Optimising megascience project leadership

Evidence from the Tevatron and the Large Hadron Collider (LHC)

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Abstract

Background - A development within the last century in scientific research has been the need for very large apparatus to explore new experimental fields, notably within high-energy physics. These 'megascience projects', which have a minimum budget of one billion US dollars are generally undertaken as cooperative ventures by countries seeking to pursue scientific experimental opportunities. Such projects are characterised by high levels of technological uncertainty, because success will likely depend on the development of new, highly-advanced technologies. However, there is a notable lack of research into the leadership of megascience projects.

Objectives and Methods - The projects investigated were the Tevatron at Fermilab, near Chicago in the United States, and the Large Hadron Collider (LHC) at CERN on the Franco-Swiss border near to Geneva. This research used a combination of archival and interview-based research to answer three research questions: (1) What are the characteristics of those who lead megascience projects? (2) Where were their leadership skills developed? (3) How were their leadership skills developed?

Results - The most important finding was the tailoring of senior leadership selection according to the needs of specific phases of the project. Four phases were identified: initiation, approval, construction, and exploitation. During the project there was a transition in senior leader characteristics from a transformational autocracy to an increasingly laissez-faire style. The characteristics of successful leaders of megascience projects at all organisational levels include 1) the primacy of technical competence, 2) strong management ability, 3) trustworthiness, and 4) team empowerment. This is somewhat unusual compared to other projects on this scale. The experiential nature of leadership training within megascience projects is also critical for success, with formal leadership training programmes acting in a support role at most. This work also has implications for the next generation of megascience projects which is addressed as a conclusion.

Megascience Definition & Study Design

The definition of megascience is *experiments or other projects with budgets in excess of one billion US dollars, undertaken by laboratories* [1]. The successful endpoint of a megascience project often occurs when both experimentation and all upgrades are complete. The focus then can shift to a new subset of science which necessitates the construction of new apparatus [2].

The case study design was formed according to the schematic displayed in Figure 1.

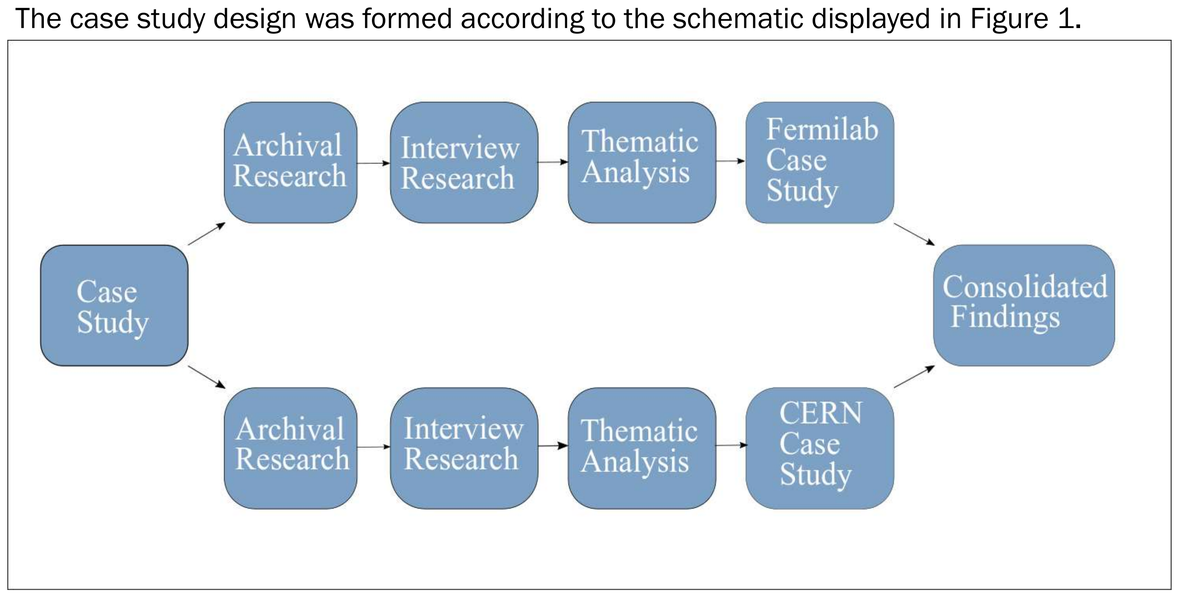
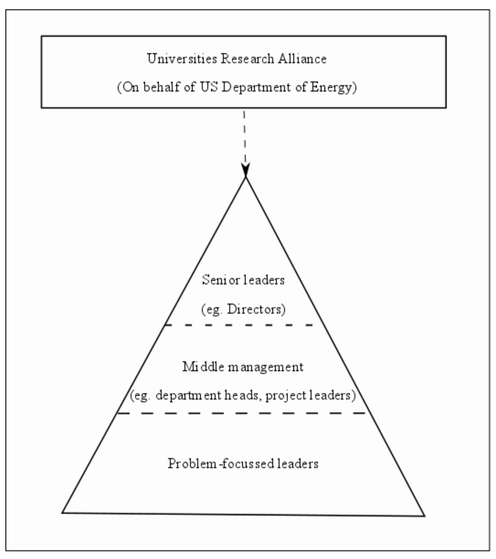


Figure 1: A schematic illustrating the study protocol

Leadership in megascience projects can be understood in terms of a three level organisational model incorporating problem-focussed leadership, middle management, and senior leadership [3]. See Figures 2a and 2b for a visual display of these models in the case of Fermilab and CERN.



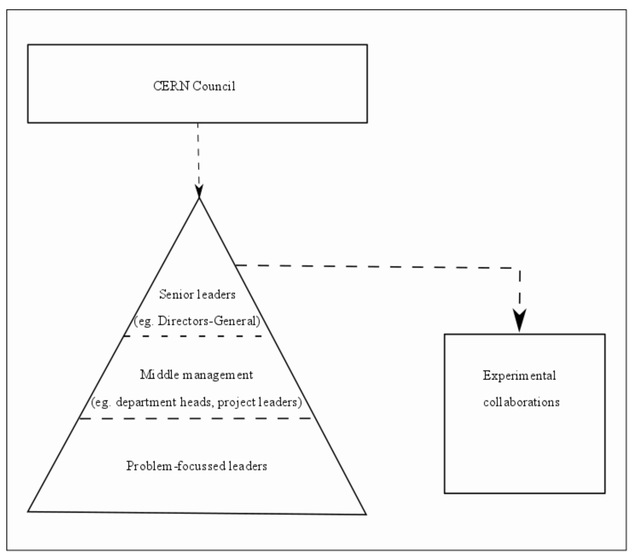


Figure 2a and 2b: Diagrams showing the organisational structure of Fermilab and CERN respectively in the context of the three level model for analysing leadership. Also illustrated is the indirect link between CERN and the experimental collaborations

Results

Characteristic	Restrictions
Technical competence	Essential for all leaders at all levels (contrary to traditional project management methodologies)
Management ability	Observed at all levels but essential for middle managers
Vision	Essential for first senior leader, less important for subsequent senior leaders. Redundant for leaders elsewhere
Charisma	Important at all levels
Transactional characteristics (Keeping to budgets and schedules)	Important for middle managers towards the end stages of a project
Guided democracy	Only observed amongst leaders within experimental collaborations
Team empowerment	Important for all leaders
Trustworthiness	Essential for all leaders and their teams, links to team empowerment

Table 1: Summary of the characteristics of leaders in megascience projects and which levels these characteristics were observed

The training of problem-focussed and middle management leaders is conducted within the laboratory using practical experience as the main training tool with formal training programmes acting only as a support tool. For these particular leaders, this training begins after being identified by a more senior colleague and receiving opportunities to develop their leadership skills.

Senior leaders usually work at universities or other research institutes. By following the academic route, these leaders become involved in developing policy for science. This experience is important when selecting new senior level leaders, but it is possible to create an apprenticeship period to provide on-the-job experience. Although these senior leaders may not have spent long periods working at the laboratory, they generally have a long-standing relationship with it.

One finding that emerged during this research was that the senior leadership of a laboratory was significantly influenced by the phase-specific needs of the project at that time [4]. Table 2 details these phases and the characteristics of the senior leaders selected to meet those needs.

Phase	Characteristics of phase	Characteristics of phase-specific senior leader
Initiation	Many technical ambiguities. Internal debate over which big machine should form basis of laboratory strategy	Authoritarian. Technically focussed. Very charismatic. Well-suited to transformational or authoritarian leaders
Approval	Internal debate settled around machine. Funding for machine required which necessitates agreement amongst stakeholders	Democratic. Consultative. Seeking to build consensus and trust amongst stakeholders
Construction	Civil engineering and machine assembled. Project leader takes lead role and has freedom to be authoritarian if necessary	Oversight of the project leader. Rarely intervenes except in the event of a major crisis which risks loss of stakeholder trust
Exploitation	Shift in focus: a) Fully exploiting the now-completed machine b) Horizon scanning to determine the characteristics of the next big machine	Support role to help the laboratory and collaborations generate data. Moving resources to help individuals investigate promising technologies for the next big machine.

Table 2: A summary of the phases identified for megascience projects and the characteristics of the phase-specific senior leader

Recommendations

This poster has identified the characteristics and training of leaders in very large physics projects (Table 1), and discovered how to optimise the selection of senior leaders to meet certain phase-specific project needs (Table 2).

Recommendations for future megascience projects such as the Future Circular Collider (FCC) are to embrace the finding that senior leadership is selected to enable certain phase specific project needs.

A. Laboratories should reconfigure such procedures to limit terms served by senior leaders
B. Laboratory stakeholders should consider how future candidates can meet the five year needs of the project in light of the four phases identified above.

References

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