**Construction Site Visit by bus - Script**

May 2016

1. Drive around Circular Road; temporary road open, driving on the gravel road, asphalt road closed.

General information

In February -14 ESS signed an agreement with Skanska and formed the project organization SKANSKA ESS Construction (SEC), where both ESS and Skanska employees work together, in a collaboration contract called contract 101 (C101).

Through this cooperation we build the infrastructure for the world's most powerful linear accelerator facility.

This contract form means in brief that we work with open books between ESS and Skanska in terms of time and money.

C101 / SEC calculates the target cost and program for the construction of the facility together with ESS.

The primary reason for the contract form is that we basically have to build the facility in parallel with designing it. The contract form facilitates managing the consequences of not fully finished documents/drawings and constant changes.

To achieve the goal to start concrete works in the accelerator tunnel in November 2014 the so-called "Early Works" phase started in June 2014. This was right after the building permit from the Environmental Court had been received.

Note: In the environmental court's decision requirements regarding radioactivity was not included, as this is to be handled directly by SSM (Swedish Radiation Safety Authority).

The first SSM verdict was promised for the autumn 2014. In order not to lose a whole year in establishing the site - a site in a green field - where some initial works could only be performed in the summer season – it was important to get started with the so-called "Non-permanent" works.

The **four focus areas** that were targeted in on the **"Early works phase"** were:

• **To establish all necessary media;** water, sewage, power, etc. in order to operate the construction site

• **To establish a water management system**, that also in the future will be able to take care of stormwater from the 75 hectares of land (4 ponds, one in every corner of the site)

• **To perform a large portion of the redistribution of the masses on site**, i.e. excavation in some areas and fill in other areas. Approximately 350,000 m3 of topsoil and clay till was moved around.

• To establish the current **site office** (moving in October 2014)

These first goals were met, and as a result the first permanent structural construction of 130 m3 concrete could be cast on December 2nd 2014 (E10 Base Slab in the Linac tunnel).

The official start of construction was in September 2014 when the initial SSM permit was obtained.

**Staff**: Currently about 350 people working in the construction project (whereof approx. 200 site operatives)

A peak, when close to 1,000 staff will be working here, is estimated for some time in 2018.

The project is planned in a number of stages where a new agreement is concluded at the beginning of each stage, with an agreed target cost.

Look towards the future office / Campus:

The future ESS offices and labs (the so-called campus) will be established here. This will be done under a different contract, with a completely different procurement process than the one with Skanska.

About 500 office spaces will be created here. The entrance to the offices will be close to the current bus stop by the Science Village mill (Bus 20).

Expected start in 2017.

Look towards "Target Area":

In the deep central parts of the Target area foundation works have been performed for the heart of the facility, "the Monolith" and "Hot Cell areas". These parts will be included in the Target Building. This will be the largest single construction part, approximately 30 m wide, 30 m high (like a 9-floor house) and 125 m long, a relatively complex concrete construction, consisting of nearly 15,000 m3 of concrete. Some parts of this will need to be made in heavy concrete (4t / m3).

The Monolith, in the central parts of the Target Building, is a approx. 1300 m3 large steel structure (some parts in solid steel) weighting 6000 tons (just slightly less than the Eiffel Tower’s 7000 tons).

In the Monolith spallation occurs; protons coming from the accelerator at nearly speed of light will emit neutrons from a helium-cooled rotating heavy metal wheel and the released neutrons are then led through glass tubes out to halls with 22 different experimental stations. When protons hit the heavy metal wheel, they have a speed equal to 7-8 times around the earth / second.

The instruments in the experimental stations can be compared to a giant microscope that makes it possible to study materials at the molecular and atomic level. (The facility will be used in a variety of sciences such as medicine, biology, chemistry, physics and engineering).

The foundation of the basement that will carry this part of the facility can handle an earthquake magnitude that will occur in Lund with a probability of 1 time / 1 million years.

On the north and south side of the central "Target Area" Experimental hall 1 and 2 are located, housing the facility’s short instrument stations. Directly below these experimental halls so-called "Installation Galleries" are currently being built (about 450 lm concrete tunnels, cross-sectional area of ​​approximately 6 m2). These installation culverts will feed the different parts of the facility with electricity, water, heating, cooling, gas, etc.

To be able to build this by far largest and most complex part of the project, four large tower cranes will be established in the corners (Hook height between 40 and 70 m - the largest of these will be able to lift 8 tons with a 70 m outreach.)

A major milestone in the project was reached end of May, as the bored piling was completed in the Monolith and Hot Cell areas, which means we are able to get started with the 2 m thick bottom slab below the Monolith. In total, about 28,000 m3 of concrete will be cast in the target area including the adjacent experimental halls.

The foundation that can withstand earthquakes consists of bored piles. Diameter 1.5 m, heavily reinforced in-situ cast piles, installed under the groundwater level, anchored in the bedrock consisting mostly of shale mixed with dolerite dykes. Total number of bored piles: 63 (completed 10/5-2016). Approx. cost / pile = 2 M SEK.

Other types of piles established in the Target area:

• 20-22 m long steel core piles (consisting of 120 resp. 180 mm solid steel cores). These are drilled and anchored 8-10 m into the bedrock. Total number of steel core piles: 356. (65% of these are mounted to date)

• Concrete piles, which are mainly used for the experimental halls:

normal tip-bearing precast concrete piles as that are knocked down and chiseled in with pile drivers in predrilled holes into the top of fresh mountain. Total number of Concrete piles: 6200 (65% completed).

The purpose of these types of piles is mainly to prevent vertical movements in the floors. High alternating loads on the floors will occur with 20-30 and even up to 40 tons / m2.

(Some environmental information about this)

• Piling works are noisy (noise is regulated by the Environmental Court); For this reason, we have built noise reduction barriers (sound barriers) along Odarslösvägen, to protect our closest neighbors from noise. We also have a time limit for when we can perform piling works (6-18).

• The Environmental Court ruling also regulates water outflow from the site to the surrounding drainage companies - for this reason we have built leveling magazines in the form of ponds where the outflow can be controlled and samples can be taken out of the water to ensure that the water quality is within the limits of the regulations - which include susp (75 mg / l ), oil and pH (6.5-9). No water is discharged to the south during the construction period as this is a "Natura 2000" area (nature conservation area - Puggängarna).

Left corner of the site: Building H05 - The ESS Primary Substation (distribution station for our incoming electricity, 20 kV) - located next to the Kraftringen power station (transforming down from 130 to 20kV) Interior works substantially completed (ABB is fanalising their switchgear construction)

Facades completed (190 m2). Testing & commissioning ongoing. Completion this summer. Handover to ESS in the autumn.

2. North Circular Road, Experiment Hall 3 to the right

**Building E01, Experimental Hall 3**. On the other side of E01: Guide halls E02 - the area where neutrons will pass through long glass tubes to finally end up in the long instrument stations which will be located in the building that is being built here on top of concrete piles.

Piling works are completed (over 1,000 concrete piles) for Exp. Hall 3 (Building E01), incl. cutting of piles to the right level. Reinforcement and casting of base slab is now underway.

A Lab building for Exp Hall 3 has started (E04) - Currently a basement part with elevator shafts and stairwells are completed.

Up on the hill we see eight groups of piles, they mark where the neutron beam guides will go down to the halls. Ramps are currently being prepared here (excavation & blinding).

To the left, outside E01/Circular Road: Out here in the area between the first and second electrical substations, H05 and H06, a high voltage cable has been installed in the ground.

3. Drive down towards Dog Leg, then proceed along North Gallery Road

**Building H06** - The distribution substation. 730 m2. Construction substantially completed. Inside the building various installation works are ongoing. From here the 20 kV is distributed to the different parts of the facility.

In H06 we also find diesel-fueled back-up power with step-up transformers, should the power supply from Kraftringen fail. - Planned completion early autumn.

**Building H01** - "CUB", Central Utility Building, the hub for all media to the facility. 3000 m2.

Will include water cooling systems - heat pumps - heat exchangers, - compressors - dryers - filters - buffer tanks - process water systems, deionization plants - etc. etc.

It will also include a large server room.

Roof works and finishing works currently ongoing – facades are to be installed this autumn.

**Building G04** - Cryo Compressor Building. Installation of steel frame and precast concrete was commenced early 2016 and is now completed - roof works and casting of the floors inside the halls also completed. A Gas Storage area next to G04 has been prepared with an in-situ cast base slab. This is where the helium tanks will be placed.

A precast culvert will be installed connecting G04 to the Cryo Transfer Line Gallery (the other side of the road, near G02 Gallery Building) – these works started early June 2016. Later this autumn, another precast culvert will be installed down to Target and Experimental Halls.

From this building, through the culverts, liquid helium at a temperature of 2K will the fed to the Linac, via the Gallery cold box. To Target we will be sending helium at a temperature of 16K.

**Building G02** - Klystron Gallery - With a number of other buildings connected to it here on the north side. The tallest part is the "Cold Box" and then a number of Substations are being built along the 489 meter long building.

G02 will supply the power needed for acceleration of protons in the tunnel. This is done by means of radio frequency power sources in the form of klystrons, modulators.

The Klystron Gallery is connected to the Accelerator tunnel with 27 chicane-shaped concrete tunnels, so-called stubs.

Through the stubs power and radio frequency waves are fed down to the accelerator. Together with cooling, vacuum and magnets we can steer and speed up the protons and the Linac will basically act as a giant superconductor.

Erection of steel frame and prefab concrete is currently ongoing to section 6 of the building, sandwich panels are being installed to section 5. Inside the building concrete floors are being cast and the first few sections have been handed over to the MEP section for electrical and ventilation installations.

The first section of the Gallery building contains the so called “Cryo office” – interior works are currently ongoing in here.

5. Drive towards Eastern Road, FEB

FEB (Front End Building, 650 m2) will contain the ion source, which is where protons are extracted from hydrogen molecules. In principle: using large microwave ovens and magnets electrons are separated from the proton - a positive hydrogen ion is thereby created) and then steered into the accelerator.

FEB connects to the Gallery Building on the north side. Right now prefab steel and concrete erection for the building at ground level is underway.

For shielding purposes, the concrete in the various structural parts around the ion source is thicker than other parts of the accelerator. For example, the top slab in the region of the ion source is 1.2 meters thick.

Drop Hatch - An opening through a shaft near the ion source for the installation of Accelerator equipment; this shaft will be converted to a permanent access point to lift equipment to the accelerator, with a crane.

Accelerator tunnel: internal dimensions W = 6m x 3.5m H

537 meters long - will be topfilled with 5-7 m of soil, green roof on a slope (sedum) above the Gallery Building.

Concrete works are substantially completed i.e. 16,000 m3. Only a few stubs and some "finishing and repair" before fully completed.

Our Landscape Architects are working on a concept of biodiversity for the whole site.

• We are working with an environmental certification, BREEAM, for the construction of ESS. This includes taking into account green measures in the design and construction (i.e. biodiversity, energy efficiency, health and safety). The level of ambition is generally "Very Good", but for each building the possibility to achieve the "Excellent" grade is assessed.

The aim is to eventually certify the entire facility - not just the offices.

6. Drive back along Gallery Southern Road

Look towards the mass balance area: Here we store modified soil to be reused for backfill for the Accelerator and other parts.

• Some environmental info about this: We have mass balance on the site, which means that we use all the excavated soil to backfill; This greatly reduces transports to site.

**HEBT Loading Bay:** This part is used for transporting equipment into the accelerator tunnel. Will also be used during future maintenance periods. All castings completed. Erection of large concrete elements is in progress for the building at ground level.

**Dog Leg** - the last part of the tunnel before the protons reach the Target: the tungsten wheel, where spallation occurs.

Construction works are completed, including an emergency exit, backfill is now ongoing.

*Drive back, out through gate B.*

Questions?