



Vetenskapsrådet

INTERNATIONAL EVALUATION OF ONSALA SPACE OBSERVATORY



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August 31–September 3, 2009

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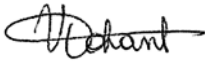
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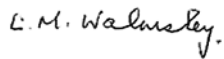
Ref: International Evaluation of Onsala Space Observatory

Hereby we submit the evaluation report for Onsala Space Observatory (OSO). The report is based on the background evaluation report (827-2009-439) and a site visit to OSO on September 1st, 2009.

Särö, September 3rd, 2009



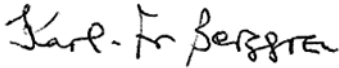
Véronique Dehant
Expert Panel



C. Malcolm Walmsley
Expert Panel



Anneila Sargent
Expert Panel



Karl-Fredrik Berggren
Chair



David Edvardsson
Secretary, Swedish Research Council

TABLE OF CONTENTS

I. PREFACE	7
II. SAMMANFATTNING	8
III. EXECUTIVE SUMMARY	10
1. BACKGROUND	12
2. THE SWEDISH RESEARCH COUNCIL AND THE NATIONAL FACILITIES	14
3. SHORT DESCRIPTION OF ONSALA SPACE OBSERVATORY	15
4. PANEL'S REPORT	18
4.1 Organization	19
4.2 Science 2006–2009	19
4.3 Technical 2006–2009	20
4.4 Community support 2006–2009	21
4.5 Education and outreach	21
4.6 The future of Onsala Space Observatory	22
APPENDIX 1. BACKGROUND OF EXPERTS	24
APPENDIX 2. TERMS-OF-REFERENCE	29
APPENDIX 3. TIMEPLAN	31
APPENDIX 4. QUESTIONNAIRE TO ONSALA SPACE OBSERVATORY	33
APPENDIX 5. ONSALA EXPENDITURE (2006–2009)	37
APPENDIX 6. LIST OF ABBREVIATIONS	38

I. PREFACE

The Swedish Research Council is a governmental agency with the responsibility to support basic research of the highest scientific quality in all academic disciplines. It is also part of the Council's remit to evaluate research and assess its academic quality and success.

The Council for Research Infrastructures at the Swedish Research Council has the overall responsibility to ensure that research infrastructures of the highest quality are expanded and exploited. Specifically, the Council advertises and evaluates applications, participates in international collaborations and works on monitoring and assessments. As part of the overall responsibility for research infrastructures the Council oversees and evaluates the two Swedish National Facilities – Onsala Space Observatory (OSO) and the MAX-laboratory.

In 2003 the Council decided on the level of operational support to OSO for the period 2004–2009. It was also decided that an international evaluation of the activities should be carried out by the end of that period to review the performance of the facility. The Council has therefore appointed an Expert Panel with the capacity to assess the research activities under evaluation in an international perspective. This report contains the findings and recommendations of the Expert Panel.

The members of the Expert Panel were Prof. Véronique Dehant, Royal Observatory of Belgium, Prof. Anneila Sargent, California Institute of Technology, USA and Prof. Malcolm Walmsley, Osservatorio Astrofisico di Arcetri, Firenze, Italy. Prof. Karl-Fredrik Berggren, Linköping University was appointed Chairman of the Expert Panel and Dr. David Edvardsson, Research Officer, Swedish Research Council acted as coordinator and secretary of the review.

The Swedish Research Council would like to express its sincere gratitude to the Expert Panel for devoting their time and expertise to this important task.

The Swedish Research Council would also like to thank the representatives of Onsala Space Observatory and Chalmers University of Technology for providing the necessary background material in a well written report and giving informative presentations and for their kind hospitality during the Panel's visit to the observatory.

Stockholm 2010-04-15



Lars Börjesson

*Secretary General, Council for Research Infrastructures
Swedish Research Council*



II. SAMMANFATTNING

Det är denna panels uppfattning att Onsala rymdobservatorium (OSO, Onsala Space Observatory) med stöd av sin partner Chalmers fyller en viktig funktion i Sverige. Onsala gör det genom att främja forskning och fostra nya generationer av astronomer, geodeter, geofysiker och ingenjörer samt genom att vara en samlande kraft för svenska intressen på olika områden inom astronomin och geodesin. Panelen har kommit fram till sin slutsats genom att studera de inlämnade dokumenten och genom att lyssna till presentationer från representativa delar av personalen. Sammanfattningsvis hjälper OSO till att hålla Sverige i den moderna forskningens front och att förse Sverige med nya generationer forskare.

Våra huvudsakliga slutsatser och rekommendationer – ej rangordnade – är följande:

- OSO sköter i dagsläget sitt stora antal uppdrag och projekt väl. Kvaliteten på forskningen och på publikationerna är hög och står sig väl i jämförelse med motsvarande institutioner i resten av världen. Det är emellertid vår uppfattning att OSO drivs av en arbetsstyrka som är under den kritiska nivån i storlek. De ökningarna i budgeten som inleddes 2004 har varit till stor hjälp, men har inte räckt för att göra mer än hålla jämna steg med de normala ökningarna av driftkostnaderna. Vi rekommenderar att kärnfunktionerna, 20- och 25-metersteleskopen och APEX (Atacama Pathfinder Experiment), bibehålls samt att nödvändig personal i form av astronomer, geodeter och ingenjörer anställs för att göra detta möjligt.
- Den tekniska utvecklingen inom gruppen för avancerad mottagarutveckling (GARD) vid Chalmers har varit bland OSO:s viktigaste prestationer under de senaste åren. Det är uppenbart att en stor del av OSO:s framgång hänger på att hitta en säkrare finansiering för denna grupp. Enskilda projekt kan föra med sig ekonomiskt stöd, men en grundläggande personalbudget som är stabil under åtskilliga år är kritisk för att programmet ska kunna fortsätta vara framgångsrikt på lång sikt. Panelen rekommenderar att sådana medel ställs till förfogande.
- Verksamheten inom geodesi och geofysik som varit baserad på en insats ”efter bästa förmåga” har varit mycket framgångsrik. Baserat på framstegen hittills rekommenderar panelen ett ökat stöd för geodesi och geofysik. Det gäller såväl finansiering som storleken på arbetsstyrkan, och att dessa aktiviteter officiellt införlivas i OSO:s uppdrag.
- Panelen ger sitt kraftfulla stöd till den begäran som OSO:s föreståndare lagt fram om ökat driftstöd. Panelen rekommenderar en gradvis ökning

av driftsstödet som efter fyra år bör uppgå till en ökning av minst 8,7 miljoner kronor. Med det ekonomiska stödet på denna nivå och med personalstyrkan på så sätt stabiliserad bör OSO:s ledning överväga att göra en mer formell strategisk plan för framtiden. En plan med noggranna prioriteringar för att ta steget in i en värld som lägger fokus på stora internationella projekt är nödvändig. Panelen berömmar de ansträngningar som gjorts till dags dato och som lett till att OSO ingår i ett antal spännande projekt, men det kan i det långa loppet krävas tuffa beslut för att ge bästa möjliga vetenskapliga utbyte för svenska investeringar. För att åstadkomma detta rekommenderar vi att föreståndaren tillsätter en rådgivande kommitté där representanter för alla relevanta intressenter ingår.

- För både astronomin och för geodetisk VLBI (Very Long Baseline Interferometry) är det viktigt med ett känsligt teleskop i själva Onsala. Det förstärker också OSO:s roll som fokus för en betydande del av den svenska verksamheten inom astronomi och geodesi. Med detta i åtanke och med tanke på ålder och status på de nuvarande instrumenten rekommenderar vi att man så snart som möjligt påbörjar en design- och utvecklingsstudie som ska leda till ett nytt teleskop i Onsala. Resultaten av denna studie kommer att vara en viktig del av OSO:s strategiska planering.
- Det verkar finnas hälsosamma länkar mellan å ena sidan OSO och Chalmers och å andra sidan svensk industri. Omnisys Instruments AB:s framgång med att få kontraktet för vattenångradiometrarna till ALMA (Atacama Large Millimeter Array) pekar på att det vore bra att satsa på en liknande proaktiv inställning till industrisamarbete inom området terahertzteknologi.
- Svenska astronomer kan spela en nyckelroll i stora internationella projekt. Det visar OSO:s tekniska bidrag till utvecklingen av europeisk VLBI, särskilt det nya, mycket imponerande och snabba dataöverföringsnätverket för e-VLBI (electronic VLBI). Panelen applåderar OSO:s inställning på det svenska samhällets vägnar och välkomnar fortsatta liknande samarbeten allt eftersom nya internationella faciliteter utvecklas.
- Det svenska deltagandet i ALMA och APEX bör fortsätta för att ge svenska och nordiska astronomer möjligheter att skörda frukterna från dessa projekt. Panelen ser placeringen av ARC (ALMA Regional Center) i Onsala som särskilt lägligt och något som borde befästa OSO:s ledarroll på detta område, inte bara i Sverige utan för alla nordiska och baltiska länder.
- Panelen noterar att den kombination av universitet och nationellt forskningscentrum, som OSO tillsammans med Chalmers utgör, har givit upphov till en mycket effektiv miljö att utbilda ingenjörer, astronomer och geofysiker i – forskare som kommer att vara en ovärderlig resurs i framtiden. OSO:s program för att engagera det omgivande samhället är också föredömligt. Allt bör göras för att försäkra sig om att dessa aktiviteter fortsätter på samma höga nivå.



III. EXECUTIVE SUMMARY

It is the opinion of the Panel, having considered the submitted documents and having heard presentations from a representative section of the staff, that Onsala Space Observatory, supported by its partner, Chalmers, is fulfilling an important function in Sweden both in promoting research, in rearing a new generation of astronomers, geodesists, geophysicists, and engineers, and in providing a focal point for Swedish national interests in various areas of astronomy and geodesy. In essence, OSO is helping to keep Sweden at the forefront of modern research and to provide the new generation of Swedish scientists.

Our main conclusions and recommendations are, in no particular order:

- OSO is currently managing its numerous commitments and projects well. The quality of research and publications is at a high level and competitive with similar institutions in the world. However, it is our perception that the facility is operating with a workforce that is below the critical level in size. The increases to the budget that began in 2004 have been very helpful but insufficient to do more than keep up with normal increases in operating expenses. We recommend that the core functions of the OSO – the 20 m and 25 m telescopes and APEX – be maintained and that the necessary support astronomers/geodesists/engineers be hired to enable this.
- Technical development activities in GARD have been among the most important achievements of the OSO/Chalmers group over the last few years. It is clear that much of the success of OSO hinges upon obtaining more secure funding for this group. While particular projects may bring with them supplemental financial support, a core personnel budget that can be sustained over a number of years is critical to maintaining a successful long term program. The Panel recommends that such funding be allocated.
- Activities in geodesy and geophysics, based on a “best effort” approach have been very successful. From the progress to date, the Panel recommends that support for geodesy and geophysics should be strengthened in terms of both funding and workforce size, and that these activities should be officially incorporated into the OSO mission.
- The Panel strongly supports the OSO Director’s request for increased operational funding. At a minimum, the increase should be 8.7 MSEK

over a 4-year period. With this level of funding and the manpower situation thus stabilized, the OSO leadership should consider more formal strategic planning for the future. A carefully prioritized plan for going forward in a world environment that places emphasis on large international projects is necessary. While the Panel applauds the efforts to date that have led to OSO involvement in a number of exciting projects, it may in the long run require hard choices to ensure optimum scientific returns for Swedish investments. To this end, we recommend that the Director appoints an advisory committee that includes representation from relevant stakeholders.

- For both astronomical and geodetic VLBI, the existence of a sensitive telescope at the Onsala site is important and enhances the role of OSO as a focus for a significant fraction of Swedish astronomy and geodesy activities. With this in mind, and taking into account the age and status of the current instruments, we recommend that a design and development study for a new telescope at Onsala should begin as soon as possible. The results of this study will be an important part of OSO's strategic planning.
- There appear to be healthy links between OSO/Chalmers and Swedish industry. The successful awarding of the Omnisys Instruments contract for the ALMA water vapour radiometers suggests that a similar proactive approach to industrial collaborations in the area of Terahertz technology should be pursued.
- OSO technical developments for European VLBI, especially the recent, very impressive, fast data transfer work for e-VLBI, also demonstrates the key role that Swedish astronomers can play in large international projects. The Panel applauds this approach by OSO on behalf of the Swedish community and welcomes continuing similar collaborations as new international facilities are being developed.
- The Swedish involvement in ALMA and APEX should be continued in order to allow Swedish and Nordic astronomers to “reap the fruits” of these projects. The Panel sees the locating of an ARC at Onsala as particularly opportune and should consolidate OSO's leadership role in this arena not just in Sweden but for all the Nordic and Baltic countries.
- The Panel notes that the OSO/Chalmers combination of university and national research facility has resulted in a very effective environment in which to educate the engineers, astronomers, and geophysicists who will be an invaluable resource in the future. The OSO public outreach program is also outstanding. Everything should be done to ensure that these activities continue at the same high level.



1. BACKGROUND

In 1994–1995 four research facilities, the The Svedberg Laboratory (TSL) at Uppsala University, the Manne Siegbahn Laboratory (MSL) at Stockholm University, the MAX-laboratory at Lund University and the Onsala Space Observatory at Chalmers Technical University, were by a decision of the Swedish Parliament established as National Facilities. The National Facilities are responsible for a unique concentration of equipment and competence in the country. They should serve as user facilities and provide the national and international user community with equipment for pursuing outstanding research. They should also channel Swedish international interest in their respective fields of responsibility. Their specific tasks are regulated via bilateral agreements between the respective facility and the Swedish Research Council (formerly the Swedish Natural Science Research Council).

The transformations of research facilities to National Facilities involved the transfer of funds from the host universities to the Swedish Research Council. In order to regulate the division of financial support and other responsibilities bilateral agreements were reached between the Swedish Research Council and the respective host universities for the National Facilities. The basic division of financial support is that the host university pays the rent including electricity and the Swedish Research Council pays for the operations. The host university acts as employer of the staff of the facility, while the Council supplies the overall scientific guidelines, monitors and periodically evaluates the ongoing activities. The host university is responsible for setting up a board for the facility, two of the members being proposed by the Swedish Research Council.

The first evaluation of the National Facilities was carried out in 1997 and resulted in the continued operation of all four facilities. Later, the facilities were evaluated again in 2002 by an international Review Panel. Overall this Panel was very positive about both the MAX-laboratory and OSO. A major conclusion was that the National Facility program had reached a critical point at which either the budget had to be increased substantially, or a restructuring phase had to start in order to reduce the number of operating facilities to match the available budget. The Panel positively commented on the efforts made by OSO to serve a wide national and international community. The scientific achievements were judged to be of excellent quality. It was the opinion of the Panel that the OSO facility has enabled many Swedish astronomers to make forefront contributions to astronomical research.

As a consequence of the recommendations given in the 2002 evaluation, the Swedish Research Council decided to phase out its support to TSL and MSL in order to give adequate funding to the remaining two laboratories MAX-laboratory and OSO. The termination of funding was made gradually over the period 2004–2006. Subsequently the funding from the Swedish Research Council to MAX-laboratory and OSO has gradually increased since 2004.

In 2007 so called mid-term evaluations of MAX-laboratory and OSO were carried out. Based on these reviews the Swedish Research Council decided on the level of financial support for the period 2007–2009. The increased funding from the Swedish Research Council during the period 2003–2009 has made it possible for OSO to mostly compensate for salary rises, cost due to inflation and the declining value of the Swedish crown but has given little room for increased activity.

2. THE SWEDISH RESEARCH COUNCIL AND THE NATIONAL FACILITIES

The Swedish Research Council has established a Council for Research Infrastructures. The Council has the overall responsibility to ensure that research infrastructure of the highest quality is expanded and exploited. Specifically, the Council advertises and evaluates applications, participates in international collaborations and works on monitoring and assessments. As part of the overall responsibility for research infrastructures the Council oversees and evaluates the two Swedish National Facilities – Onsala Space Observatory and the MAX-laboratory. The Council also decides, on a three-year contract period, the operation budget of the facilities.

In the figure below, the Swedish Research Council's funding for the operation costs of OSO are shown for the period 2000-2009.

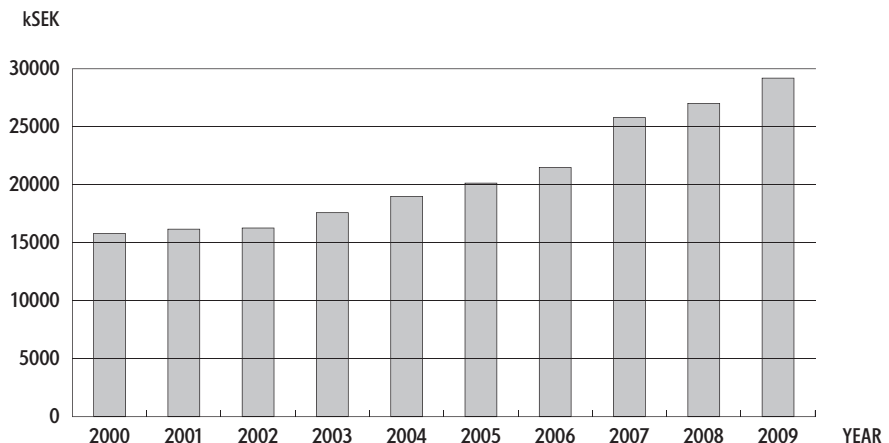


Figure 1.

Swedish Research Council operating grant for Onsala Space Observatory.

In addition to the operating grant, user groups and individual scientist can also apply for funding of scientific equipment.

The present evaluation of OSO will form the basis for the Council's decision on the level of support for the period 2010–2013. A parallel evaluation of the MAX-laboratory has been performed in May 2009. The Council has been responsible for the planning and execution of the review and in defining the terms-of-reference.

3. SHORT DESCRIPTION OF ONSALA SPACE OBSERVATORY

As a national facility the Onsala Space Observatory serves the Swedish astronomy community in different ways. One is to make available the OSO research infrastructure, give user support and supply observational data to Swedish research groups. Presently, out of a total of about 160 scientists pursuing research in astronomy¹ in Sweden about 60, from primarily Stockholm University, Chalmers/Gothenburg University and Uppsala University, have used the radio astronomy facilities at OSO. Another task for OSO is to serve as the Swedish node in international networks and collaborations as well as to be open to an inter-national community. OSO is also to promote applications of radio astronomy in other fields, *e.g.*, geodesy and geophysics and communications².

OSO is operated by Chalmers Technical University and is associated with the Department of Radio and Space Science (RSS) at Chalmers (see figure 2). There are particular strong links to the GARD group, the Group for Radio Astronomy and the Group for Space Geodesy and Geodynamics. Chalmers has appointed a Board for OSO and its constitution in 2009 was as follows:

Ivan Öfverholm	<i>chairman</i>
Hans Olofsson	<i>director</i>
Rüdiger Haas	<i>Chalmers University of Technology</i>
Göran Olofsson	<i>Stockholm University (representing Swedish Research Council)</i>
Krystyna Stiller	<i>Chalmers University of Technology</i>
Melvyn Davies	<i>Lund University (representing Swedish Research Council)</i>
Glenn White	<i>Open University & Rutherford Appleton Lab. (UK)</i>

OSO operates two telescopes at Onsala, a 25 m cm-wave telescope and a 20 m mm-wave telescope. It is one of three partners in the APEX project, a 12 m sub-mm telescope at 5100 m of altitude in the northern part of Chile, Llano Chajnantor; the others being the European Southern Observatory (ESO) and the Max-Planck-Institute für Radioastronomie in Bonn. Together with

¹ Estimate by OSO

² NFR: Dnr 405-331/99

research groups at Chalmers the observatory is in charge of the scientific investigations with the Odin satellite. OSO is also involved in the Herschel telescope project. OSO provides the channel through which Sweden is involved in large international radio astronomy projects such as the LOw Frequency ARray (LOFAR), the European VLBI Network (EVN), ALMA, and the Square Kilometer Array (SKA).

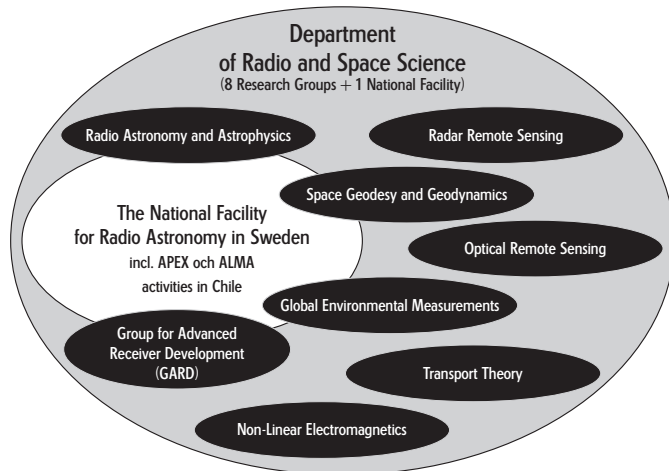


Figure 2.

*Onsala Space Observatory and the relation to the Department of Radio and Space Science at Chalmers*³.

Since the installation in 2009 of the superconducting gravimeter, OSO is now covering the three pillars of geodesy – geokinematics, gravity field and Earth rotation. Hence, OSO acts as a fundamental geodetic station serving both national and international research communities in geosciences with high quality observations by co-located sensor systems such as geodetic VLBI, Global Navigational Satellite Systems (GNSS), relative and absolute gravimetry, climatology and aeronomy.

³ Onsala report Dnr RR 2009/10.

The figure below shows how the different activities at OSO are reflected in the number of publications from 2006-2009.

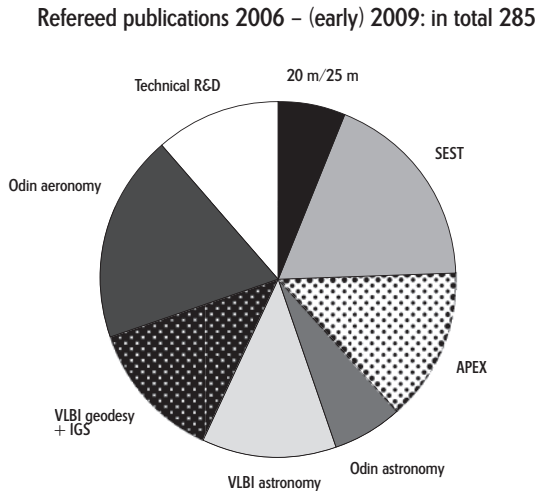


Figure 3.
Distribution of publications from Onsala Space Observatory by subject area.

4. PANEL'S REPORT

The Onsala Space Observatory has always built on an interdisciplinary foundation of science and instrumentation. The science and technology program between 2006 and 2009 continued this tradition, enabling active Swedish participation in SEST, APEX, ALMA, VLBI, EVN, and LOFAR, as well as scientific returns from the space missions ODIN, and more recently Herschel. For astrophysics, a particularly useful component – modeling and theory – was also added to the interdisciplinary mix. As we note below, the strong science program has been accompanied and enhanced by an innovative instrumentation effort. The new ventures in geophysics/geodesy have followed a similar pattern, taking advantage of the OSO expertise in VLBI, and have also been successful.



Foto: Hans Olofsson

Figure 4.

The Expert Panel at Onsala Space Observatory. From left: David Edvardsson (Swedish Research Council), Véronique Dehant, Karl-Fredrik Berggren (chair), Anneila Sargent, Malcolm Walmsley.

Funding for OSO has been increasing since 2004 but, due in part to the unanticipated loss of key staff members, the quality of the observing support at the Onsala 20 m telescope has been maintained with some difficulty. In spite of this, in both astronomical and geodesic/geophysical activities, the OSO is fulfilling its mission to support cutting-edge research and to help educate the scientists and engineers of the future.

Organization

Nevertheless, the world is changing, with considerably more emphasis on very large projects. How should OSO be positioning itself to fulfill its mission and compete in a changing world? The Panel found that the overall organization of the OSO has been effective over the years. The OSO Board appears to be particularly supportive. However, as discussed later in this Report, the changing times may require more interaction with, and support from, the Swedish, and perhaps even the international community. Given the size of OSO, an advisory committee to the Director is probably the best way to provide the appropriate kind of feedback and advice; the Panel recommends that such a committee be put in place. Committee members should reflect the interests of the various stakeholders.

Science 2006–2009

The Panel was impressed by the scientific programs carried out at OSO over the period 2006–2009. The effort to take advantage of the new opportunities offered by the APEX telescope is particularly noteworthy. Likewise, rather unique science was enabled by the ODIN mission, leading nicely into ongoing research with Herschel. Equally impressive are the new results from VLBI studies where, quite clearly, the recent increase in sensitivity is allowing great steps forward. In particular, the advent of e-VLBI provides for much more interactive and productive observing modes.

Research highlights are presented in the OSO Evaluation Report for 2009⁴ and additional intriguing examples were provided in the oral presentations by OSO staff to the Panel. The variety of science projects underway is especially striking and encompasses some of the most important topics in modern astrophysics, geodesy, and geophysics, and ranges from the formation of stars and other planetary systems to key questions regarding the origin of the Universe. This has the great advantage of giving students a wide range of

⁴ Dnr 827-2009-439

possible thesis topics. In part, it is made possible as a result of well-conceived collaborations. For example, the Panel was happy to note that the observational astronomy work is in large part accompanied by theoretical modeling with links to Chalmers and other theoretical groups in Sweden. Synergies between different disciplines are important for providing multidisciplinary approaches for both astronomy and geodesy. For the latter, for example, co-location of instruments and sensors at Onsala provides a sound footing from which to tackle global geodesic and geophysical problems.

Technical 2006–2009

Historically, the technical expertise at Onsala has been acknowledged world-wide. It is the view of the Panel that this tradition is being maintained at the same high level. Particularly impressive in 2006–2009 has been the GARD production of the facility receiver for APEX and its development work on the ALMA Band 5 mixer and cold cartridge. GARD deserves particular congratulations for the completion of the state-of-the-art Terahertz capability of the APEX heterodyne receiver. In addition to opening up a relatively new astronomical window, this is a real technological success, with possible industrial implications. OSO, in collaboration with the UK Cambridge/Cavendish Astrophysics group, was also instrumental in developing a prototype Water Vapour Radiometer (WVR) for ALMA. This technology is of critical importance to ensure that this new array reaches the highest performance levels in terms of detailed imaging of astronomical sources. It is worth noting that the contract for ALMA WVRs went to Omnisys Instruments, a Swedish company with connections to Chalmers.

The Panel is also excited by the technical developments for European VLBI, especially the relatively recent e-VLBI fast data transfer experience. This effort was led by the OSO group and resulted in a dramatically improved data transfer rate. Experience gained to date with these extremely challenging projects will provide a solid foundation for many future instrumental developments, including SKA. At present, Onsala is one of the best VLBI stations for geodesy, and co-located with a GPS station and with complementary sensors such as WVR and a gravimeter. Recent technical developments, such as the above mentioned e-VLBI, have been used successfully for a quasi-real time approach. This has been a broad-based Swedish success story. The instrumental advances not only benefited from the expertise of partners at Chalmers and/or GARD, but fine calibrations of the co-located instruments were made available thanks to other national institutions such as the National Land Survey of Sweden and other visiting research groups from several Scandinavian institutions.

Community support 2006–2009

As a major part of its mission, the Onsala Space Observatory provides scientists with the equipment to pursue research in astronomy. To this end, OSO operates the 20 m and 25 m telescopes on site and manages the Swedish observing time on APEX. All of these operations appear to be conducted both efficiently and fairly. In addition to serving Swedish astronomy and geodesy, the open skies policy for the Onsala telescopes has attracted international astronomers. The OSO itself is an invaluable training ground for students, not only from Chalmers but from elsewhere in Sweden. While the 20 m telescope is clearly aging, it is nevertheless still a useful instrument and, particularly for VLBI, all the telescopes are making a useful contribution. The oversubscription factor for APEX Swedish time is of order 2.5, reflecting community enthusiasm for its capabilities. The Panel notes that geodetic VLBI is of considerable value and increasing importance to the community.

Education and outreach 2006–2009

The connection between Onsala Space Observatory and Chalmers is a key component of the service which OSO provides to the Swedish community. The combination of university and national research facility has resulted in a particularly felicitous environment for the education of engineers, astronomers, and geophysicists who will become an invaluable resource for the next generation. The 12 PhDs, 13 Licentiate, and numerous Masters degree graduates produced over the last 3 years, is impressive, especially when taken together with the career successes of previous generations of Onsala-educated students. The Panel was aware of academic successes but was pleased to hear from the Chair of the OSO Board, that local companies were also enthusiastic about hiring such engineering graduates.

Secondly, the outstanding public outreach program at Onsala helps make the current generation of school children aware how fascinating science can be. The Panel was particularly impressed by the intelligent planning that went into the development and implementation of projects such as SALSA. SALSA is a particularly innovative introduction to radio astronomy and our place in the Milky Way galaxy. Last but not least, the Panel finds that a critical characteristic which distinguishes OSO from many competing groups within Europe is having the technical groups “anchored” in Chalmers. This facilitates interdisciplinary projects of many different kinds, with useful by-products such as the Omnisys instrumentation company. While it is often difficult to demonstrate

synergy between basic and applied science, the Chalmers-Onsala collaboration is an excellent example.

The future of Onsala Space Observatory

As already noted, Onsala Space Observatory needs to innovate in order to compete in a changing world. This implies a need for budget increases. It is clear to the Panel that any large budget cuts (for example due to external economic circumstances) will inevitably lead to a loss of quality. Indeed, it is not clear that the mission of OSO could continue to be realized in the face of such cuts. Put simply, a 25 percent decrease in funding would lead to abandonment of one or more of the Observatory's facilities. There are several options, but the most obvious perhaps would be an abandonment of the 20/25 m operation. The presentations which the Panel heard made it clear that this would impinge on both the productivity of the astronomical and geophysical communities in Sweden as well as detracting from the attractiveness of the educational and industrial relations opportunities offered by Chalmers.

On the other hand, a 25 percent increase in funding would allow current activities to continue and to be enhanced. Indeed, the OSO Director's request for an operational funding increase of ca. 8.7 MKr over 4 years is modest by this standard. The Panel finds these requests amply justified and in some cases critical to the survival of the activities concerned. Obvious examples are the requests for 3 FTE for the GARD operation and for 2.5 FTE support astronomers. These are needed in order that current operations merely continue!

At the same time, the Panel recognizes that the observatory is involved in many apparently disparate activities and that some savings both in staffing and funding could be made by abandoning some of these. The Panel suggests that it would be useful to begin to set priorities, at least in the form of guidelines. In particular, it is clear that the 20 m telescope is aging and a discussion of the future, and its replacement with a larger more sensitive instrument, would be timely. The Panel recommends the commissioning of a study of the possible options. These could be developed in collaboration with the staff and with a Director's advisory committee (suggested earlier in this Report) and subsequently presented to the OSO board for consideration. Such a study should take into account the needs and interests of the geophysical/geodesy community as well as of ongoing developments in astronomical VLBI.

In this context, the Panel heard with interest the arguments for outfitting the 20 m with a sensitive wide band 3mm/4mm receiver. OSO has a tradition of spectral scans that prove useful to the community world-wide and the 3mm/4mm system would offer new opportunities for work of this type. It is certainly true that the 70–80 GHz frequency range is a niche which the observatory could usefully occupy in the foreseeable future. The 3mm effort will allow a useful Swedish contribution to mm VLBI which, as sensitivity increases, is likely to produce useful astronomical results.

Another clear priority for the observatory in the next few years will be to participate in ALMA-related projects. The Nordic ARC is the most obvious example of this and it is important that this be sufficiently funded to be useful. The ARC could be a key focus not only for radio astronomers but also for optical astronomers in all the Nordic and Baltic countries, as well as in Sweden. It is certainly also a priority to continue the APEX contract until 2015, if possible. Currently the scientific output is very high and the telescope is also an excellent testbed for new instrumentation. The Panel is hopeful that the GARD group finds useful future challenges within the framework of ALMA.

The scientific output of OSO is in no small degree linked to the development of EVN and European VLBI. It is clearly important that OSO is involved in constructing the roadmap for EVN₂₀₁₅. This is important both in itself and because of the technological spin-offs (high speed data links etc.) which are involved. The Panel believes that this activity should be maintained. Likewise the Panel understands the scientific potential of the LOFAR project and its attractiveness to OSO at this time.

It is also clear that thought has to be given to the requirements of geophysics and geodetic VLBI. This is linked to the evolution of the EVN discussed above. The geophysical results being acquired at the Onsala site are of increasing importance for the geophysical and environmental sciences. The Panel believes that a sustained effort in this area is certainly justified and a more formal approach to funding, as well as incorporation into the overall mission of OSO, is required. Thus, the Panel enthusiastically supports the request for 1.2 FTE for Geodetic support and stresses that geophysical activities must be maintained and put onto a permanent basis.

APPENDIX 1: BACKGROUND OF EXPERTS

Personal information

Name: Véronique M. Dehant
Affiliation: Royal Observatory of Belgium
Native country: Belgium

Academic degrees

1981 Degree in mathematics at the Université Catholique de Louvain (UCL), Belgium.
1982 Master degree, UCL, Belgium
1986 Ph.D., UCL, Belgium

Recent employment history (selection)

1986–1990 Post-doctoral Researcher at FNRS
1990–1993 Senior Research Scientist at FNRS
1993–present Project Leader and Senior Research Scientist at ROB
1994–present Head of Section at ROB
2004–present Part time Lecturer at Université de Nantes, France
2009–present Extraordinary Professor at UCL

Recent professional activities (selection)

2007–present Member (as Past-President) of the Executive Committee of Commission 3 “Geodynamics and Earth Rotation” of IAG (International Association of Geodesy)
2006–present Member (as Past-President) of the Executive Committee of Commission 19 “Earth Rotation” of IAU (International Astronomical Union)
2006–present Member of the Selection Committee for the Bowie Medal of the American Geophysical Union
2006–present PI (Principal Investigator) of the Lander Radioscience experiment (LaRa) in the frame of the AURORA/ExoMars mission to Mars

Research interests

Professor Dehant's major area of interest is geodesy and geophysics, with specific interest in Earth/Mars/Mercury rotation/libration and interior modeling; gravity studies of Mars/Venus/Mercury.

Her present research includes: Influence of the Earth's internal structure, free oscillations, internal convection, rheology, and external fluids (atmosphere and oceans) on the Earth's rotation and deformation in order to improve the precession-nutation model and the realization of the terrestrial and celestial reference frames, and in order to better understand the physics of the Earth's interior. The same research is being applied to the planet Mars (where she also proposes a radio-science experiment), Venus, Mercury, and the icy satellites.

Personal information

Name: Anneila I. Sargent (née Cassells)
 Affiliation: California Institute of Technology, USA
 Native country: Scotland

Academic degrees

1964 B.Sc. Honors in Physics, University of Edinburgh
 1967 M.S. Astronomy, California Institute of Technology
 1977 Ph.D. Astronomy, California Institute of Technology

Recent employment history (selection)

2008– Vice President for Student Affairs, California Institute of Technology
 2004– Benjamin M. Rosen Professor of Astronomy, California Institute of Technology
 2003–2007 Director, CARMA (Combined Array for Research in MM-wave Astronomy)
 2000–2003 Director, Michelson Science Center, Caltech
 1998–2004 Professor of Astronomy, California Institute of Technology
 1996–2008 Director, Owens Valley Radio Observatory
 1992–1996 Associate Director/MM-wave Operations, Owens Valley Radio Observatory
 1977–1980 Postdoctoral Research Fellow (Astronomy), California Institute of Technology

Recent professional activities (selection)

2007–	United Kingdom Science and Technology Facilities Council (STFC)
2002–	Atacama Large Millimeter Array (ALMA) Board Chair 2006, 2008 –; Vice-Chair 2007–2008
2003–2007	United Kingdom, Particle Physics and Astronomy Research Council (PPARC)
2002–	Max Planck Institut für Astronomie (Heidelberg), Science Advisory Committee
2001	NRC Blue Ribbon Committee on the Organization and Management of Astronomy & Astrophysics
2000–2002	President, American Astronomical Society; Past President 2002–2003
1994–1998	Chair, NASA Space Science Advisory Committee
1994–1998	NASA Advisory Council

Research interests

Professor Sargent’s research concentrates largely on understanding how stars form in our own and other galaxies. She is particularly interested in how other planetary systems are created and evolve. These studies have depended on astronomical observations at infrared, millimeter, and sub-millimeter wavelengths, and involved the use of a variety of telescopes, both ground- and space-based.

Personal information

Name: C. Malcolm Walmsley
 Affiliation: Arcetri Observatory, Florence, Italy
 Native country: Ireland

Academic degrees

1963 B.A.(Mod) Trinity College Dublin
 1969 Ph.D. University of California San Diego

Recent employment history (selection)

2008–	Associate Research Scientist, Arcetri Observatory
2004–	Scientific Editor, Astronomy and Astrophysics
2006–	Chief Letters Editor, Astronomy and Astrophysics
1995–2008	Senior Scientist Arcetri Observatory, Florence, Italy
1994–1995	Full Professor, University of Cologne, Germany
1978–1994	Senior Scientist, Max Planck Institut für Radioastronomie, Bonn, Germany

Recent professional activities (selection)

1999–2003	Member of the scientific advisory committee for the ALMA project
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Research interests

Professor Walmsley's work has centred on molecular clouds and their relationship to star formation. He has been especially interested in the structure of dense molecular clouds just prior to star formation as well as the chemical abundances in such dense gas. His work has involved observational millimeter wave and far infrared (ISO) projects.

Personal information

Name:	Karl-Fredrik Berggren
Affiliation:	Linköping University
Native country:	Sweden

Academic degrees

1963	B.Sc, Uppsala University
1965	Licentiate degree, Uppsala University
1969	Ph.D. Quantum Chemistry, Uppsala University

Employments (selection)

	Full Professor Theoretical Physics, Linköping University
2003–2007	Guest Professor Lund University (Planning Unit, Project Manager European Spallation Source-Scandinavia)

Recent professional activities (selection)

2005–2009	National micro- and nanofabrication laboratories (MYFAB), member of the board (Representative for the Swedish Research Council)
2007–2009	National Supercomputer Center at Linköping University (NSC), Chairman
2009–2011	Member of Board, Dept Applied Math, Linköping University

Professor Berggren has served as board and committee member in a number of Swedish research councils (Swedish Natural Science Research Council, Swedish Research Council for Engineering Sciences, Swedish Research Council, Swedish Research Council/SIDA Research Links, National Board for High Performance Computing).

He has participated in a number of evaluations related to research infrastructure and education *e.g.*

- International evaluation of three major academic laboratories, Swedish Research Council 2002 (Chairman)
- Swedish Research Council, International evaluation of the Swedish organization of polar research (chairman, final report 2008)
- Evaluation of the Nordic Data Grid Facility (NGDF), Joint Committee of the Nordic Natural Science Research Councils (NOS-N), (2007)

Research interests

In general terms Professor Berggren's research is focused on theoretical condensed matter physics. Current research deals with electronic aspects of low-dimensional semiconductor structures such as quantum wells, wires, dots and related nanostructures. Quantum chaos in mesoscopic and classical wave systems (microwaves, acoustic waves and electric networks). Visualization and high-performance computing. He has participated in a number EU projects within these areas.

APPENDIX 2: TERMS-OF-REFERENCE

Review Panel

The review will be conducted by a “Review Panel” consisting of internationally recognized experts, with broad views and expertise in the research fields covered by OSO. None of the members shall be personally engaged in the activities at OSO.

The chairperson of the Review Panel, appointed by Swedish Research Council and its Council for Research Infrastructures, is Professor Karl-Fredrik Berggren, Linköping University. Professor Berggren heads the review and is the rapporteur of the Panel. A research officer from Swedish Research Council acts as the co-ordinator of the review.

Review schedule

The review shall be made during the summer of 2009 and the Panel shall have at least one site visit to OSO. A preliminary report, including the main findings, shall be presented to Swedish Research Council by the rapporteur, or his representative, on September 17th, 2009. OSO will be requested to submit the necessary material on which the review shall be based not later than April 6th, 2009.

Review procedure

The Review Panel shall investigate the general scientific/technical activity of OSO in view of the budget given to the activities. The Review Panel should from a strategic point of view also comment on the importance of OSO as a national facility. New areas of science that have been developed during the last six years shall be highlighted.

The Review Panel is asked to write a report on the performance of the present OSO. In this report the Panel is requested to:

- Evaluate, from an international point of view, the scientific quality of the ongoing activity, in particular activities in radio astronomy, but also other research activities, at OSO, such as those in geodesy.
- Comment on the role of OSO as an international partner in radio astronomy.

- Comment on the role of OSO as a research infrastructure for Swedish astronomy from the perspective of other infrastructures used by Swedish astronomers (such as NOT and ESO).
- Comment on the impact which the increased funding from the Swedish Research Council has had on the scientific activities.
- Comment on the management of the facility with regard to the projected goals and functions of the facility.
- Estimate if the user support is on an appropriate level compared to other space observatories of similar size.
- Identify the most important scientific achievements at OSO during the last six years.
- Evaluate, as an alternative to OSO, the possibility for Swedish scientists to perform their research at other existing and planned observatories.
- Comment upon the relation between international and Swedish users.
- Estimate if the cost for running OSO is appropriate and give an opinion on what effects a 25 % increase or decrease in the funding would have on the scientific performance.
- Comment on the balance between the activities in radio astronomy and other activities, in particular geodesy.
- Comment on the full operational concept of the facility, in particular for serving the users.

The Panel is also asked to report about any other issue (scientific, administrative or financial) which can be of importance for Swedish Research Council when deciding the new operational budget for OSO.

APPENDIX 3: TIMEPLAN

Monday, August 31

Säröhus

- 14:00–16:00 Introduction and initial discussions
David Edvardsson, *Research Officer, Swedish Research Council*
Hans-Åke Gustafsson, *Expert committee for astronomy and subatomic physics*
Karl-Fredrik Berggren, *Chair, Review Panel*
- 19:00 Dinner
-

Tuesday, September 1

Site visit to OSO

- 9:00–9:15 Introduction
Karl-Fredrik Berggren, *Chair*
- 9:15–9:25 Chalmers as the host university of OSO
Stefan Bengtsson, *First Vice President, Chalmers*
- 9:25–9:45 The importance of National facilities to modern astronomy
Glenn White, *OSO Board, Open University & RAL, UK*
- 9:45–10:10 Overview and future vision of OSO
Hans Olofsson, *Director, OSO*
- 10:10–10:25 Coffee break
- 10:25–12:30 Presentations of activities and research at OSO:
(Presentations will be available in paper format at the meeting)
- | | |
|----------------------|---------------------|
| Outreach | (Magnus Thomasson) |
| APEX and Onsala 20 m | (Per Bergman) |
| VLBI | (Michael Lindqvist) |
| LOFAR and SKA | (Hans Olofsson) |

ALMA	(Hans Olofsson)
Space astronomy	(René Liseau)
Receiver development	(Victor Belitsky)
Geodesy and aeronomy	(Gunnar Elgered)

Short break

Galactic studies	(John Black)
Extragalactic studies	(Susanne Aalto)

12:30–13:15 Lunch at the Observatory

13:15–15:00 Discussion and comments about the activities with Director Hans Olofsson and representatives from OSO and Chalmers

15:00–15:30 Coffee break and a tour of the Observatory

15:30–17:00 Closed meeting of Review Panel. Report drafting

19:00 Dinner

Wednesday, September 2

Säröhus

09:00–17:00 Closed meeting of Review Panel. Report drafting

19:00 Dinner

Thursday, September 3

Säröhus

09:00–13:00 Closed meeting of Review Panel. Report drafting.

Departure

APPENDIX 4: QUESTIONNAIRE TO ONSALA SPACE OBSERVATORY

Dnr 827-2009-439

Onsala Space Observatory Background report

Introduction

Vetenskapsrådet currently funds two National Facilities – MAX-lab and Onsala Space Observatory (OSO). The operational support for these facilities is provided as a result of periodic reviews. The current review of OSO is scheduled to take place during the spring of 2009 and will be conducted by a “Review Panel” consisting of internationally recognized experts. Part of the material on which the review will be based consists of a background report provided by OSO. At least one site visit will also be performed. The background report shall be submitted to Vetenskapsrådet no later than **April 14, 2009**. The format of the background report can be similar to the “mid-term review” submitted in January 2007. Please make sure that answers are provided to the specific questions below. The results and conclusions of the review will be made public in a written report.

Name of person submitting the report

University/corresponding

Address

www

Telephone

Telefax

E-mail

Signature,

Place, Date (yyyy-mm-dd)

Name

General

a) Give a brief summary of Onsala Space Observatory's goals and objectives.

b) Describe how Onsala Space Observatory fits into the picture of Swedish astronomy as a whole.

c) Describe the role of Onsala Space Observatory as a national and international infrastructure for radio astronomy and other activities, in particular geodesy.

d) Describe Onsala Space Observatory from the perspective of a user facility. In particular, explain the organisation, management, operational concept, user support and principles for allocating observation time.

e) Comment on the increased funding from Vetenskapsrådet, following the previous evaluation of the National Facilities, and its impact on the scientific activities.

Specifics for the period 2006–2009

a) Describe the most significant scientific achievements, results and impact.

b) Describe the most significant technical and development achievements. Please provide a summary of all upgrades and investments including costs and financial support (Swedish Research Council, EU, Chalmers or other specified contributor). Describe cooperation with Swedish industry and other national and international partners.

c) Provide a list of publications resulting from observations with, or describing the technical development of, Onsala Space Observatory's telescopes.

d) Present a compilation of active national and international users, telescope time allocation and user statistics (age, title, affiliation, *etc.*).

e) Present the operational and personnel costs. Please provide a total budget (divided into sub-areas if necessary). List all financial support (Swedish Research Council, EU, Chalmers or other specified contributor). Present a list of personnel including an age profile of the staff.

f) Describe the outreach activities.

Specifics for the period 2010–2013

a) Present the planned scientific activities and motivations for why pursuing them.

b) Present the planned technical and developing activities, *e.g.* investments and improvements related to the facilities. Include the proposed financial contributors.

c) Present the estimated funding required for operation and personnel. Include the proposed financial contributors.

d) Present the planned outreach activities.

Other

a) Other information relevant for this review.

APPENDIX 5: ONSALA EXPENDITURE (2006–2009)

Swedish Research Council operation funding

Expenditure covered by the Swedish Research Council operation grant (in kSEK; a kr/€ exchange rate of 9.5 is used for 2009).

	2006	2007	2008	2009
Salaries	9750	10080	12460	13260
Operation costs	1820	2160	2370	2380
Upgrades	1460	1520	710	1300
LOFAR station install				800
APEX operation	6250	6540	6300	6370
APEX rec.inv			660	500
JIVE	1300	1285	1305	1330
ESKAC			237	240
CRAF freq.manager	175	130	161	130
Chalmers overhead	600	737	635	100

Chalmers contribution to central administration

The Chalmers funding is used to cover costs for rent, electric power, central administration, IT-service, etc. (in kkr):

	2006	2007	2008	2009
Chalmers contribution	6593	6646	6700	7573



APPENDIX 6: LIST OF ABBREVIATIONS

ALMA	Atacama Large Millimetre/submillimetre Array
APEX	Atacama Pathfinder Experiment
CRAF	Committee on Radio Astronomy Frequencies
ARC	ALMA Regional Centre
ESKAC	European Square Kilometre Array Consortium
ESO	European Southern Observatory
e-VLBI	Electronic Very Long Baseline Interferometry
EVN	European VLBI Network
GARD	Group for Advanced Receiver Development
GNSS	Global Navigational Satellite Systems
IGS	International GNSS Service
JIVE	Joint Institute for Very Long Baseline Interferometry in Europe
LOFAR	Low Frequency Array for Radio Astronomy
NOT	Nordic Optical Telescope
OSO	Onsala Space Observatory
SALSA	Such A Lovely Small Antenna
SEST	Swedish-ESO Submillimetre Telescope
SKA	Square Kilometre Array
VLBI	Very Long Baseline Interferometry
WVR	Water Vapour Radiometer

Onsala Space Observatory (OSO), situated outside Göteborg, is the Swedish National Facility for Radio Astronomy. OSO is operated by Chalmers University of Technology and associated with the Department of Radio and Space Science. The recent review shows that OSO manages its many commitments and projects well and that the quality of the research conducted at the observatory is at a competitive level compared to other similar facilities. The Panel was impressed by the scientific and technical program carried out at OSO over the period 2006–2009. The Review Panel noted that the connection between Chalmers and OSO has helped to create a felicitous environment for educating engineers, astronomers and geo-physicists who will be an invaluable resource in the future. The review covers the years 2006–2009, with a look into the future, and served as guidance when the Council for Research Infrastructures made its positive decision on the level of funding for OSO for the period 2010–2013.



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The Swedish Research Council is a government agency that provides funding for basic research of the highest scientific quality in all disciplinary domains. Besides research funding, the agency works with strategy, analysis, and research communication. The objective is for Sweden to be a leading research nation.

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