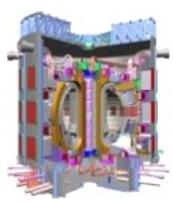
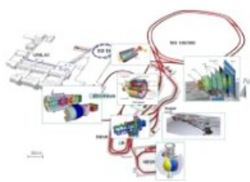
Virtual Engineering Study in ATLAS Collaboration

Nowadays High-Energy Physics (HEP) research with it ambitious goals intensify pressure on engineering activity for designing and construction of extraordinary scientific devices for the experiments. HEP research itself sets ambitious goals to perceive what happened after the big bang, how matter was created, are there extra dimensions and microscopic black holes, how to manage the thermal energy 10 time greater than sun's energy, how to use matter/antimatter interaction to beat nowadays invincible illness, etc. Several HEP international projects are going on today:

LHC (Large Hadron Collider), Geneva, Switzerland. 7'000 scientists and engineers from over 50 countries, budget 6bn euros

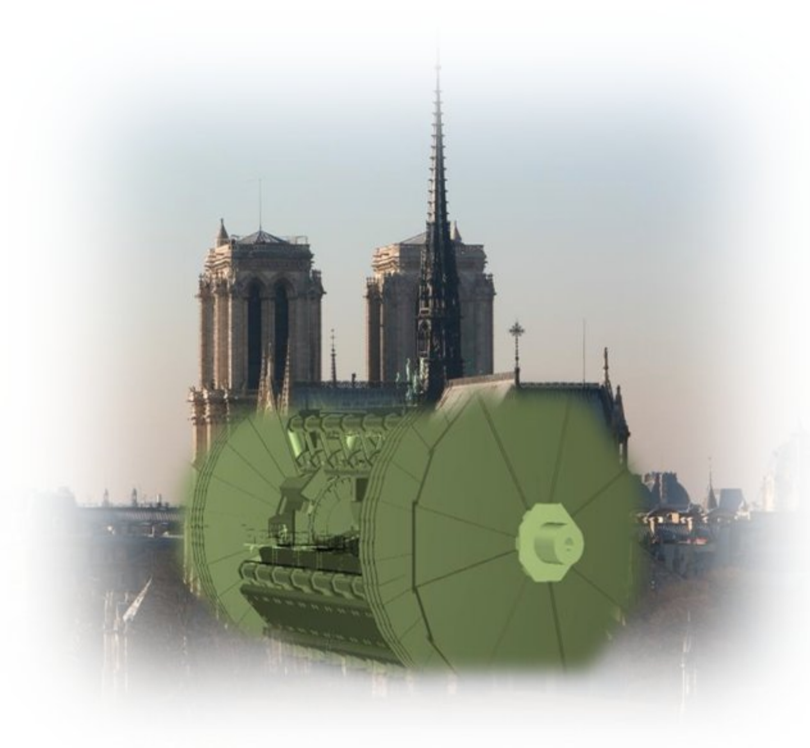


ITER (International Thermonuclear Experimental Reactor), Cadarach, France. 33 countries, budget 10bn euro's



FAIR (Facility for Antiproton and Ion Research), Darmstadt, Germany. 11 countries, budget 1.2bn euro's.

ATLAS collaboration is the part of LHC project. The aim of collaboration is to build world largest and most complex scientific facility – ATLAS detector.



7'000 tones

ATLAS detector is 46 meter long and 25 meter diameter device situated on 100 meter underground Geneva, Switzerland and weighted 7'000 tones as Eifel Tower. ATLAS collaboration unifies 169 partners from 37 countries with 2'500 scientists and Engineers.

Therefore, that enormous collaboration together with most complex and unique device sets completely new challenges to engineers. This is the new field of engineering activity, so called Nuclear Engineering, which has no similarity with traditional designing and construction activity of auto-moto, aerospace or ship building engineering fields.

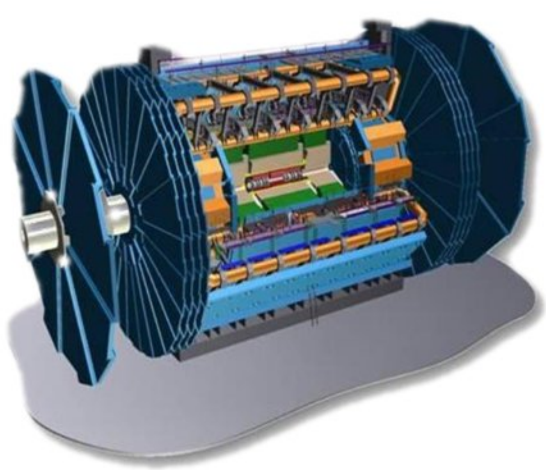
HEP facilities designing and construction life cycle characterized with standard phases as follow:

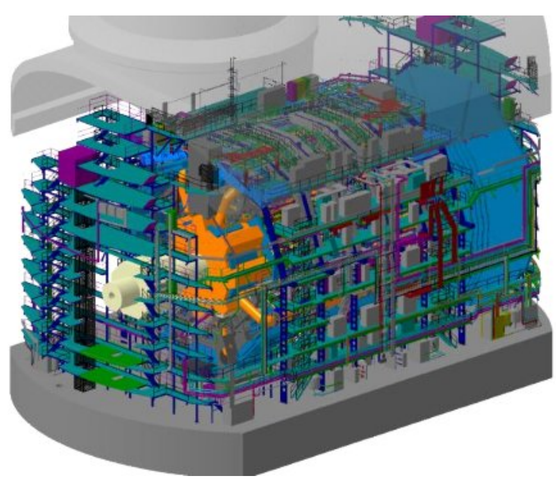
I. Geometry modeling
II. Engineering analysis
III. Fabrication and Assembly
IV. Installation
V. Survey control

However, each of them has special characteristics:

Complexity of Geo Model

Detector has comparatively simple profiles, mostly lines and arc's but assemblies have enormous complexity. Development of entire geo model of detector is caring out by large number of collaborative partners in heterogeneous environment. Usually partner institutes are using the CAD platforms, design methodologies and designers which normally exist there before. No one is looking for to change the own basis while it is extremely costly. Therefore there are no strict requirements inside the collaboration for the implementation of one CAD platform. Thus, entire geo model is distributed into different representations which cause difficultness and in many cases

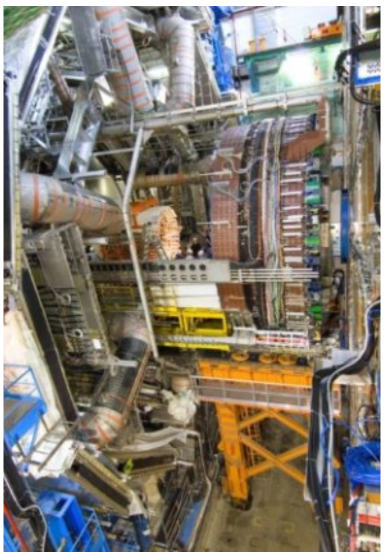


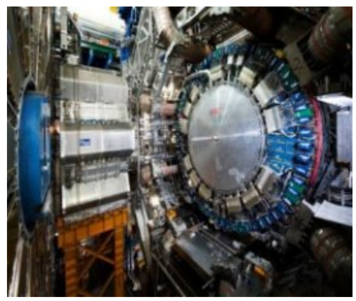


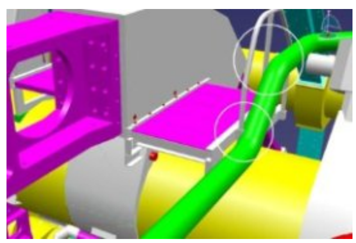
it is impossible to implement of entire geo model. Solution in this case is formation of special team inside the collaboration responsible for models selection, migration into one platform and development of entire geo model of facility. Geo model of ATLAS detector was built on CATIA v5 platform and consists of 3'705 big assemblies with 32 GB data. It contains more than 10'000'000 functional elements which are 2 time more than geo model of US military boat with all helicopters and gun devices on it. Geo model was built by migration of models from Euclid, Pro/Engineering and MDT platforms. 40% of models where failed during the migration and was recovered by geo model development team.

High Dense Environment for the Integration

High complexity cause high density of assemblies. Admissible clearance in ATLAS detector is 50mm.





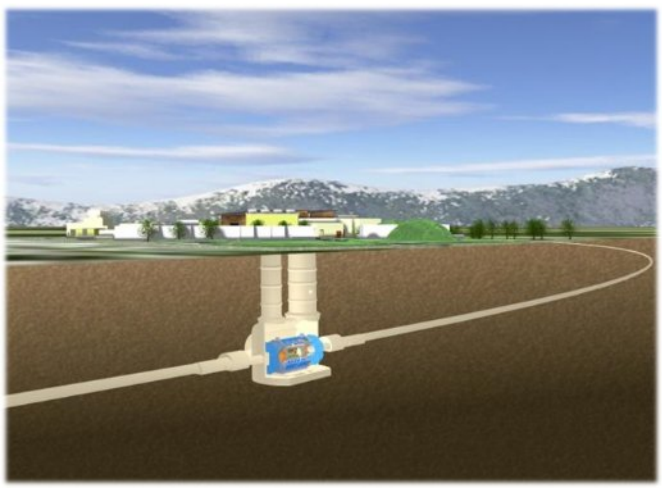


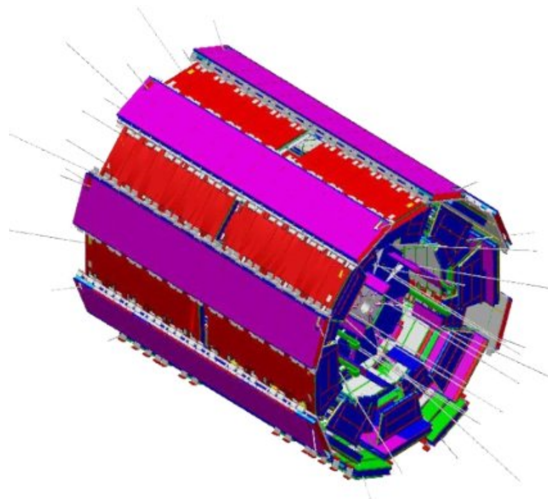
Big Dimensions and High Accuracy for Fabrication and Assembly

Big dimensions of detectors part to be manufacture are constrained with strict requirements to maintain high accuracy of machining and assembly. For instance, Tile Calorimeter is the one of the part detector. It is 8 meter diameter, 6 meter length iron construction with 22 tones weight. It consists of 64 segments assembled with 50 micron accuracy.

Specific Areas and Conditions for the Installation

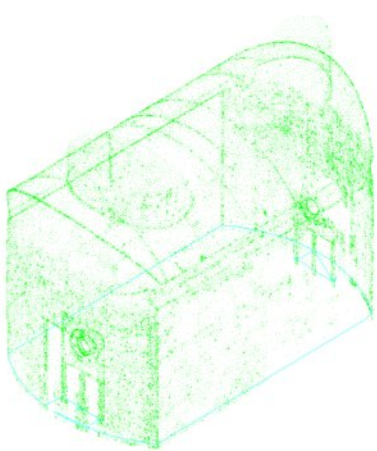
Large size of objects to be positioned, dense environment, underground installation and special approaches for the alignment cause difficultness to find out engineering solutions. ATLAS detector was installed in 100 meter underground. Installation precision was checked by 50 mm diameter alignment rays which are going through the detector without intersection up to the point preliminary setting up for the installation. ATLAS installation has been done in consideration of 124 alignments.

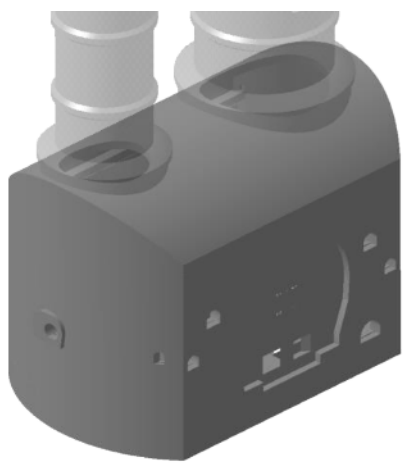




Survey Control

Big dimensions of HEP facilities makes impossible to do survey control in special workshops. It is possible just in the final place with implementation of special units and methodologies. ATLAS survey control was done by the laser scanning and comparison survey data with geo model.





Thus from one side we have special tasks for designing and construction and from other distribution of task between the big amount of collaborative partners. Virtual Engineering (VE) is the only way to proceed above described life cycle phases.

3 projects were done in virtual engineering environment:

I. Models migration and development of entire geo model of ATLAS detector
II. Integration conflicts checking
III. Installation modeling

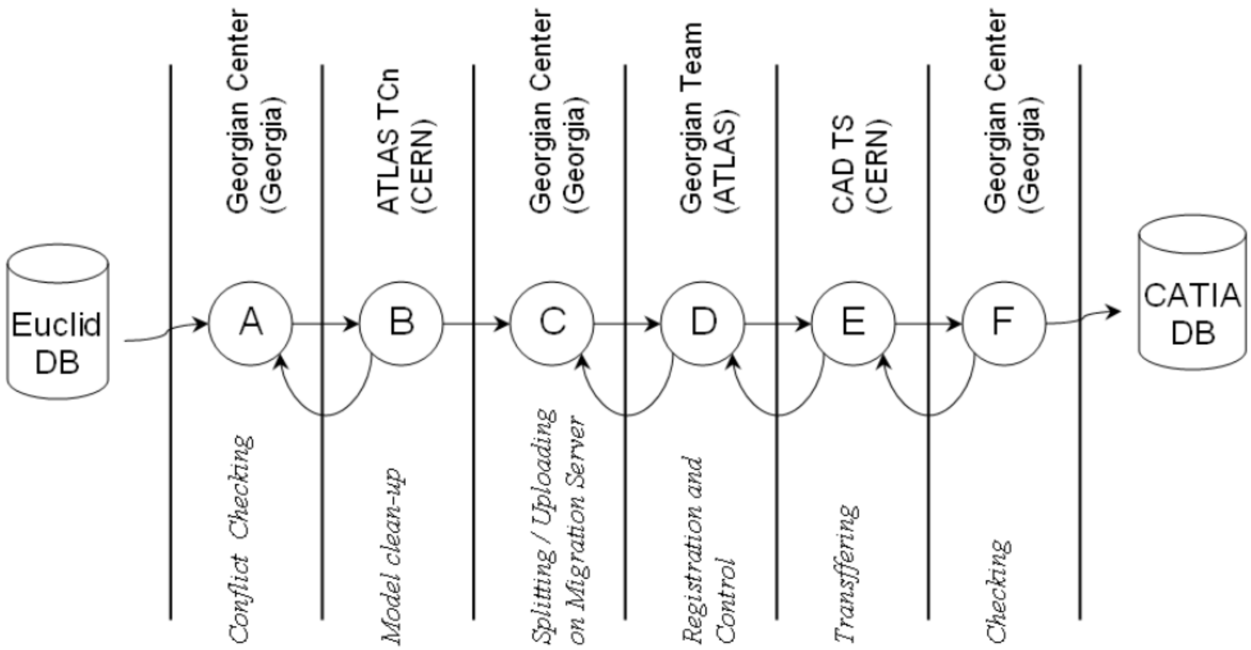
For each project steps as follow have been done:

1. Identification of partners
2. Development of VE process technology
3. Creation of VE architecture
4. Organizational management

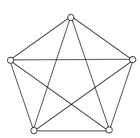
For the models migration 10 collaborative partners of virtual office were identified:

1. ATLAS TCn, Geneva, Switzerland
2. ATLAS Integration team, Geneva, Switzerland
3. GCCEC, Tbilisi, Georgia
4. CAD Support team, Geneva, Switzerland
5. CERN IT department, Geneva, Switzerland
6. CERN Design Drawing team, Geneva, Switzerland
7. EDMS team, Geneva, Switzerland
8. CLRC Rutherford Appleton Labs, UK
9. DAPNIA - CEA, Saclay, France
10. Institute of Physics, Freiburg, Germany

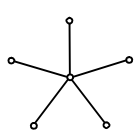
VE process technology has been developed. On the first step models were extracting from database by involving CERN EDMS team. Than it was checking on compatibility with entire geo model of detector, step .A. by GCCEC. On the next step .B. model was considered with ATLAS TCn and Integration team to check updates and correct faults founded on previous step. On the next step .C. model was splitting according to technical limitations of migration and uploading on the CDD server by GCCEC. Step .D. foresee registration of model for future transformation on CDD by CERN CDD team and GCCEC. On the next step .E. model was transferring into CATIA v5 by CAD support team and finally on .F. converted CATIA model was checking with initial model by GCCEC. At the end converted model with the checking reports were uploaded on EDMS server by EDMS team and GCCEC.



For the VE office architecture 2 schemes were established, cobweb and star.



Cobweb was using when partners organizing working sessions on the host partner platform. It was for the cases when relatively small amount of partners where organizing session for the local tasks.



Star was using for the cases when partners organizing large scale working sessions on common platforms, so called virtual office nodes. For that purpose 3 nodes were established and supported by CERN IT department.

Virtual office was based on the platform as follow:

- Windows XP – operation system
- TeamViewer – for desktop sharing and file transferring
- Skype – for audio/video conferencing
- 3 nodes – with double 3Ghz course and 4Gb memory
- CAD Software – CATIA v5, Pro/Engineering, Euclid, MDT, Workview, ECC