The international factory crane magazine

September 2006 Issue 54

# HOIST

www.hoistmagazine.com

# Lifting underground



Eastern Europe • Demag refurbishment project • Wood yard crane • CeMAT Asia 2006 preview

# Lifting the lid on the secrets of the universe

**Richard Howes goes deep underground the Swiss and French borders and finds hoists of every shape, size and capacity operating**

Deep underground astride the Franco-Swiss border near Geneva, not far from the foothills of the Alps (about an hour by car in fact), CERN (the European Organization for Nuclear Research), the world's largest particle physics centre, uses around 1,000 hoists to assist scientists in one of the most fascinating experiments ever known. A total of 43 manufacturers from Europe alone have supplied lifting gear.

CERN exists primarily to provide these scientists with the necessary tools. These, primarily, are accelerators, which accelerate particles to almost the speed of light and detectors to make the particles visible. However, without lifting gear the project would quite literally not have got off the ground.

The construction and assembly of accelerators and detectors would simply not be possible. In addition, all material transfer from surface buildings to underground tunnels/caverns is done with long travelling EOT cranes with shaft depths of down to 154m. The average depth of the accelerator tunnels is 80-100m.

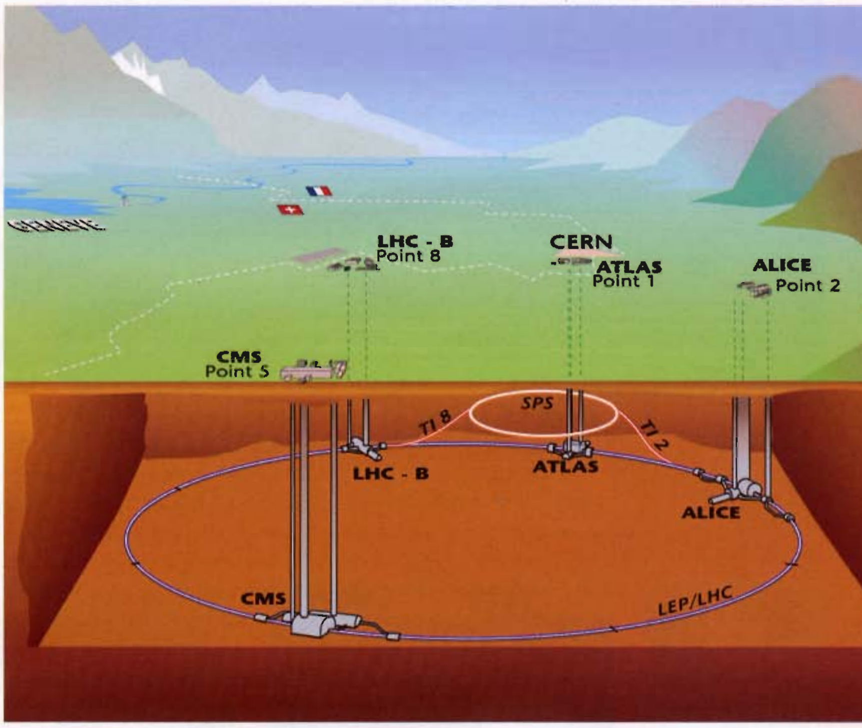
The site boasts a massive perfectly circular tunnel with a circumferance of 27km. Workers travelling around on push-bikes in hard-hats and head-lamps just adds to the overwhelming sense of surrealism of the place. A cable system to maintain mobile phone signals and a back-up generator for lighting keep workers in touch with humanity during long enduring shifts.

Put simply, CERN aims to recreate the conditions just after the Big Bang to understand why the universe is like it is today. Over a thousand dipole magnets guide the particles around the 27km ring. Several hundred quadrupole magnets focus the particle beams, squeezing them so that more particles collide when the beams cross.

At the centre are tracking detectors. These record particle tracks with hundredth of a millimetre precision. They are used to catch shortlived particles. A system of superconducting magnets surrounding the detectors bends the path of charged particles, allowing their charge and momentum to be measured.

The 'master plan' foresees that the lid will be closed on the LHC (large hadron collider) in August 2007 and a low energy beam will circulate in the accelerator in order to calibrate the machine and detector components.

The tunnel originally housed the Large Electron Positron (LEP) collider but this was switched off in September 2000 after 11 years of operation. The LEP was decommissioned and construction of the LHC started. LHC differs from LEP in that advances in technology enable the project to be cryogenically cooled to absolute zero - using helium.




**Overall view of the LHC experiments**

The four experiments of the LHC are called ATLAS (a toroidal LHC apparatus), CMS (the compact muon solenoid), ALICE (a large ion collider experiment), and LHCb (a study of CP violation in B-meson decays at LHC).

Both Atlas and CMS are large general purpose experiments, designed to be sensitive to anything the LHC may throw up. Atlas's main distinguishing feature is its toroidal magnet system, in which the magnetic field is contained in a ring defined by the toroid coils. This allows the detector to be about eight times the volume of CMS, whilst being about half the weight.

CMS takes the approach of using a solenoidal magnet, which requires a large steel yoke to capture the field. Atlas components have been built by over 150 institutes and universities around the world, and are being assembled directly in the experiment's underground cavern. CMS has a similar number of institutes, but is assembling the detector on the surface.

Top of the physics agenda for these experiments is finding the Higgs boson, which will help CERN understand where mass comes from, and looking for supersymmetry, which could start to explain the mysterious and invisible dark matter of the universe. They will also be sensitive to more exotic phenomena, such as mini black holes and extra dimensions of space.

LHCb will be trying to understand nature's preference for matter over antimatter. The universe seems to be made entirely of matter, yet we believe that matter and antimatter must have existed in equal amounts at the Big Bang. A slight difference in the way nature treats matter and antimatter has already been measured in certain particle interactions, but it is nowhere near enough to account for the observed imbalance in the universe.

ALICE will be trying to create matter as it would have been in the first fraction of a second of the universe's live, and observing how it transforms into the ordinary matter from which you and I are made.

There are actually two more, much smaller, experiments. TOTEM will observe protons that collide with other protons but don't transform into other particles. This is an important measurement for interpreting some results from the other experiments. LHCf will do studies that will help in analysing measurements of cosmic rays.

There are eight access shafts leading directly to the LHC ring, with one more dropping to a transfer tunnel from the SPS accelerator to the LHC. This is the shaft that all the LHC magnets go down. CERN's other underground accelerator, the SPS, also has access shafts.

Only CMS is building the detector on the surface, all the others are being assembled directly underground. However, *there are workshops of varying kinds everywhere.*

Overseeing the transport and materials handling team is German national Ingo Ruehl. He guesses that 50% of the LHC machine and about 60% of the four LHC experiments in total are currently installed or assembled. "Hence the hard work for the lifting gear will continue until mid 2007," he says.

Aside from installing the four huge detector machines, the materials handling team is responsible for moving and lowering 1,600 super-conducting magnets, cryogenically sealed and in the shape of 17m long pipes.

The size of the LHC needs to be seen to be believed - and the complexity of its structure is impressive both in its massive hulking shell and in its tiny intricacies. To the untrained eye, workers seem lost in its labyrinth-like structure.

The largest lifting equipment onsite is a EOT crane with two 140t lifting trolleys (total capacity 280t), which arrived in 2003. It was supplied by German company Brunnhuber Krantechnik. The CERN engineer in charge of its operation is Gilles Roche.

It is responsible for lowering components of the ATLAS detector from the surface building to the underground cavern (which is about 100m below the surface). The crane has a micro speed of 0.03m/min for exact positioning and a smooth speed/frequency converter set up (acceleration/deceleration of 0.3g) to avoid damages on the detector components during lifting operations.

It helps to understand that each experiment is constructed on the surface in sections before being lowered down chambers into the tunnel. It makes the loads on the end of the hooks all the more valuable. In fact, ATLAS components are worth between a staggering Euros 128m-192m. The detector in ATLAS has six million components, which means that even at 99% efficiency there are still 60,000 things that can go wrong, explains David James, work supervisor (inspection, coordination, planning) for lifting and handling activities at LHC point five (assembling and installation of the CMS detector).

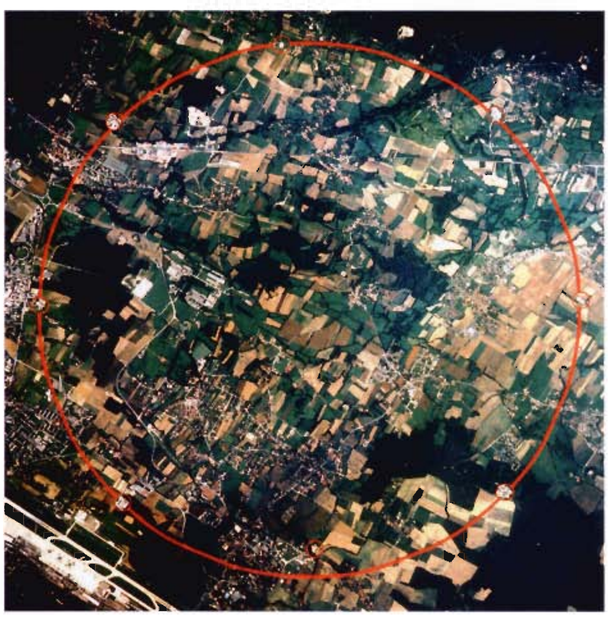
The 280t crane lifts on a daily basis mainly heavy, fragile, unique and very expensive components (values up to several hundred millions of Swiss Francs). For smaller, lighter and less important components (metallic beams etc) a smaller 20t EOT crane is installed in the same building.


**There's one lonely hoist - which is in a room at the end of a long tunnel - that sticks in the mind. The 30t Italkrane machine resides in the LHC dump cavern. Set against the backdrop only of its own shadow, it seems such a waste**

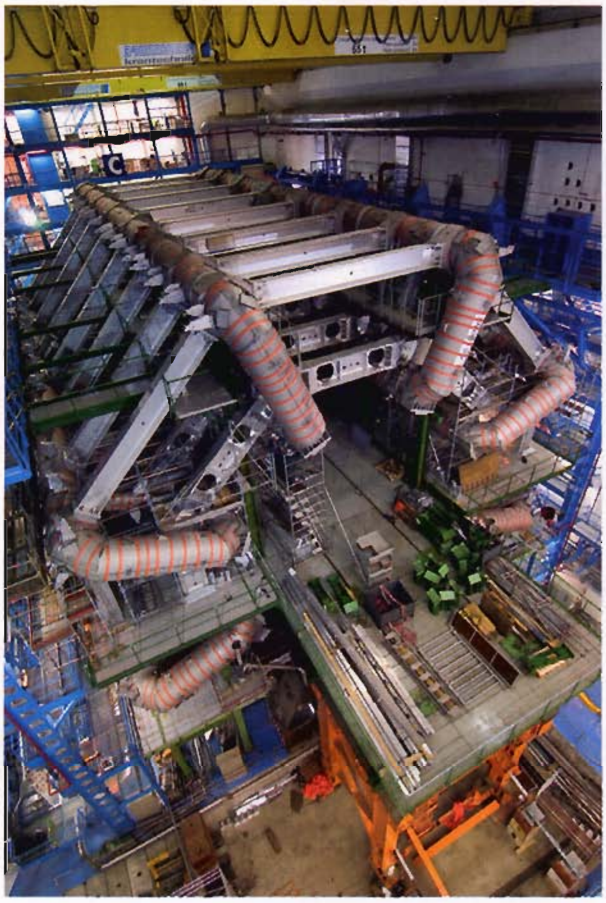
Ruehl says the most complex crane on site is a EOT crane with two parallel crane bridges with a 7.5t on one side and a 5t hoist on the other. It is installed in the target chamber of the CNGS accelerator on a 120m long rail with a 7% slope.

The crane movements are fully redundant (motors, brakes etc) since it will operate in a controlled area because of radiation. An innovative position measurement system (resolver) allows the positioning with a tolerance of 1-2mm.

The positions of the major machine components are all memorised so that the crane can travel to an exact position. In addition, the crane can be operated from a distance via a camera/monitor system. All applied materials are radiation



**Aerial view of the CERN site showing the path of the 27 kilometre tunnel to house the LHC collider. The tunnel was excaveted in the 1980's to house the LEP collider. This was closed in 2000. Geneva airport is visible (lower right)**



View of the ATLAS cavern with its eight barrel toroids installed and fixed

resistant, including cables, colours, steels, grease etc.

A 'straddle carrier' type vehicle from the Finnish manufacturer Rocla is another complex machine that combines automatic guided vehicles with straddle carrier and crane technology. The three vehicles are used for the handling and transport of cryo-magnets (35t) between the assembly hall, storage surfaces and cold test building. The actual crane was supplied by Brunnhuber Krantechnik. Antonino Calderone oversees its operation. Responsible for the vehicle are CERN engineers Keith Kershaw and Oliver Böttcher.

This crane was on site just last year following the arrival of the vehicles two years prior to that. From its commissioning in April 2005 until April 2006 it installed the entire CNGS machine equipment. The vehicles lifted the magnets - dipoles (35t) and quadrupoles (8-17t)

During this period of time the crane was operating about eight to 12 hours a day. As explained, the positions of all important machine elements were memorised and the crane can move to the position without the need for an operator.


An installation of two identical hoists inside the tunnel

Now the CNGS machine has started (the first beams in July this year) the crane will only be used for maintenance - a scenario which could render it redundant for any number of years. Therefore, the crane is now in a garage position that protects it from a large part of the expected radiation.

On average, the vehicles' lifting operations per day are between 10 and 20, while the average operation time per day will be six to eight hours (during a 24 hour shift).

Out of the 350 EOT cranes at CERN about half operate daily and out of the 1,000 hoists Reuhl estimates that not more than a third (probably even less, he adds) are used every day. "After the LHC installation phase is finished the daily use should even further reduce," he says.

Because so many cranes are used for the installation, replacement or decommissioning, large numbers no longer lift at all. "As a rough estimate," says Reuhl, "I would guess that less than 5% of the cranes are redundant but probably more than 20% of the hoists."

There's one lonely hoist - which is in a room at the end of a long tunnel - that sticks in the mind. The 30t Italkrane machine resides in the LHC dump cavern. Set against the backdrop only of its own shadow, it seems such a waste.

Redundant hoists are installed for two different reasons. First, for safety reasons - for the handling of radioactive material. Secondly, for operation/priority reasons - in order to avoid the delay caused by a faulty hoist in case an important machine component has to be changed.

Ruehl says: "In some cases we also prefer to install two identical hoists (for example, two 8t hoists instead of one 16t hoist). This is sometimes for practical reasons (limited available space in the tunnel) and for operation reasons."

Once heavy lifting has taken place, some hoists are down-rated. It is less problematic to have a redundant 5t hoist hanging around than it is a massive 280t machine - especially when it comes to maintenance and service etc.

Ruehl explains that, in general, it is only equipment that has been declared non-conform (following a periodic inspection) that is taken out of service. "In the near future we will proceed with a more specific assessment of the crane and hoist installation in order to optimise the use and upkeep of the installations," he says.

He adds that the main objective will be to down-rate the maximum load capacity (presuming the crane is no longer required) in order to ease the annual load tests or to put the crane in stand-by for the time it will not be used.

Only very few cranes and hoists are indeed taken out of service due to the very different interests of operators, maintenance staff and clients. Even less conform equipment may remain in service provided a special operation procedure was accepted and put in place.

Alone through CERN's contractor for transport and handling service DBS (a consortium involving three companies - Delattre, Belleli and Setrova) already more than 100 licensed crane operators work on site. "But," explains Ruehl, "to this we have to add an unknown number of different contractors for installation works and CERN users/associates from all over the world (including Russia, China and India). Altogether I would estimate at least 200 licensed crane operators work onsite."

As a general rule, cranes are used by one operator and one operator assistant, since in many cases the crane has to travel over obstacles that one person cannot observe totally by himself.

The ATLAS calorimeter before being lowered into the ATLAS canvern

As the coils arrived, each was placed in its final position, supported on platforms. Then all the coils were attached together to make a huge torus that also supported about 300t of ATLAS's muon chambers and enveloped the inner detectors

A cryogenic magnet about to be lowered into the tunnel

The biggest hoist contracts have come from Cerretti-Tanfani, MARS-UTO, Kone, Mohr-Federhaff, Munck and Reggiane. More recently, Italkrane, Brunnhuber and Brunmech have won large-scale jobs. Each of these companies has supplied between 10 and 20 EOT cranes.

The project hasn't been without its missaps. For example, one cryo-magnet was dropped after one of the four wire ropes of the Rocla vehicle ruptured. The cryo-magnet was worth about 350,000 Swiss Francs (Euros 224,000) but it seems that the cold mass (the major part of the cryo-magnet) can be recuperated. Analysis to prove this is still ongoing.

The busiest hoists onsite are the four 10t EOT cranes supplied by Italian manufacturer Reggiane. They had to lower and take out all the LEP accelerator machine equipment. During the dismantling work of the LEP accelerator in 2001 three of the four gearboxes broke down after the cranes operated permanently at the maximum load (slightly above 10.5t). The gearboxes were repaired and the cranes have been running satisfactorily ever since.

By contrast, a typical example of far less productive cranes are the new 30t EOT cranes supplied by the Italian manufacturer Italkrane that were installed at the LHC beam dump caverns. The cranes will be only used for the installation of the beam dumps, for the change of the beam dump, if required, and the decommissioning.

Says Ruehl: "It is quite an investment for a crane that probably will not make more than 500 operation hours over the next 10 or 15 years." There are a number of examples like this at CERN but heavy loads cannot be moved without proper hoists and cranes - especially not in confined underground areas.

The first 7.5 EOT crane was installed by the company UTO-Schindler in 1954. The first lot of cranes was installed in 1957 for the construction of the PS accelerator, which is still in service today. The project used three EOT cranes (20t, 20t, 30t) from Italians Cerretti-Tanfani, two EOT cranes (5t, 5t) from UTO-Schindler and one EOT crane (40t) from Mohr-Federhaff. They lifted so-called warm-magnets (water cooled) and other PS machine equipment.

All of these EOT cranes are still installed and operational. In 2003, in fact, the 30t Cerretti-Tanfani crane underwent a major overhaul and the lifting capacity was even increased to 35t.

CERN remains a European success story to have brought together technicians, engineers and physicists from all over Europe (and beyond) for more than 50 years now. In this time, CERN has become the leading laboratory for particle physics worldwide. The only laboratory comparable to this is NASA (National Aeronautics and Space Administration) in the US.

The normal human management conflicts may be a bit amplified due to the different nationalities and social/cultural differences at CERN but in general it has worked perfectly.

Admits Ruehl: "Onsite it is of course more difficult to coordinate the work from companies coming from all over Europe. This is mainly because of differences in the 'safety culture' and interpretation of safety and other issues." He concludes: "For example, crane operator license requirements vary from one country to the other."

Significantly, CERN itself has to adhere to both Swiss and French legislation - depending on which side of the border on which it is working - and Switzerland is not in the European Union (EU), which adds all kinds of complications. But CERN gets special treatment. For example, CERN personnel living in France can come to work through a gate into the CERN site on the French side of the border, and it has a tunnel joining the main site to France which is managed by CERN directly - this allows them to transfer material between the French and Swiss sites. CERN also enjoys VAT free status in both host states.

Underground, there's only one nation. H