the approach via the Regional Development Agencies, nor on combining efforts on microtechnology with nanotechnology. (Science and Technology Committee, 2004, p. 15)

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[7] LINK was and still is a DTI funding instrument that aims to support innovation through collaborative research of academia and industry.

[8] Another source mentions that DTI and SERC together invested about 11.5M pounds. (PA Cambridge Economic Consultants & PA Technology, 1993)

[9] I have no data on why the Advisory group was installed and by who.

The Netherlands

The structure of the Dutch research councils is cross-over between Norway and the UK. Formally there is one research council, viz. the Nederlandse Organisatie voor Wetenschappelijk Onderzoek (NWO; Netherlands Organization for Scientific Research). NWO, like NFR is the result of a merger operation. However, contrary to NFR, it was a gradual process in which earlier existing organizations kept their names and identities whereas they also became a division within NWO. One of these is the foundation Fundamenteel Onderzoek der Materie (FOM; Fundamental Research on Matter)[10], which currently funds all nanotechnology programs within NWO. Next to FOM also NWO's division of Technical Sciences, embodied by the Stichting Technische Wetenschappen (STW; Foundation for Technical Sciences) plays a role in the Dutch nanotechnology funding.

In terms of explicit targeting of nanotechnology the Dutch research council and ministries were not among the early investors. Nanotechnology was however noted as an interesting and promising new technology. In its 1995 strategy document NWO identified 'Mesoscopic physics or nanophysics'[11] (NWO, 1995, p. 21) as an example of an interesting trend but also explicitly not as a priority indication.

In 1996 the then existing Overlegcommissie Verkenningen (OCV; Consultative Committee on Foresight) published a report on the Dutch knowledge system. The report identified and reported on foresight exercises in about thirty areas and disciplines. Nanotechnology was also covered and ranked as an interesting area. The OCV recommended promoting nanotechnology via inter-disciplinary research themes linked to applications that have interesting potential in The Netherlands. (Meulen, 1996)

NWO's Division Chemical Sciences identified molecular nanosciences as one of four priority areas in 2001. It was announced that industry, government and NWO promised to fund a new program in this area (NWO, 2002, p. 29-30). I found no data on the follow up of this priority choice, but I assume it became obsolete with NWO's 2001 strategy document *Themes plus Talent* (NWO, 2001). Although the report identified nanotechnology as a theme area, it was not one of the top priorities. Not only was an amount far less than one tenth of the average per theme assigned to the nanotechnology theme, the annual amount decreased as well. (NWO, 2003) Top themes were System earth, Digitalization and Cultural heritage.

Nanotechnology received a major financial impulse in The Netherlands when the Ministry of Economic Affairs granted nanotechnology applications for BSIK support. The BSIK fund receives government income from sales of Dutch gas and is used to stimulate the Dutch economy through funding of knowledge infrastructure. For the latest call for applications a number of priority areas were identified, such as sustainable system innovation, information and communication technologies, high-grade use of space, microsystems- and nanotechnology, and finally the cluster of health, nutrition, genomics and biotechnology. The third round made about eight hundred million euros available for the period 2003-2010. In all 37 applications were granted. Among these were three applications in the area of nanotechnology: Biomade (7 million euros), MicroNed (28 million euros) and Nanoned (95 million euros)[12]. The Ministry of Economic Affairs delegated program control to STW.

In 2004 FOM identifies 'Nanophysics/nanotechnology' as priority area in its strategic plan 2004-2010, by simply adding it to its list of priority areas. Then running programs in

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[10] To be exact and to illustrate NWO's rather convoluted organization, NWO's Physics division used to delegate funding of physics to FOM. In 2003 a separate division for physics was founded, which has the same Executive Board as FOM.

[11] Freely translated from 'mesoscopische of nanofysica'

[12] http://www.senternovem.nl/bsik/ March 2006

other priority areas were transferred without change of content to the Nanophysics/technology area. FOM intends to spend three million euros annually on the new subfield. As a consequence of introducing the new priority, two other priority areas were merged into one and in view of future cutbacks FOM downgraded some priority areas in favor of the new area of Nanophysics/technology and two others.(FOM/GBN, 2004) Taken together this boils down to a policy reorientation to create space for nanotechnology.

How did the research councils become involved with nanotechnology?

In the introduction, three questions were introduced that drive the pilot study presented in this paper. How did research councils become involved with nanotechnology? Did they adapt their respective internal organization in order to deal with nanotechnology and if so, why? What actions did the research councils take towards science? The latter question is answered via the data presented above. The other two will be addressed in this section and the following.

Summarizing the previous sections: Germany is a well known early investor in nanotechnology, Norway on the other hand is a relatively late investor, The Netherlands are somewhere in between and shows a mixture of bottom-up or 'organic' change and policy driven change. The UK was an early starter but blamed by some for late and/or insufficient follow up. Most, if not all four research councils became involved via a bottom up development and some also became involved via a top down policy steering.

All councils have at least one instrument to fund individual projects via open competition, sometimes called 'Individual grants' (Germany and The Netherlands), 'free application' (UK) or 'Independent projects' (Norway). Since nanotechnology covers a wide range of themes, topics and disciplines it is likely that all councils fund nanotechnology via individual projects. Another instance of bottom up financing is where councils also launch instruments based on applications without identifying priorities in advance. In other words, open competition for programs. EPSRC uses this approach for their Networks instrument and DFG uses this approach for its Priority Programs instrument. In fact, DFG uses open competition without ex-ante prioritization for almost all its instruments.

Because of such bottom up developments, all research councils can show that they fund nanotechnology, if they are put to the test. This for example happened in the UK when the research councils were asked by the Standing Committee for Science and Technology to show how much money they had invested in nanotechnology. Another example is Gerd Bachmann's (1998) report *Innovationsschub aus dem Nanokosmos* (Innovation impulse from the nanokosmos). In both cases the 'collecting strategy' was to describe the area of nanotechnology, then collect from all instruments available all those grants that fit the description. In case of the UK, next to that all grants that carry the phrase 'nano' in the title and/or description were added to the list for one of three councils. These collection strategies result in somewhat substantial[13] total amounts invested in 'nanotechnology'.

It should be stressed here that the councils did not do this out of free will. Somebody put them to a test and then it was established that they did fund nanotechnology and to what extend. One can not say that they funded nanotechnology because they deliberately strived to do so. After all, open competition is not a strong means to prioritize[14].

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[13] Bachmann adds BMBF investments and planned investments over the period 1993 to 2001 to a total of 185 M DM. Bachmann makes a list of DFG actions, but adds no amounts to the list. (Bachmann, 1998, p. 94-97). Th UK research councils arrived at steadily increasing amounts starting from about 26 M Pounds around 1999 to 50 M Pounds around 2001. (Science and Technology Committee, 2004, p. 39)

[14] However, it may be pointed out that there are indirect prioritization processes going on. There may be intricate mechanisms in the review procedures worthy of further investigation. Secondly, developments in the science

Another route through which a few research councils became involved was via top down policy steering. The UK research councils were urged by the Director General of Research Councils to fund Interdisciplinary Research Collaborations for nanotechnology and bionanotechnology. In The Netherlands, STW, one of NWO's semi independent branches, was appointed as administrative body to control the NanoNed program.

Government policy initiatives also bypassed the research councils. For example DTI's Micro and Nano Manufacturing Network operates through DTI and the UK's regional development agencies. In Germany, BMBF's Networks of Competence are administered by the VDI-TZ.

Finally, I found only a few cases where research councils opened funding space explicitly for nanotechnology. The Norwegian Large-scale research programs (launched in 2003) with the NANOMAT program might[15] be an example. The second example consists of NWO's 'themes and talents' initiative that included the theme nanotechnology. This however hardly counts since NWO planned nanotechnology to be a relatively small theme and it proved difficult to raise funds for nanotechnology. The last example, also from The Netherlands, is FOM's 2004 strategic choice for nanotechnology in 2004, although this then was little more than re-labeling a number of already existing programs.

Concluding, the four research councils mainly became involved because of other powers that be, viz. scientists and governments. As a priority setting body they were bypassed by both science and government, in other words by both layers that they intermediate.

Research councils' internal organization and adaptation

Did the research councils adapt their respective internal organization in order to deal with nanotechnology and if so, why? This is the third question of the pilot. After the conclusion of the previous section this question hardly makes sense since the research councils did not do that much. However, one or two remarks can be made.

In the first place, where research councils funded nanotechnology through open competition without ex-ante prioritization it should be noted that these instruments were indeed fit to finance nanotechnology because of their open character.

Secondly, I found no internal reorganization that - based on my sources - could be attributed directly to the emergence of nanotechnology. However, strikingly, in some cases where a research council did take action in the field of nanotechnology, it used a relatively new instrument. See NFR's large scale program, where nanotechnology was among the first. See also NWO's 'themes and talents' which also included nanotechnology from the start. The last example are the UK Interdisciplinary Research Collaborations for nanotechnology and bionanotechnology. Besides being new, these instruments also have in common that they explicitly address an interdisciplinary approach which fits with descriptions of nanotechnology as an interdisciplinary field.

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layer may constitute a de facto prioritization or indirect prioritization. After all, what goes on in the science layer is in part determined by earlier research councils' actions.

[15] I am not entirely sure, because the instrument's website does not specify exactly how the funded programs were selected.

Where research councils[16] did finance nanotechnology, the existing organizational structures were and currently are in place. In some cases, one can at least suspect that the emergence of nanotechnology was a trigger to start a new instrument. For the time being, I hypothesize that in the early and mid 1990s research councils had no instruments at hand to prioritize nanotechnology on a large scale. Since then, instruments like network funding and later centers of excellence funding have made that possible.

Science and change

Having answered the pilot's research questions, it is now time to put the findings into the workshop's perspective. The data presented in the sections above at least shows that there were and are government initiated attempts to policy driven change of science's agenda towards nanotechnology and issues that nanotechnology seems to address, viz. innovation and cooperation between science and business enterprises. See for example the UK DTI initiatives of the LINK Nanotechnology Programme and the Micro and Nano Manufacturing Network, and the German Competence Networks for nanotechnology. The data that I used can only show a recent state of affairs. It can not show a shift towards policy driven change, because it only covers the last fifteen years and within this period I see no change in the data.

Yet, on the other hand, there also are bottom up developments such as the The Netherlands NanoNed application, and the application driven DFG's investments in instruments. Next to that there are the numerous applications of projects and (less numerous) programs that could be filed under nanotechnology, as addressed above. Due to a lack of data on this, I can not tell if there was a change in these bottom up developments.

In one case, I encountered evidence of a research council's strategic shift towards more program based funding in the course of the 1990s. This one case was NWO in The Netherlands. I stumbled upon this data and did not check for similar developments in the other countries. However, Hackmann (2003, p. 80) observes that until at least the mid 1990s there was a virtual absence of national priorities in the UK. Some of her interviewees claimed that the Technology Foresigh Programme in 1994 was the first occasion, others point at the publication of the science budget for 2001.

The workshop also addresses the issue of change of the functions and structural position of research intermediaries. As far as the presented data goes, I found little evidence of change of functions of the research councils: their dominant function has been and still is funding science. One exception might be that NFR ever since its founding has had the task to evaluate Norwegian research. Since the last reorganization it also has a policy division for innovation besides a division for science funding.

When it comes to the research councils' structural position, the bypassing of the councils as noted above calls for an explanation. After all, if the research councils are acknowledged experts in the art of science funding, then why are they little involved in major policy initiatives? As far as the explanation lies within Ministries, I can not answer the question because I am not investigating the Ministries. Another part of the explanation may rest within the research councils. The question would then be why do they not take their own initiatives in nanotechnology? Here follow some answer these questions.

The first answer calls the question into question. The research councils do take initiatives. However, they have just started as the examples of the Norwegian Large Scale Research Programs and FOM's strategic choices show. Given more time, one will see more initiatives

[16] Does this also hold for government initiatives?

on the part of the research councils. A counter to this argument would be that, if so then they are late. It would make research councils followers of trends, rather than trendsetters. Moreover, it still leaves the question open for the early period of about ten to fifteen years[17]. It would be interesting to compare their dealings with nanotechnology to their dealings with earlier (then) upcoming new fields of science, such as for example materials science, biotechnology or computer science[18].

The second answer would be that research councils' budgets and earlier policies do not allow a fast change of course. Their budgets usually are partly labeled by the councils' respective sponsors. The budget parts that research councils may spend on their own account are in part determined by earlier commitments. Illustrative here is FOM's priority switch towards nanotechnology because it started with a mere to re-location of existing programs to the new priority, rather than redirecting budgets.

The Dutch NWO in 2001 tried to break away from these restrictions by new prioritizations through themes and funding of individuals (talents), assuming that the expansion of budget would be provided by their main sponsor. Unfortunately after three years NWO had to conclude that the sponsor only or mainly sponsored the talents initiative, not the theme initiative. This would mean that research councils are under tight budgetary control, which in turn begs the question why are they?

A third possible answer to the question why did the research councils not take their own initiatives in nanotechnology may lie in their internal organization. One hypothesis of my PhD research holds that if the institutional structure of a research council would match that of the perceived structure of nanotechnology, then nanotechnology will be treated as business as usual. The other hypothesis is that if a research council is dominated by science, then it will more easily adapt itself to facilitate a new field of science. In light of these hypotheses it is striking that those policy choices that were made in favor of nanotechnology, were made in cases where a research council initiated a new instrument.

Taken together these answers imply a general observation that new emerging fields of science are problematic to the research councils' respective state of affairs, including organizational structures, ruling science and innovation policies, available instruments and distribution of budgets.

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[17] The data shows that research councils did not leave nanotechnology unnoticed in the late 1980s and early 1990s.

[18] It would be interesting, but may be not definitive because the older fields may have differed too much from nanotechnology and the social, economic and political background may have differed too much from the current situation.

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