Coordination in building an observatory: a case study of Eastern Anatolian Observatory (DAG)

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ABSTRACT

Eastern Anatolian Observatory (DAG) is designed to build on one of the summits of Palandöken Mountains in Erzurum, Turkey, at an altitude of 3,151 meters. The building is under construction since 2015 and expected to be completed in 2020. The building is designed as an integrated building, having operational departments, services, mechanical and electrical infrastructure for observations as well as cleaning and coating units, adjacent to the main observatory building. As one might expect this integration creates serious coordination problems between architect, engineers, telescope, enclosure, and cleaning & coating unit manufacturers. The construction progress of the investment is almost 20%. There are quite an amount of “lessons learned” in this period, and need to be developed by the parties, for their existing and future works. The building has so many challenges such as geological and geographical limitations, environmental and meteorological constraints, engineering and structural considerations, energy efficiency and sustainability, materials used and their performances at these limitations.

Keywords: Observatory, Observatory Design, Building Information Modelling (BIM), Design Coordination, Construction Coordination.

Abbreviations:

DAG: Doğu Anadolu Gözlemevi (Eastern Anatolian Observatory)
ATASAM: Atatürk Üniversitesi Astrofizik Araştırma ve Uygulama Merkezi
A&E: Architectural and Engineering
MEP: Mechanical and Electrical Engineering Projects
BIM: Building Information Modelling

1. INTRODUCTION

Doğu Anadolu Gözlemevi (Eastern Anatolian Observatory), in short DAG, is under construction on Mount Karakaya in the Konaklı region of the city of Erzurum, at a latitude of 39°46’50, longitude of 41°13’35 and an altitude of 3,151 metres. An area of 1.5 million square metres was previously granted to Ataturk University for the construction of the observatory. The area is easily accessible from the city centre and is only 20 km to the airport. There are good transportation links to the area, including asphalt roads up to the popular ski resort nearby and a dirt road from the resort to the area of construction. Furthermore, there is a good water, electricity and communications network in the area necessary for living at and operating the facility.

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DAG project has four physical components. These are telescope, enclosure, building including cleaning and coating unit and infrastructure. Almost all infrastructure, access roads, geological and atmospheric surveys, power supply, communication infrastructure (fiber optics), water supply, electric generator, etc. of DAG site have been completed.

Architectural and Engineering (A&E) design of the building has started on 2015 and almost completed. The reason for the prolongation of A&E design process is the uncertainty of building requirements. Therefore, design process has divided into two parts to speed up the completion of the project. Basic building layout and structural design was the initial stage. Structural design has completed on 2016 and subsequently, ATASAM called for construction tender. While the construction of the concrete and steel structure of the building continued, as a second stage, mechanical, electrical and architectural detailed designs have completed.

Project stakeholders, ATASAM as an owner, enclosure and telescope companies, engineers and architect have contributed to the project throughout the design process. Naturally, many problems have been encountered while making these contributions. In this paper the authors would like to share the lessons learned.

2. ORGANIZATION

Because there are many stakeholders in the project, ATASAM has established a project management organization.

![ATASAM Organization](https://www.spiedigitallibrary.org/conference-proceedings-of-spie)

Figure 1. ATASAM Organization

Figure-1 shows the organization chart of the ATASAM. The organization has administrative, scientific and technical units. All related subjects are carried out as a whole, while the unit studies are carried out independently. In this organization, the interfaces between the building, telescope and enclosure are coordinated by the department namely “PTT-Project Technical Team”. Although this unit appears to be a simple unit in the organization with complex components, the performance of the project depends on the success of this unit's coordination.
In figure 2, the interaction and information flow between the parties carrying out technical works is given.

**Figure 2. Interaction and Information Flow Between the Parties**

As seen in Figure 2, DAG has several contracts with different service suppliers, contractors and manufacturers. These contracts are independent, but all are implicitly related of each other. Each are different entities, has different responsibilities and limited scopes. After all, DAG should coordinate, communicate and collaborate with them all. While doing this, the project should be on track and time.

3. **DESIGN PROCESS AND PROPOSED METHODOLOGY**

The design procedure of each component of the project shows similar behaviour. This cycle can be summarized as Planning – Doing – Checking – Acting (PDCA).

Planning
  Step-1: Define the scope, characteristic and inputs,

Doing
  Step-2: Create the design,
Step-3: Test with necessary engineering solutions, list the “design outputs”;

Checking

Step-4: Check the solutions with scope and find out the results

Acting

Step-5: Redesign the components

Step-6: Back to the third step until achieving the final design

Design process, therefore, shows continuous and repetitive behaviour. Each and every “design output” should be the input to another component.

Information from one party to another may have a direct effect on shaping the design. Therefore, all components behave like black-box and require inputs and generate outputs.

Some examples about inputs and outputs:

- Soil investigation results are the input for structural engineer to design suitable and stiff foundations (information flow from geological engineer to structural designer);
- Defining the operational volumes of each component in telescope buildings are the inputs for creating suitable architectural solutions, which will also affect the cost of investment (information flow from manufacturers to architect);
- Technical specifications are the inputs for architectural material selections to fulfil the extreme geographical conditions (information flow from material providers to architect);
- Mirror installation and removal procedures are the input for architectural design solution to provide and operable mirror removal shafts (information flow from telescope manufacturer to structural designer);
- The calculated dead weight of telescope and enclosure are the input for structural engineer to design suitable pillars (information flow from manufacturers to structural designer);
- The expected stiffness of telescope pillar is the input for the design of telescope pillar (information flow from manufacturers to structural engineer);
- The anchorage details of enclosure and telescope are the inputs of designing the rebar allocation of structural pillar to prevent the overlapping of the bolts and rebars (information flow from manufacturers to structural designer);
- The “K” values of the enclosure and mass of each component are the inputs for heating/cooling capacity design of the observing floor (information flow from manufacturers to mechanical designer);
- Measured wind load information is the input for enclosure manufacturer to design suitable enclosure structure and structural design (information flow from meteorological engineer to enclosure manufacturer and structural designer);
- The procedures of shipment of telescope and enclosure are the inputs for the selection of Logistic company as well as necessary installation equipment and access roads;

These are some examples of mutual exchange of information and can be increased.

Another important problem is that all parties are in different locations and the communication between them is done by remote access. For this reason, information sharing is slowing down. Beyond that, every major component manufacturer does not want to share their proprietary data fully, which is understandable. Therefore, through the design process there may be some missing points and can be solved pragmatically during implementation.

In DAG project, information sharing media was 2D drafting programs and written documentation. The use of these media has become somewhat of a necessity, as there is no special notice about the way of sharing information in the
contracts, made with the parties. After having the implementation practise, it is obvious that the use of common sharing platform, such as BIM (Building Information Modelling), would be much practical, accurate and speedy.

Traditional design of any physical objects (buildings, telescope, enclosure etc.), was largely reliant upon two-dimensional technical drawings (plans, elevations, sections, etc.). However, Building Information Modelling (BIM) extends this beyond spatial dimensions (3D) with time as the fourth dimension (4D) and cost as the fifth (5D). BIM also covers spatial relationships, light analysis, wind modelling, structural behaviour, geographic information, as well as quantities and properties of components. Therefore, BIM covers more than just geometry.

With the use of such a media, parties can instantly share all their inputs and works on the same common drawing. Therefore, use of BIM, goes beyond the planning and design phase of such a complicated project, extending throughout the life cycle, supporting processes including cost, construction, project management and facility operations.

The process of planning and designing in BIM is based on three-dimensional realization. This makes possible to visualize the final product before staring the construction of any part. This visualization can be defined as visual design-to-construction (VDC). The BIM manager is retained by a design build team on the client's behalf from the pre-design phase onwards to develop and to track the object-oriented BIM against predicted and measured performance objectives, supporting multi-disciplinary building information models that drive analysis, schedules, take-off and logistics.

4. CONCLUSION

Participants, in building an observatory, are constantly challenged to collaboration successfully collaboration to create proper design despite tight budgets, limited manpower, optimised schedules due to extreme geographical and meteorological conditions, and limited or conflicting information. The significant disciplines such as architectural, structural and MEP designs, beside the telescope, enclosure and coating unit manufacturers' designs should be well coordinated. BIM, aids in detection of any overlapping and unexpected discrepancies at the very initial stage. The BIM concept envisages virtual construction of a facility prior to its actual physical construction, in order to reduce uncertainty, work out problems, and simulate and analyse potential impacts.

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