# NIA Close-Down Report

## Alternative Tower Construction
## NIA_SHET_0003

Prepared By

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| | | | |

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# Executive Summary


### Project scope

The project focussed on initial development, production and implementation of an adapted emergency bypass tower as a tower crane which could be used to erect and dismantle transmission towers at 275kV and above. Following mechanical and functional testing within a controlled environment, field based testing on a number of selected towers was to be completed to allow demonstration of the system on the SHE (Scottish Hydro Electric) Transmission. This would allow an assessment to be made of the suitability of the system and method for operational use going forward.

### Aim

The principle aim of the project was to assess the suitability of the tower crane as a tool for the erection and dismantlement of transmission towers in a safe and sustainable manner.

### Activities

The main activities for this project were to:

- Carry out development and production of a prototype system
- Complete functional and mechanical testing of the system within a controlled environment
- Conduct field-based testing of the prototype system
- Assess and evaluate the suitability of the system as a method of erecting and dismantling transmission towers
- Capture knowledge and lessons learnt from information generated by the project

### Outcomes of the project and key learning

The main outcomes of the project were:

- Design and development of a prototype system
- Mechanical and functional testing of the assembled prototype system
- Development of a second prototype following testing

### Conclusions and future work

The project has been partially successful with SHE Transmission continuing to trial the project in preparation for advancing the method and technology through to business as usual practice. The main conclusion from the project was that the technology and prototype system are almost at a Technology Readiness Level (TRL) for business implementation. The field based trials and final inspections are still to be completed but it is expected that they will verify that the method is fit for purpose. Over the duration of the project a number of the objectives identified at the outset have been achieved.

Moving forward further practical experience and knowledge through implementation is needed to build on the current progress made and generate further learning.
Any additional information required can be requested through future.networks@sse.com.

# 1 Project Background

SHE Transmission owns and operates the transmission network in the North of Scotland, largely a rural area. It is faced with the challenge of building and maintaining overhead lines through areas which are not hospitable to traditional construction methods, such as cranes. The physical impact of traditional cranes on environmental sensitive areas can be severe, requiring roads to be constructed for no other purpose than to support the crane.

Construction of transmission tower lines is currently a prominent activity on the SHE Transmission network as reinforcement work is under way to cater for increased renewable generation. Transmission tower lines do not always follow routes close to existing roads to enable cranes to access tower locations. This results in the need for temporary access tracks or the use of a Derrick, a lifting device that can be assembled at the point of use.

In addition to costs incurred with installing such access tracks, SHE Transmission are concerned about the visual and environmental impacts of temporary access roads as these can cause public concern, particularly in protected areas such as Sites of Special Scientific Interest, National Parks and National Scenic Areas. The costs associated with provision of temporary access roads raise project costs significantly. Using a Derrick as an alternative to temporary access roads and cranes has its own problems. A Derrick is attached by being freely hinged about an already constructed part of the tower and then lifting via a system of lines operated from an independent prime mover. This lack of independent solid ground fixation by Derricks imposes a constant hazard which increases the risk of safety incidents during tower construction.

Additionally, a number of the substations which form part of the transmission network are situated within tight physical boundaries which do not easily allow for the traditional employment of cranes without taking outages and reducing the security of the system.

SHE Transmission do not have any tools or methods at present to erect and dismantle transmission towers within the tower's own footprint and which would limit or remove the environmental impact.

In addressing the foregoing issues, the most cost-effective method of transmission line construction is one which has a short construction time, limits environmental impact to as low as is reasonably practicable, and has significant financial savings for customers. This project proposes using Acier Profile SBB's Emergency Restoration System (ERS) as an alternative tower construction method to address all the issues raised so far. It is anticipated that employing the proposed method in conjunction with all-terrain vehicles and/or helicopters will reduce the need for temporary roads, thereby reducing environmental impact. Successful implementation of the method is also expected to provide a safer working environment and reduce construction costs significantly.

SBB manufacture and sell emergency bypass towers, the original purpose of which is to act as a stand in for a damaged tower in the event of tower failure, or to temporarily hold conductor whilst an overhead line is being repaired or maintained. The proposal was made to combine one of these towers with a winch mechanism in order to form a lightweight crane operable within the tower footprint.

### 1.1 Budget and Project Timescales

The project commenced in April 2010 and was due to be completed in March 2013 with a total budget of £260,000. Due to manufacturing, delivery and safety delays, the project did not complete until March 2015 and final expenditure totalled £299,000. These delays were due to:

- initial issues regarding the design
- late delivery of components from SBB's suppliers and
- International shipment of the product.

## 2 Scope and objectives

The scope of the project was to investigate the use of a modified SBB Emergency Restoration System (ERS) as a Lightweight Tower Crane (LTC) in the construction and dismantlement of 275kV and 400kV transmission towers in SHE Transmission's license area to establish if it was technically feasible, economical, minimised environmental impact and mitigated safety issues inherent in existing construction methods.

The initial objective of the project was to have a fully developed, assembled and working tower crane which had been both mechanically and functionally tested within a controlled environment. Once this was complete the tower crane would be put through field-based testing on a number of selected towers. The towers would be selected based on their environmental location and any inherent access issues. This field based testing would provide practical experience in operating the tower crane and allow for refinements to be made if required.

Providing this was successful and SHE Transmission was confident in the tower crane this would then be implemented into business as usual.

The objectives of the project were:

- Carry out development and production of a prototype system
- Complete functional and mechanical testing of the system within a controlled environment
- Conduct field-based testing of the prototype system
- Assess and evaluate the suitability of the system as a method of erecting and dismantling transmission towers,
- Establish if the method can achieve:
    - Reduction of construction time and costs

    - Reduction of environmental impact by reducing need for temporary access roads
    - Mitigation of safety issues of concern in tower construction that uses Derricks
- Capture knowledge and lessons learnt from information generated by the project

# 3 Success criteria

The two distinct stages of this project were development and demonstration. Successful completion of each stage, with sufficient results to inform viability of subsequent stages, would represent success for that stage.

Successful demonstration of the system's suitability or otherwise would provide enough knowledge about the system and hence indicate overall success of the project.

# 4 Details of the work carried out

## 4.1 Development

The project involved a number of distinct phases; initial design, assembly and development, testing and refinement and ultimately operational demonstration on the network.

The project, with particular application to towers, was based on the technical development and demonstration of an adapted emergency bypass tower. SBB had previously developed and manufactured a bypass tower which was easily assembled and could be carried into site by hand.
During the project, SHE Transmission worked with SBB to modify the bypass tower to carry a winch such that it formed a lightweight tower crane. This system would be designed to be much more suited to the end user practical requirements, permitting erection and dismantlement of transmission towers in environmentally sensitive areas or sites which, for a number of reasons, were difficult to access with a traditional crane. Once the system had been assembled in a controlled environment and gone through initial functional and mechanical testing, it would be trialed on a number of selected towers.

Upon development and manufacture of the initial prototype, initial functional tests were carried out. These tests were initially delayed due to issues regarding the design, late delivery of components from SBB's suppliers and the international shipment of the product. A testing session was planned for October 2011, however detailed assembly instructions had not been received from SBB and testing had to be delayed until SBB engineers could make themselves available to attend. Initial testing was finally completed in February 2012 in a controlled environment.

The functional testing session comprised of the following:

- Assembly of the tower crane,
- Installation of the base plate, articulate base, big pulley over the articulated base,
- Installation of one mast section,

- Installation of the crane mechanism on top of the parts mentioned above,
- Rigging of the crane was also performed.

The system was tested and some modifications were performed on site. The changes were found to be useful by all parties and allowed the time to complete the rigging of the crane to be decreased.

Upon completion of the testing session, the following modifications were proposed and agreed:

- Head of the sliding ginpole should have a 30cm long collar with two bolts to affix it to its tube. The tube should also have an additional collar, fixed to the rail of the mast, for maximum support and thereby removal of any single point of failure issues,
- The bottom of the sliding ginpole required a pulley change to remove sharp edges, and the hooks used to hang the ginpole to the mast were to be on independent ropes and attached to a double eye-bolt to avoid damage to the cable,
- A roller system was to be installed at the top of the crane in place of a big sheave,
- The lifting cable was to return to the tower after passing near the lifting pulley,
- The backstay arm was no longer required,
- The base plate was to be replaced with one fit for 12 inch bolts and recessed to hide the bolt heads,
- The capstan winch was to be replaced with one of larger capacity,
- Lifting ropes with a splice and thimble were to be provided to avoid making a knot at the top of the rope.

*Figure 1- Prototype trials*

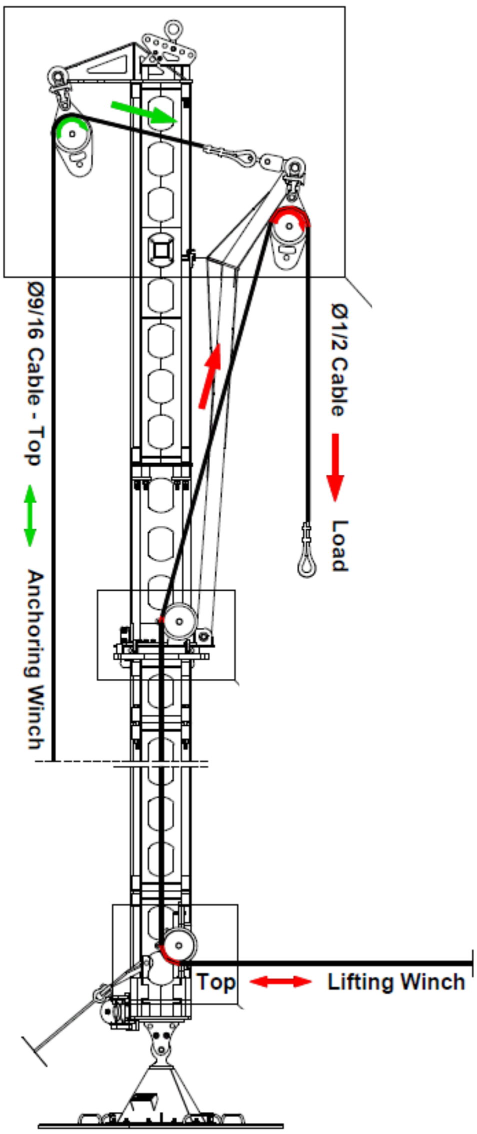
Whilst these modifications were being carried out, the bypass tower (without the winch modification) continued to be used by operational staff in order that they continued to familiarize themselves with the assembly and usage of the structure. The tower crane structure was well received by operational staff. Feedback received from the field indicated that this model was significantly lighter than the existing solution requiring fewer men to lift it. It was also easier to assemble and more user-friendly than the solution currently in place.

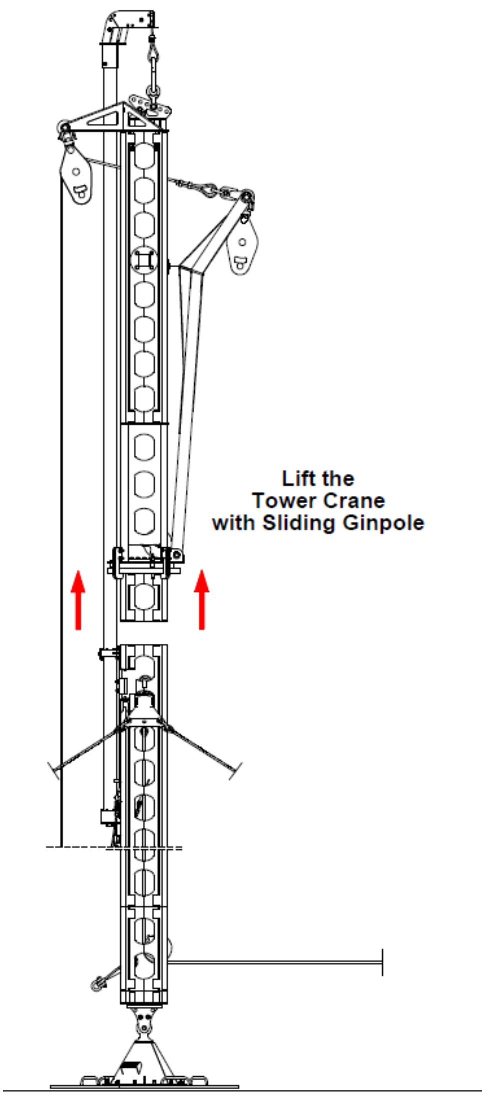
On receipt of the second prototype (after significant manufacturing delays) in March 2013, it was recommended that an independent mechanical analysis of the crane be carried out and LSTC were engaged to undertake this. SBB had been requested to divulge the necessary information to LSTC in order for them to complete their work but SBB were, initially, extremely reluctant to cooperate and the whole process significantly increased the project timescales. Alongside issues with the availability of required SHE Transmission staff, this delayed the trial of the second prototype to November 2014.

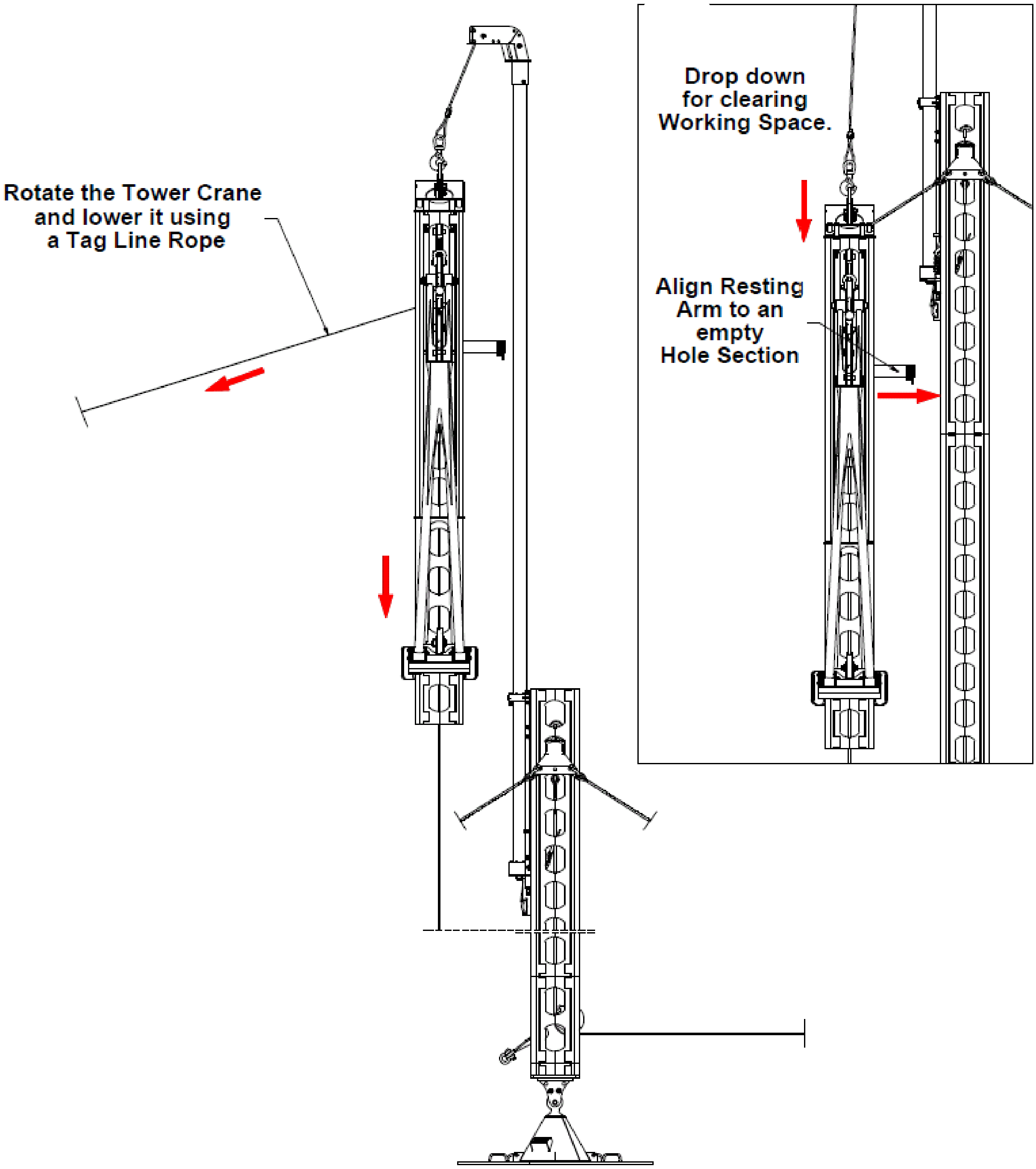
However, it emerged prior to trial that the Canadian components on the tower crane did not have the requested safety marks and, as such, the trial could not be completed. The decision was made that, given the timescales of the project, all further required trials could be carried out through the implementation of the project into business as usual.

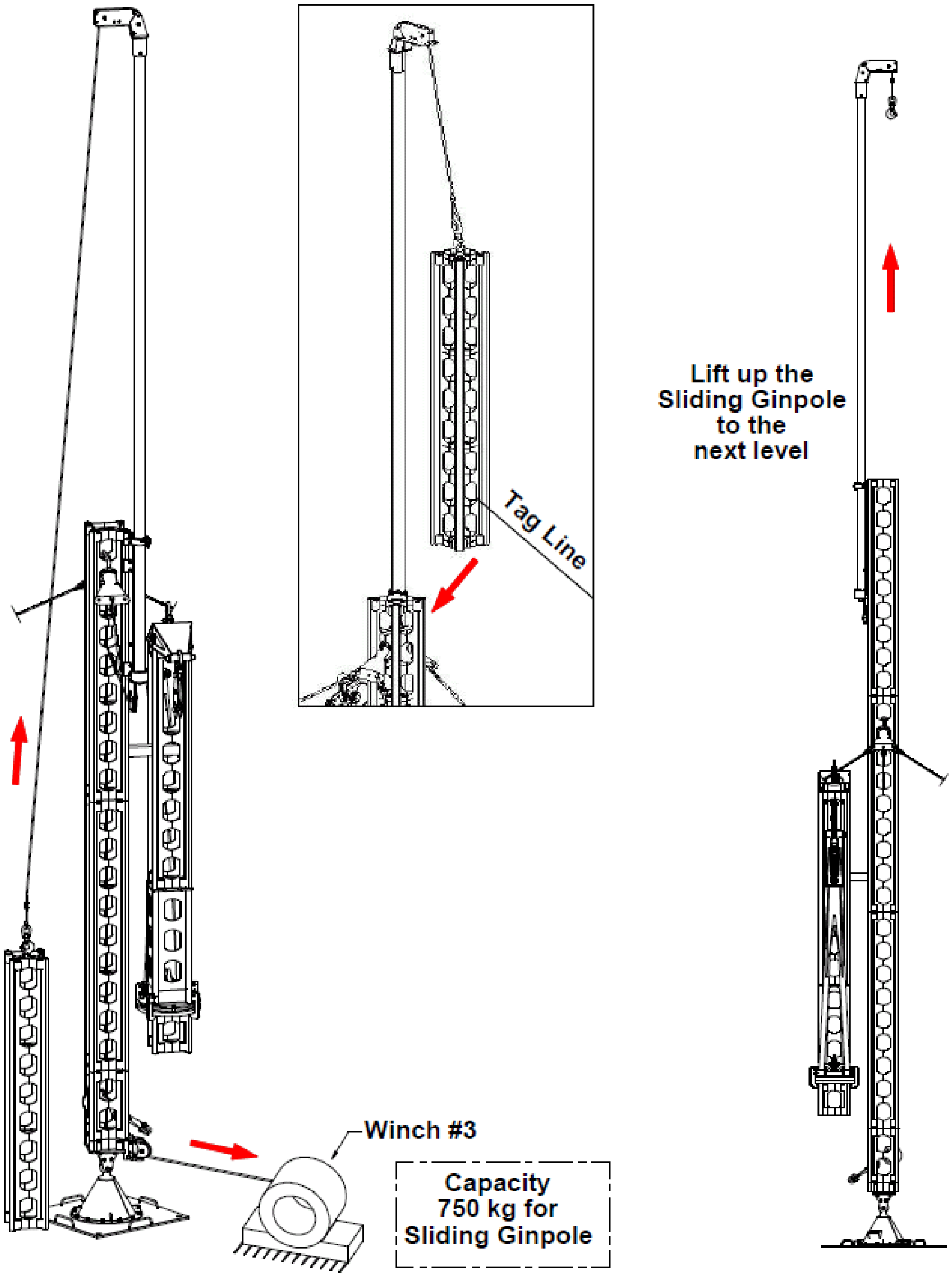
## 4.2 Tower Crane Usage Methodology

The tower crane is erected within the footprint of the tower. As the required height increased, the internal gin-pole mechanism is used, as illustrated below, to lift additional sections of the crane into position, essentially making the tower crane a "self-lifting" unit. The winch mechanism is then used to lift tower steel or other components as required. Further information on the tower crane assembly can be found in Appendix 1.




Rotate the Tower Crane
and lower it using
a Tag Line Rope
Drop down
for clearing
Working Space.
Align Resting
Arm to an
empty
Hole Section


Tag Line
Winch #3
Capacity
750 kg for
Sliding Ginpole
Lift up the
Sliding Ginpole
to the
next level

## 5 The outcomes of the project

The project provided valuable new learning relating to:

- Management of international suppliers with particular emphasis on differing international Health and Safety Regulations and import/export scenarios.
- Capacity of the tower crane to lift the required loads
- Viability of the tower crane to operate without its winch as a bypass tower

A second prototype has been produced and is awaiting operational deployment on towers within the SHE Transmission network.

# 6 Appendix 1

SBB Tower Crane Step-by-Step Assembly Instructions