DESIGNING, INTEGRATING, AND COORDINATING THE INSTALLATION OF MEDAUSTRON

B. Nicquevert, C. Hauviller, M. Benedikt,
CERN, Geneva, Switzerland, and EBG MedAustron, Wiener Neustadt, Austria

Abstract

"Give me a layout good enough and a building to place it, and I will install your accelerator". To paraphrase Archimedes, this is the role attributed to the Integration team in the MedAustron project. Starting with the optics layout and a building sketch, the integration work consists of a series of activities, interlinked in a complex manner. First the design and the integration of accelerator: list all items, define geometrical envelopes with interfaces, put them in position in CAD, identify conflicts and define input for design of items and of infrastructure. Then the various equipment is procured: verify and validate design data, follow-up manufacturing, fiducialize equipment and build supports. Lastly the global installation: check building and infrastructure, define survey framework, install and pre-align equipment on supports, move assemblies to their final location, survey actual position and adjust to theoretical position. The whole chain of operations from the layout to a real beam in MedAustron, is illustrated. The help from item-driven data management is emphasized. Grouping all the activities within a single team favours interactions between stakeholders and the consistency of activities.

THE MEDAUSTRON PROJECT

MedAustron (Medical Austrian Synchrotron) is an ion therapy centre, which will deliver proton and ion beams for tumour treatment [1]. The accelerator complex is based on a synchrotron that will use slow resonant extraction to provide beams with the time structure required for active scanning [2]. The overall layout shown in Fig. 1 includes an injector complex with ion sources and a linear accelerator; a 25 m diameter synchrotron, fed by a medium-energy beam transfer line; and a high-energy beam transfer line, split into three treatment lines and a line to a research room. The accelerator complex will be installed in a dedicated building, currently under construction in Wiener Neustadt (Lower Austria) [3].

The project benefits from technical cooperation: CERN for the transfer of know-how and common preparation of the accelerator project; PSI (Switzerland) mainly for a gantry medical device; and CNAO (Italy) for their experience with a similar project in Pavia.

The main milestones of the project are: constructing the building (2011) and technical infrastructure (until summer 2012); installing and commissioning the accelerator elements (until mid-2013); probe testing and installing medical equipment (by end 2013); commissioning the overall installation (2014); and treating the first patient (2015).

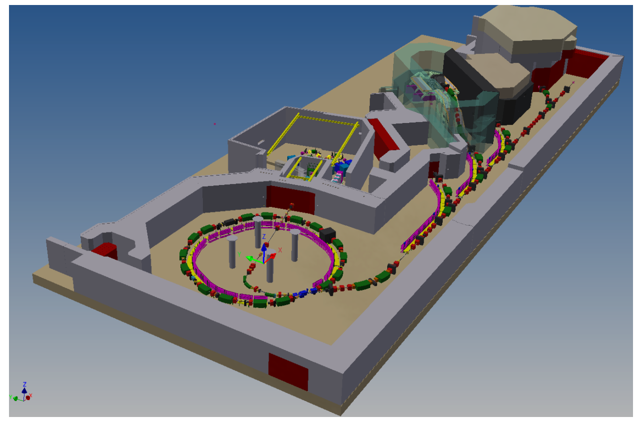

Figure 1: Layout of MedAustron.

The accelerator project is split into several work packages covering the main areas of the items to be procured: sources, linac, normal and special magnets, vacuum, beam diagnostics, power, radiofrequency, beam dump, and gantry. In addition, transverse work packages cover optics, controls, radioprotection, and integration issues. This paper deals with the role, organization and tasks of the latter so-called integration work package.

THE INTEGRATION WORK PACKAGE

The role attributed to the integration work package in the MedAustron accelerator project includes the tasks usually devoted to the technical coordination of such a project. It can be summed up, by paraphrasing the famous sentence of Archimedes: "*Give me a layout good enough and a building to place it, and I will install your accelerator*". This role is split into three parts (Fig. 2), strongly bound together: Integration, Design activities, and Installation coordination.

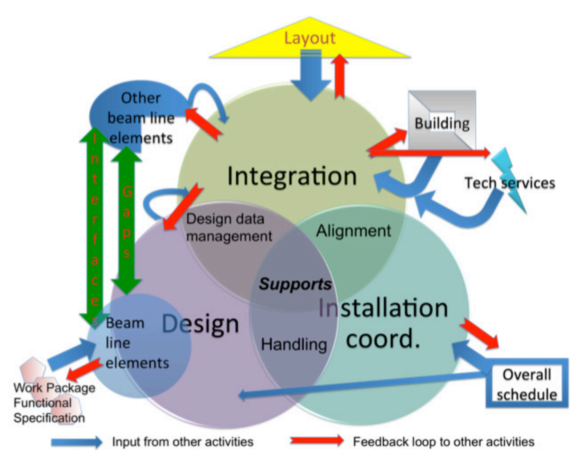

Figure 2: Integration tasks and links with other activities

The first set of tasks is the Integration:

- Layout representation: put the 3D envelope of each item in its theoretical location as defined by the beam optics;
- Geometrical integration: with the help of digital mock-up tools, check the design of each item against geometrical conflicts, define interfaces and ensure configuration management;
- Link between the accelerator and technical facilities: building and technical infrastructure

The second set of tasks is the Design activities:

- Provide the other work packages with design office services;
- Establish design rules and define the data model;
- Starting from the functional specifications defined by the work packages, design the items, and manage design data until completion of their release.

The third set of tasks is the Installation coordination:

- Establish the overall strategy for installation;
- In accordance with the overall schedule, define and assign resources and duration to each assembly task;
- Provide handling tools and dedicated resources for hardware installation.

At the interface of these three sets of tasks lay the supports and adjustment systems, forming a project on their own, with their design being strongly linked to the technical services and building, and also to the survey strategy which depends on their capabilities. The supports are therefore a direct and concrete material contribution of the Integration work package.

The following section describes how the above tasks are performed and which specific tools were introduced in order to help the team and project management.

DESIGN AND INTEGRATION PHASE

During this phase, the object is to deliver all the necessary design data to the suppliers of the accelerator elements, whilst ensuring the consistency of this data with geometrical constraints (infrastructure, neighbourhood), in line with the positions defined by the optical layout.

In order to get a clear view of all elements, a list of items (an item being a class of elements) was established and the design data was attached to the corresponding item node in the PDM (Product Data Management) information system [4].

Based on a basic knowledge of the size and dimension of each item – either from previous projects or from already existing 3D models – an envelope is created. This envelope is the combination of both the space allocated to the corresponding item, the geometrical parameters such as the optical centre, beam and vertical axes, and interface with its neighbours (vacuum, support, etc). The theoretical position of the survey marks is also defined therein. The use of an envelope is multiple:

- Thanks to its smaller file size, it can help either to build the master layout model shown in Fig. 1, or to set up local scenes of a digital mock-up (see Fig. 3);
- It is the basis for approval and set-up of the baseline of the project, and follow-up of its configuration;
- It serves as a geometrical gauge for as-built 3D data, in order to check whether the allocated space was respected by the suppliers.

In the example shown in Fig. 3, the scene was reconstructed with a mix of envelopes (bottom left), of so-called shrink-wrap models (a simplified 3D model derived from the design) and of full 3D models.

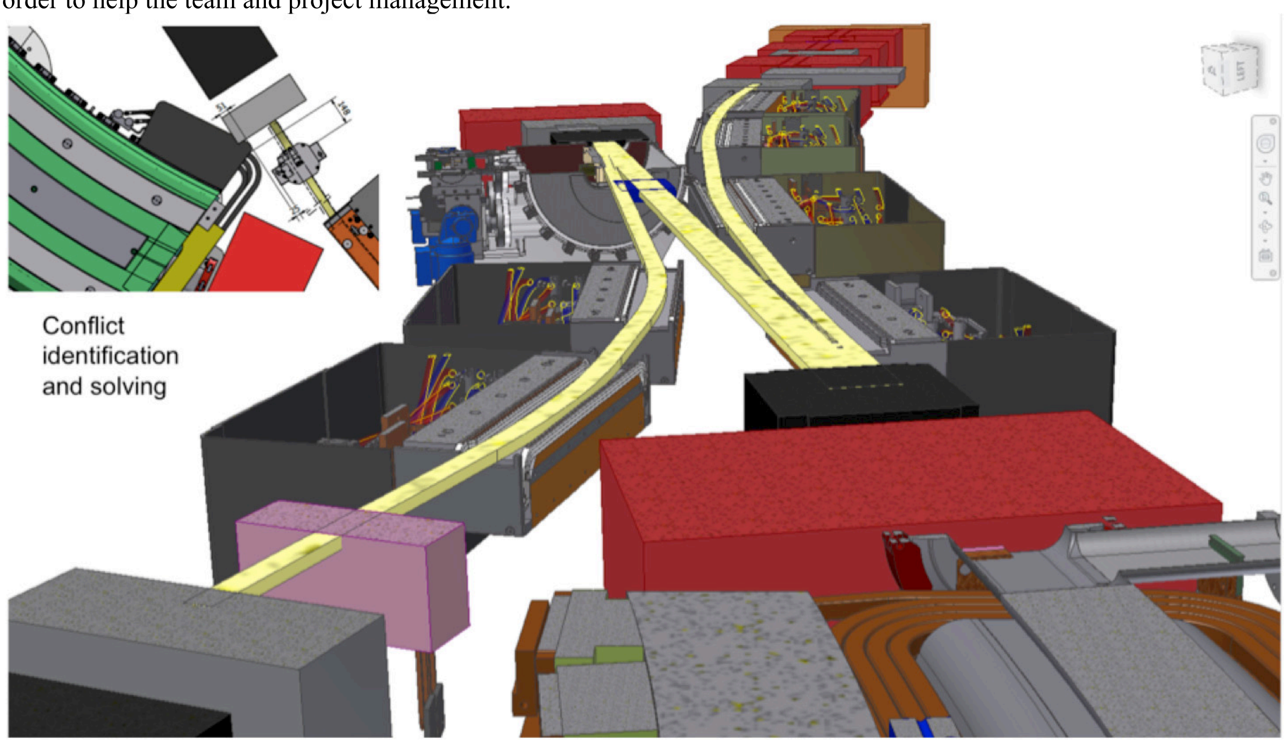

Figure 3: Integration (cut in the beam plane) of the injection / extraction area, one of MedAustron's most crowded ones

The integration work consists of dealing with these various representations of the same item, taking into account the different degrees of maturity of the information they contain. In the inset of Fig. 3, the insertion of a supplier's model of a magnet allows the conflict with another equipment to be identified.

Conflicts of this type will be solved through an Engineering Check Request procedure, ending with an update of the envelope and/or to a move of the position of the elements according to the solution found by partners.

FUTURE PHASES

To date (summer 2011), the master layout is available, most of the envelopes are set up, and the first items are entering their active procurement phase.

Production follow-up

During production, it is important to track back compatibility with the envelope defined, and to properly document results of the fiducialization task: measurement of the actual position of active elements with respect to the survey marks. This information is the basis for later alignment.

Installation coordination

Once the building and technical infrastructures are delivered at the end of summer 2012, according to the experience acquired by part of the team for the more complicated case of the LHC at CERN [5], the following phases will occur:

- Compliance check of the infrastructure;
- Set-up of the survey network and positioning of the theoretical beam line on the floor (blue line);
- Installation and pre-alignment of all supports, and finalization of technical services;
- Installation and connection of heavy equipments;
- Installation of lighter equipments, regrouped on girders, pre-installed, connected and pre-aligned in specific areas;
- Global alignment and smoothing;
- Individual hardware commissioning, and global test.

The installation will start in parallel in the injector and synchrotron areas. The injection/extraction area, as shown in Fig. 3, will be installed first in order to give the exact positioning of the four lines linked to it. The extraction line will be installed later, during the commissioning of the linac and synchrotron.

A limited set-up, the ITS (Injector Test Stand) is planned at CERN to probe performance, which will also serve as a pilot project for all the phases of integration and installation coordination.

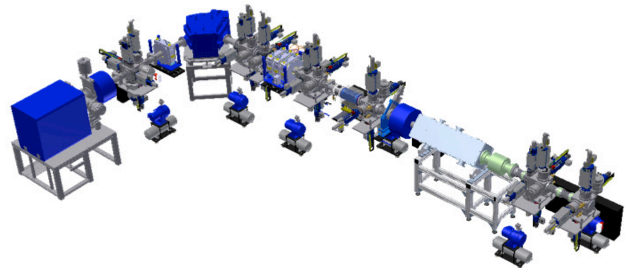

Figure 4: 3D view of the Injector Test Stand at CERN

ORGANIZATIONAL ISSUES

The quality of the integration work reached so far is due to three major key success factors:

- The use of an information system (based on Vault from Autodesk) allowing a quasi item-centric management of data [3];
- The modelization of integration processes and those leading to release of data;
- Grouping the three sets of activities (Design, Integration, and Installation coordination) under one single operational entity.

The complexity of such an endeavour, the merging of an equipped building, a nice optical layout and sophisticated elements, cannot be mastered without the proper management of all the integration issues. The team is now ready for Archimedes' task: integrate the actual accelerator in its building according to the planned optics.

ACKNOWLEDGMENTS

The authors would like to thank all of those who contributed to the organization and running of the Integration work package of MedAustron, at CERN and within the project.

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