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Soapbox

Cast iron promises

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ABSTRACT

During the Victorian era, a fiercely competitive industry emerged to build and operate Britain's railways. Many of the design and construction skills required were still fairly rudimentary, and were typically developed through practical experience. The resulting mix of entrepreneurship and new technology reshaped the landscape, but often in ways which proved hazardous for passengers. Minor accidents were commonplace, and a number of major failures occurred, one such being the collapse of the Tay Bridge, in 1879.

Events in the ten years prior to this disaster still have some resonance today. Ambitions to exploit new technology are not always matched by foresight in the planning, financing or management of projects. Contracts may be based on wrong assumptions, and prove difficult to enforce. Once a project has gathered momentum, those working on it may fear that any attempt to draw attention to risks or defects will be seen as disloyal. When work is completed, it cannot be assumed that formal inspections will reveal potential flaws, or that those using the technology will appreciate the need to follow the procedures laid down for them. Some possible parallels with recent experiences in NHS computing are noted.

Keywords: escalation, governance, innovation, NHS Connecting for Health, project management

Introduction

> When I see so many young engineers, and such a variety of notions, I am convinced that some system should be laid down, to prevent wild and visionary schemes being tried, at the great danger of injury or loss of life to the public.
>
> George Stephenson, 1841[1]

Stephenson was alarmed at the rapid and often ill-disciplined growth of the country's railway system. Most of these 'wild and visionary schemes' were being promoted by railway companies. The merits of each scheme had, in theory, to be tested by means of a debate in Parliament. But getting a Railway Bill enacted was a lengthy and chaotic process, involving bitter feuds between landowners, rival transport companies, town councils and other vested interests. Fighting for routes and profits tended to take priority over more fundamental questions about safety and practicality.

Meanwhile, a steady stream of collisions, explosions and derailments bore witness to the dangers of the new technology. Occasionally, an accident was so dramatic that its safety implications could not be brushed aside. So, in December 1879, when part of the newly-built Tay Bridge collapsed and 75 people died, an official inquiry was set up within days, and its findings were published six months later.[2]

The proceedings and report of this Inquiry, and the technical debate which has rumbled on ever since, make fascinating reading. The sequence of events, and the tactics of parties involved in this ambitious and prestigious project, suggest that there is nothing new under the sun, or, more specifically, under the mantle of NHS Connecting for Health.

Contracts and deadlines

The first Tay Bridge project was proposed by the Board of the North British Railway (NBR) in December 1869. It was to cost £229 000 and to be completed within three years. After extensive wrangling, and the withdrawal of the original contractors, a new contract was signed in May 1871: the bridge would now cost £217 000 and be ready in November 1874. In the event, it opened to traffic in May 1878, and cost over £626 000.[3]

Two years into the contract, it was discovered that the original surveys of the river bed had been inaccurate, and so the majority of the bridge's structure had to be redesigned. Different foundations would now be required for many of its pillars, and cast iron structures were introduced in place of brick, in order to save weight. Argument still continues as to whether the new design was inherently weaker than the old, but the increased use of cast iron undoubtedly led to problems of quality control in the bridge's construction. Nor did it help that the bridge designer, Thomas Bouch, was by this time absorbed in another major project, developing his ideas for a revolutionary suspension bridge across the River Forth.

At around the same time, the main contractor on the Tay Bridge, Charles de Bergue, died, and his firm withdrew from its commitments. They had in any case been incurring losses on the work. Bouch quickly struck a deal with one of the other bidders, Edgar Gilkes, to take over, using substantially the same workforce. Despite these key changes, and a series of accidents in the often appalling weather conditions on the Tay, shareholders in the railway company were assured that everything was going according to plan. Completion, they were assured, would be before the end of 1874.

The stage was now set for a series of deceptions, as various parties set about protecting their own interests, and colluded in keeping problems under wraps. The increased dependence on cast iron meant that a new foundry had to be set up near the bridge site. The general engineering manager, Frank Beattie, was based on site, but was regularly duped by the foundry foreman. Whenever Beattie was sighted heading for the foundry, cloths were draped strategically over flaws in the castings. Some really bad castings would be left prominently displayed, for Beattie to examine and reject. Having survived this 'inspection', the defects would be concealed by filling them with a mixture of beeswax, resin, iron filings, and lamp black.

Meanwhile, other lapses of oversight were occurring in Middlesbrough, where two sub-contractors were casting ironwork for the bridge. Knowledge of the shortcomings in some of the components being sent north to the Tay must have been quite widespread, but it suited no-one to draw attention to them.

By 1876 the project was running well behind schedule, and getting short of money. The NBR, as sponsor of the project, now had little option but to raise the funds for a significant amount of extra labour and machinery, in order for the bridge to be completed. The contractors agreed to a new deadline of 1 September, with a bonus of £2000; this was renegotiated soon afterwards, to 15 September and £4200. Powerful lamps were purchased to enable the foundry to operate through the night, and the workforce was expanded. This frantic activity improved the rate of progress on the bridge, but at the cost of still more bodges and compromises in its assembly. Again, it would have taken a brave soul to draw attention to any of the skimped workmanship, especially when so many of the construction workers were risking their lives in the stormy conditions on the Tay.

It was not just expediency that led to an acceptance of imperfections. Legitimate doubts surrounded the standards which were to be expected. As the Inquiry pointed out subsequently:

> In regard to the imperfection of workmanship and fitting, it appears that as the substitution of iron for brick piers ... was made after the contract was let, there are no clauses in the specification describing the class of workmanship to be employed.[2]

The renewed efforts resulted in completion of the main bridge structure close to the revised deadline. The contractors collected their bonus. A VIP train rode out onto the bridge and back to Dundee, after which the passengers had a splendid lunch. A spectacular firework display was given from the bridge structure that same evening.

The celebrations were perhaps a little premature. The bridge could not be opened to traffic, as it was not yet connected with a railway line in either direction. To the north, slow progress was being made on a tunnel through Dundee. To the south, track was still being laid to Leuchars Junction.

The inspector's report

The bridge also had to be approved by the Board of Trade. This was intended to provide some reassurance for the travelling public, but the inspection process was not particularly thorough. Like many home surveys today, it only recorded defects that were readily apparent. As the chairman of the later Inquiry, himself a lawyer, noted:

> There seems to be an impression abroad that, after a work has been inspected and passed by the officers of the Board of Trade, the engineer and others, by whom it has been constructed, are relieved from responsibility for any defects, which may subsequently be discovered; but this can hardly be so.[2]

The Tay Bridge was, at the time, the longest bridge in the world, and so there was some debate as to how exactly it should be tested. In the event, six heavy engines were driven out onto the bridge, and stopped and started at various points on it. What the testing could not establish, since the weather was fine, was how the bridge, or carriages crossing it, would fare in bad weather, and particularly in high winds.

The inspector, aware of this, recommended that trains should cross the bridge at no more than 25 miles per hour (mph).[2] Since the bridge had various gradients and a long curve, this called for some fine judgements, which many engine drivers were reluctant to bother with. Their cabs had no speedometers, and, like today's lorries, they were keen to keep up momentum. One witness at the Inquiry claimed to have timed trains crossing at more than 40 mph, and the station master in Dundee had become accustomed to complaints from passengers, alarmed at the swaying sensations they had experienced while crossing the river.

When tragedy eventually struck, it was during a particularly violent storm. The train was probably seeking to make up time, as it was running a few minutes late. The exact cause of the tragedy, however, may never be known. The barrister who chaired the Inquiry seems to have been determined to pin as much blame as possible on the designer, Thomas Bouch. Accordingly he wrote a long and at times impassioned personal report, highlighting the evidence pointing in this direction. The two other members of the panel, both engineers, were more hesitant. They listed some of the deficiencies in the way the bridge had been built, and reviewed the calculations – often based on rather vague estimates – concerning the strength of the ironwork and the effect of wind speeds.[2] They recommended the development of new rules 'regarding wind pressure in railway structures'. But (perhaps in some measure because of professional solidarity) they were reluctant to apportion blame.

Failures of oversight

Like NHS Connecting for Health, the Tay Bridge project was ambitious in its scale, but not particularly innovative in its design or use of technology. The great length of the bridge, and its dramatic setting, captured the popular imagination, and public reputations were quickly bound up with its success. Commercial pressures meant that the NBR pushed its contractors hard, to enable it to open up the new eastern route into Scotland as quickly as possible, and contracts for the bridge included both incentives and penalties. Events showed, however, that these counted for little if the contracts themselves were incomplete, or based on wrong assumptions.

Management of the project was formally divided between the NBR, as commissioners of the bridge, and the Tay Bridge Undertaking, who were responsible for building it. But it was not quite as simple as that. The appearance of an adversarial relationship was useful in trying to placate irate NBR shareholders, but behind the scenes the parties often had a common agenda. For example, neither was keen to draw attention to any setbacks in the construction work, or escalations in cost. As time went on, with more and more investment committed to the project, the influence and bargaining position of the NBR gradually weakened.

The engineers responsible for constructing the bridge faced a number of pressures: to meet deadlines, to constrain costs and to carry on working regardless of the weather. These problems would have been familiar to them, as would have been the remedy – a judicious use of short cuts, based on the assumption that the original design had been deliberately overspecified. Often this was indeed the case, but not always: for example, Bouch had opted for a minimal approach to some aspects of the bracing, in order to save on cost and weight.

Engineering was in any case a young profession, comparable in some ways to IT today. Individuals earned their reputations through experience in a particular aspect of project work, such as sinking caissons or erecting girders. This did not necessarily equip them to spot potential weak points in the structure as a whole. Once the bridge was built and routine maintenance began, the dangers of this compartmentalisation became particularly evident. Henry Noble was appointed to oversee the maintenance work, and as the two engineers on the Inquiry team observed, with impeccable courtesy:

> The arrangements for the supervision of the bridge after its completion were not satisfactory, inasmuch as it was intrusted solely to Henry Noble, who, although an intelligent man and very competent in the class of work to which he had been accustomed, possessed no experience in structures of iron work ... [2]

Mr Noble did, nevertheless, attempt to carry out repairs on the ironwork, not always to good effect. To eliminate looseness in some of the bridge's tie-bars, for example, he hammered wedges into the gaps which had opened up. This was an inappropriate and dangerous remedy, since although it eliminated the rattling, it also distorted and weakened the structure.

After the Tay Bridge disaster, engineering gradually moved towards more systematic methods for the management of major projects. Politicians, entrepreneurs and journalists, on the other hand, were less inclined to see any of the systemic problems. Joseph Chamberlain, as President of the Board of Trade, joined the clamour for blame to be laid squarely on Thomas Bouch. The press, having at first hailed the bridge as a triumph for modern engineering, abruptly changed its tune, and made heroes and villains according to its favourite prejudices. The NBR, anxious to rebuild or replace the bridge, began to distance itself from those involved in the original venture.

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VIEW OF THE TAY BRIDGE BEFORE THE ACCIDENT.

VIEW OF THE TERRIBLE RAILWAY ACCIDENT AT TAY BRIDGE ON DEC. 28.

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Little attempt was made to explore or understand some of the more institutional factors that lay behind the disaster. Quality checks had apparently been in place, but had often been circumvented with ease. The Board of Trade inspection carried out in three days of fine weather had not revealed any serious structural weaknesses. Precautionary measures recommended by the Inspector, such as the speed limit, were not adhered to. Throughout the project, many of those who built and maintained the bridge felt it would be prudent to keep quiet about any worrying signs they had noticed, suggestive of defects in construction. In any case, there was no guarantee that such concerns would have been passed on: Henry Noble, for example,

had no contact with the company engineer responsible for the state of the rails over the bridge, even though the track and bridge were bolted to one another.

The project showed quite clearly, for anyone prepared to look closely, that a hasty commissioning process, based on inadequate information, followed by aggressive contracts and deadlines, invited trouble. Also, that the dividing line between reasonable ambition and recklessness was a fragile one. Once everyone had been recruited into the project's dramatic vision, it was hard for any dissenting voice to be raised; even if it had been, poor lines of communication reduced the chances of it having any effect.

Some conclusions

The moral of the story is not that NHS Connecting for Health is doomed to failure. It is that human responses in large projects remain forever the same, regardless of the technology. For example, builders may overestimate the foresight of designers. Supervisors may take a blinkered view of their responsibilities, and processes of regulation may be warmly endorsed, even though no-one quite believes in them. Where the profession surrounding the technology is young (as is the case, relatively speaking, in IT), people may misjudge the skills of themselves or others. And where people are required to follow rules, whether in driving engines or using smart cards, it is essential that the rules are practicable, and their purpose is widely understood.

A new Tay Bridge was eventually built alongside the old, and opened in 1887. It still stands. Much greater care went into its design and construction, in the light of experience from the previous venture. The London Ambulance Service went through a similar catharsis with its despatch service: a disastrous first implementation,[4] in 1992, was followed by a model project which successfully achieved its objectives (but with much less publicity).[5] Perhaps one moral is that major projects should all be executed as though for the second time.

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CONFLICTS OF INTEREST

None.

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