

# AN EXAMPLE OF COOPERATION IN THE FIELDS OF HIGH TECHNOLOGY:

## “CERN – LARGE HADRON COLLIDER - CIVIL ENGINEERING CONSULTANCY SERVICES”

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### *Abstract*

In early 1996 an Anglo-Swiss-Austrian JV consisting of three companies, Sir Alexander Gibb & Partners Limited (GB) – SGI Ingenierie (Switzerland) - Geoconsult ZT Ges.m.b.H. (A) was awarded the contract for the civil engineering consultancy services for the new Large Hadron Collider LHC, Package 02 in CERN. The present paper shall give an example of how a functioning client-consultant relationship may be developed by means of consequent acquisition and maintenance of personal contacts, which in this particular case was rewarded with the award of a major design contract. After a brief introduction of the project and the involved consultancy services of the GIBB-SGI-GC - JV, the history of awarding the contract and establishing of the relationship to the client shall be illuminated.

### 1 INTRODUCTION

The European Laboratory for Particle Physics (CERN) is the worlds largest research laboratory for particle physics. Founded in 1954, CERN is supported by 19 member states. The laboratory has over 2800 permanent staff and is used by more than 6500 scientists of worldwide 80 nationalities. The laboratory facilities themselves are located at the Franco-Swiss border adjacent to Geneva airport. It includes a series of linear and circular particle accelerators, which are hosted in tunnels in a depth of approximately 100m. The main Large Electron Positron (LEP) accelerator, which is operating since 1989, has a circumference of 26.7 km. Along the LEP, several access points and so-called experimental or detector points are located. At these experimental points, energy from particle collisions is measured in the so-called detectors, which are hosted in large underground caverns or cavern systems. The older Super Proton Synchrotron (SPS) has a circumference of 6.9 km and is connected to the LEP at experimental Point 1.

### 2 CIVIL WORKS FOR THE LARGE HADRON COLLIDER

#### *General*

In late 2000 the LEP will be shut down and will be replaced by the Large Hadron Collider (LHC), which shall start its operation in 2005. The LHC will use all the existing LEP structures but will also require substantial new surface and underground works. The two new detectors, the ATLAS at Point 1 and the Compact Muon Solenoid (CMS) at Point 5, will be larger and more complex than any built to date. The new detectors, weighing up to 15.000 tons, will be installed in newly built caverns. Due to the extraordinary size and the three-dimensional complexity of the openings, the challenging geology and the adjacency of the existing structures, which will be partly operating during the construction phase, the new underground structures are beyond precedent experience and on the limit of feasibility, presenting a real challenge to designers and contractors.

#### *Contracts*

The contracts for the design and for the construction of the underground and surface works have been let in three packages and consortia of international leading Engineering companies awarded the contracts. The contract for the design of point 1 (package 01) was awarded an Anglo-French JV consisting of Knight Piesold (GB) and Electricite de France (F). A JV of Teerag-Asdag (A), C.Baresel (D) and Zschokke-Locher (CH) won the contract for execution of the works.

At Point 5, a JV of GIBB (GB), SGI Ingenieure (CH) and Geoconsult (A) where selected to do the design of the works. The construction contract is let to a Spanish-Italian JV of Dragados (E) and SELI (I).

The third Package 03 comprises a series of smaller structures, which are to be constructed at several locations around the LEP. It was designed by a JV of Brown & Root (GB) and INTECSA (E). Contractor is a JV of Taylor Woodrow (GB), AMEK (GB) and Spie Batignolles (F).

## *Civil Works at Point 5*

Point 5 (Package 02), the subject of GIBB-SGI-Geoconsult JV's design contract, mainly consists of two parallel caverns, which are separated by a massive concrete pillar. The Experimental Cavern UXC 55, which will later host the 15.000 tons CMS-Detector has a width of 27 m, a height of 34 m and a length of 53 m. The parallel-located Service Cavern USC 55 will later, among lots of other equipment, host the extensive computer site for control and evaluation of the experiments. It has a width of 19m, a height of 17m and a length of 85 m. To reduce the total lengths of optical cables, required for data transfer between Experimental and Service cavern, it was a requirement by CERN to keep the distance between the two caverns to an absolute minimum, representing a major cost factor. Due to the total span of the cavern complex of more than 50 m a massive concrete pillar of 7 m width was designed to support the loads induced by the wide spanned rock canopy.

Each of the caverns is connected to the surface by a central shaft in the cavern roof. The permanent access shaft above the Service cavern has a diameter of 12m. The ventilation and detector installation shaft above the experimental cavern has a diameter of 21m. The size of this shaft is guided by the requirements of the largest size of detector rings, which will be pre-assembled at the surface and then descended down the shaft into the cavern in parts of up to 2000 tons.

The remaining elements of Point 5 consist of several smaller service caverns, access and connection galleries and galleries for monitoring and measuring purposes (utilized during construction as well as for the operational phase).

The rock cover above the cavern roofs at Point 5 is app. 70m. The geology, descending from the surface, consists of app. 50 m of water-bearing glacial moraine, followed by appr. 20 m of the so-called Molasse. The Molasse, which is typical for the Geneva area consists of alternating horizontally bedded marl and lime stones of varying strength and material properties. A special challenge for design and construction represents a 8m thick weakness zone, which is located more or less directly above the cavern roof, consisting of the so-called 'marl grumeleuse'. It has a relatively low strength, a quite high creep capacity and is prone to swelling if in contact with water.

In the moraine the shafts will be excavated utilizing ground freezing for shaft wall support and ground water control. Concrete rings are cast progressively to form a 1–1.4 m thick primary lining ring. Below the moraine fibre-reinforced shotcrete and rock bolts are used for primary support. Once shaft excavation is completed and the primary lining ring is in place, a secondary 80cm thick concrete lining will be slip formed from the bottom up, separated from the primary lining by a plastic membrane with fleece backing.

The cavern system is excavated, starting from the service cavern 'access' shaft, with the excavation of the central pillar by sequential top-down operation and subsequent concreting of the pillar. After pillar construction is completed the caverns are excavated by road headers. The primary support consists of 20-25cm fibre-reinforced shotcrete and systematic, partly prestressed fully grouted rock bolts with up to 12 m length. The reinforced secondary concrete lining has a thickness of 80cm in the Experimental and 50cm in the Service Cavern. As water ingress is a sensitive issue and no hydrostatic water pressure is allowed to build up behind the linings, water tightness of the whole cavern complex including the pillar will be achieved by a plastic membrane with fleece backing, which is connected to the extensive drainage system designed around the whole cavern complex.

For construction supervision and design verification an extensive instrumentation and monitoring program is established, comprising the preconstruction of a so-called 'Monitoring and Observation Gallery' above the cavern roofs. From there, monitoring instruments as well as support contingency measures may be installed.

## **3 CIVIL ENGINEERING CONSULTANCY SERVICES AT POINT 5**

The contract for Civil Engineering Services Package 02 is split into four, actually five (including the Defects Liability Period) Phases of Services:

- Phase I: Carry out Primary 'Frozen' Design.
- Phase II: Carry out Tender Design and provide Assistance for Contractor Prequalification.
- Phase III: Carry out Detailed Design and provide Assistance for Tender Evaluations.
- Phase IV: Site Supervision – Carry out duties and obligations of the Independent Engineer.
- Phase V: Carry out obligations during Defects Liability Period until issue of Final Certificate.

The split of the contract obligations among the JV partners is as follows:

- Geoconsult: Caverns and Tunnels
- GIBB: JV-Leader + Shaft Works
- SGI: Surface Works

The format of the civil works contract for the contractor is conforming to FIDIC but reflects particular requirements of CERN.

## **4 HISTORY OF CONTRACT AWARD**

In the following the history of awarding the LHC-Package 02 (Point 5) contract shall be illuminated from Geoconsult's point of view. On hand of this example of awarding a CERN contract, it shall be exemplary shown,

that usually a long and patient process of introduction and contact establishment is necessary prior to a major success in awarding such a contract.

The awarding of the contract for the consultancy services for the LHC Project in 1996 was the result of a long and consequent acquisition process which was followed up by Geoconsult actually since the year 1982 when the civil works for the LEP tunnel were called for tender. A brief listing of these efforts shall be given to outline the history of the present contract.

As mentioned before, the first contacts to a CERN project were established as early as 1982 when Geoconsult provided consultancy services for an international JV of contractors who bid for the civil works of the LEP – accelerator ring. The JV consisted of Dragages et Travaux (F), Bilfinger & Berger (D), Kopp (CH), Codelfa (I) and Schmalz (CH). Unfortunately the JV was not successful.

Only one year later Geoconsult was admitted to the ‘list of Austrian suppliers’ by the Austrian Chamber of Commerce and another year later, in 1984, Geoconsult submitted for the first time the ‘CERN – Questionnaire’ and thus achieved the registration at CERN.

The next milestone in building up a relationship with CERN was, when Geoconsult was invited by CERN in March 1993 for prequalification for the ‘Preliminary enquiry for the design, studies, specifications and supervision for the restoration and improvement works of the LEP underground structures in the ‘JURA section’’. The existing LEP tunnels under the French Jura had at that time massive problems with water inflow and consequently needed restoration works to be done.

In April 1993 Geoconsult submitted prequalification documents for the study and after an invited lecture of the new general director of CERN, Mr. C.Lewellyn Smith, at the Chamber of Commerce in Vienna, in March 1994 Geoconsult was invited to prepare a study on the restoration works of the JURA section. The study was completed and submitted in July 1994. The technical solution proposed by Geoconsult was appreciated and was subsequently awarded by CERN with a premium of 35.000 SFr (together with only two other competing studies). However, in January 1995, Geoconsult got informed that an alternative technical approach was selected for execution of a detailed design and the solution for restoration of the Jura section of the LEP tunnel proposed by Geoconsult was finally rejected.

In the meantime, in September 1994, Geoconsult got invited to tender for a ‘Preliminary study of the Large Underground Caverns at point 5 of the LHC’, which was the first contact related to the present contract. However, the submitted Geoconsult offer for the ‘Preliminary LHC Study’ was not awarded with a contract.

In March 1995 the Chamber of Commerce in Vienna organized an information session and subsequently a CERN delegation visited selected Austrian companies, including Geoconsult Salzburg, where it was possible to establish good contacts to leading persons of the LHC

project and obviously Geoconsult made a advantageous impression. As a consequence, in April 1995, Geoconsult was invited for prequalification for the Civil Engineering Consultancy Services for the Large Hadron Collider and the prequalification documents were submitted in April 1995.

In September 1995, CERN informed about the prequalification of the JV consisting of GIBB-Geoconsult-SGI, who were subsequently invited for tendering for all 3 LHC Design Packages. During the months of November and December 1995, the group submitted offers for all three Design Packages.

Finally, in March 1996 CERN informed the group about the principle acceptance of the offer for Package 02 and the decision to undertake detailed contract negotiations, which led to the awarding of the contract for Package 02 in April 1996.

## 5 CONCLUSION

It is believed, that the circumstance, that the offer included a technically consistent, innovative and safe design concept and a competitive price, finally led to the decision of giving the design contract to the Geoconsult group.

Additionally, the basis of the success of awarding the contract was the cooperation with a strong and recognized international partner together with a experienced local partner who was familiar with CERN requirements and preferences.

A further important fact is, to establish a relationship in the long-term, which gives the client the opportunity to build up confidence in the capabilities of the potential consultant.