Big Science: Do These Dollars Make Cents?

The Social, Political, & Technological Impact of Big Science and the Big Engineering Behind it

Executive Summary

The desire to expand the realm of knowledge is an attractive one, drawing in many hopefuls throughout the ages. At this point of scientific endeavour, humanity has moved on to Big Science, where the energy is big, the machinery and tooling are big, the revelations are fundamental and the price tag is elephantine. Under consideration are four projects, in two categories (particle accelerators and fusion reactors), chosen for their popularity and size. These projects are the National Ignition Facility, the International Thermonuclear Experimental Reactor, the Relativistic Heavy Ion Collider, and the Large Hadron Collider. The objective of this report is to determine the legitimacy of funding these types of projects, as well as how the performance of said projects might be improved.

Engineers play a significant and critical role in all of these projects. They are crucial during the design, construction and maintenance phases. During construction, engineers are challenged to design complex and new machines that have to endure the extreme conditions of the experiments. Furthermore, once the projects have been constructed, engineers need to maintain the operational status of the machines. Different projects highlights the role of engineers from various viewpoints, with engineering focused projects like ITER emphasizing engineering more than a more fundamental science project like the LHC.

The extreme nature of these projects leads to unique challenges. These challenges are can be categorized as those related to extreme size, high technical risk, and large complex organizations. The combination of massive size, with the components often being thousands of tons, the tight tolerances, specialized equipment and techniques are required. In addition, due to the fact that all big science projects involve working in physical regimes not yet explored, there is a high degree of technical risk, with new technologies needing to be developed as part of the project. These are both compounded by the large team size (thousands of people), and the international character of the organizations often behind the projects.

These challenges can actually lead to societal benefits of big science. Because new technologies need to be developed as part of these projects, they can subsequently be used in a wider range of applications. The world wide web is the most famous example. These projects also spur both the creation of competent professionals and increase public excitement and interest in science and technology. Big science can also provide direct economic benefits to the involved countries from the construction and development of the experimental apparatus. However, there can also be downsides,

with public safety sometimes being a concern. The largest downside is, of course, the massive amount of money required to undertake these projects, with each costing billions of dollars, with projects often going way over budget and behind schedule.

As a result of our research, we make five recommendations to improve the performance of big science: Better exploitation of technological innovation, strong independent multi-project international organizations, acknowledgement of risk and better budget oversight, committed year-to-year funding, and an emphasis on strong project management.

We find that while these kinds of large projects are expensive and fraught with cost overruns and delays, the value provided from mega-projects is worth the time and resource investment that Big Science demands. To ignore these undertakings and opportunities is to ignore the future of human progress.