Energy Networks Innovation Process Project Closedown Report Document

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Project Closedown Report Document

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Project Title (*This cannot be changed once registered*)	Project Reference
Smart Hammer	NIA_SSEN_0044
Funding Licensee(s)	**Project Start Date**
Scottish and Southern Electricity Networks Distribution	February 2020
Project Duration	**Year**
4 Years 2 Months	2024
Nominated Project Contact(s)	
Tim Sammon, Innovation Programme Delivery Manager at SSEN	

1. Scope

STAGE 1 - SMART HAMMER DEVELOPMENT - X-Models
X Model Development
Define Hammer Evaluation Test strategy.
Evaluate Accelerometer sensors.
Make Sensor Selection

STAGE 2 - SMART HAMMER DEVELOPMENT - A-Models
A Model Development
Create automated testing environment.
Determine Utilization Parameters
Develop Data extraction.
Field Trial Smart Hammer to Identify the Sensor Selection.
Create Draft Training Material

STAGE 3 - SMART HAMMER DEVELOPMENT- B-Models
B Model Development. Refine & Build Prototype Hammer with finalised Sensor Selection
SSE Evaluate IT System for Maximo Integration
Refined Automated Swing Test for operational improvement.
Prototype Field Trials & Evaluation

STAGE 4 - SMART HAMMER DEVELOPMENT - Pre- Pod-Models
Build Pre-Production of finalized Hammer.
I.T – Maximo integration
Data Analytics Trial
Pre-Prod Models Field Test & Evaluation
Policy & Procedure to approve network testing.
Create Training Material

STAGE 5 - Field Trials
Undertake Field Trials
Capture Trial Data
Field Trial Evaluation
Compare Baseline & Field Trials
Recommendations for BAU

STAGE 6 - Closure
Finalize Policies & Procedures
Finalize Training Material

2. Objective(s)

By the end of the project

1. To have established the technical and commercial viability of using a Smart Hammer with accurate and repeatable results.

2. Conduct consistent and reliable initial wood pole inspections as an alternative to the traditional hammer test method.

3. The ability to capture pole data and integrate with asset databases

4. To have disseminated the learning from the project through annual or exceptional events for the benefit of GB customers.

3. Success Criteria

1. Early identification of equipment not to take through development phases and field trials.

2. Ability to test poles within asset health scoring matrix.

3. Ability to detect pole replacements without the need for secondary invasive techniques.

4. Ability to notify systems that secondary testing is required with more advanced technical equipment.

5. Low-cost Smart Hammer which is affordable to issue to all overhead line assessors and linesmen.

6. Efficient consistent pole test scores no matter who uses the hammer.

7. Ability to capture the information from the Smart Hammer in the asset database via a Smart Phone application.

8. Ability to capture granular detail of pole condition to enable desktop assessments for efficient planning.

9. Ability to demonstrate wood pole asset health with accuracy – Data assurance and improve accuracies in reporting.

10. Opportunity to improve and make internal processes more efficient adopting Smart Hammer as a front-line tool and a create a response matrix.

4. Performance compared to the original project aims, objectives and success criteria

Details of how the Project is investigating/solving the issue described in the NIA Project Registration Pro-forma. Details of how the Project is performing/performed relative to its aims, objectives and success criteria.

1. Has proven that it is possible to use a standard commercially available hammer from a long-established British manufacturer as the basis of a low-cost Smart Hammer, albeit with the need for some skilful machining operations to accommodate the battery pack and Bluetooth module in the shaft and the sensor electronics in the head. Although adequately waterproof for normal use, it has however, not been possible to achieve full IP68 compliance with this approach, neither has it been possible to achieve the original aim of a plug-in battery pack for rapid replacement during servicing if necessary.

2. The components used and the construction techniques developed have been shown to withstand repeated impacts of up to at least 1000g without noticeable degradation, suggesting that the Smart Hammer could well achieve the design aim of 56 strikes per pole, 50 poles per working day, over a 5 year lifespan.

3. It has been shown possible to transmit complete waveforms from each strike to a Smartphone at a speed such that the tester cannot out-run the data reception. Push button switches on the hammer itself allow the tester to rapidly take corrective action in the event of squint strikes, and to inform the phone software of any points inaccessible for test.

4. Display of numeric results and battery state in full sunlight has been achieved on the hammer electronics capsule, although removed in the later stages of the project on the grounds that data presentation on the Smartphone alone was adequate, with a working speed being reached at which the tester had insufficient time to view the hammer display in any case.

5. Rather than passing the phone data to an office PC for later analysis and assignment of pole grade, as per the original proposal, an extremely successful web portal has been developed for collection and presentation of all test results and calculation of pole grade based on a number of assessment criteria which evolved during the duration of the project.

6. The smart hammer has demonstrated that granular data can be captured regarding the pole health via the hammer in the context of a waveform. Research has shown that pole health characteristics can be derived from the waveform analysis. This generates greater confidence, accuracy and reliability for front line staff when scoring poles by using the smart hammer device.

7. The better-quality pole health data is being employed by the SSEN policy team to look at how smart hammer can be adopted into BAU by front line staff.

5. Required modifications to the planned approach during the course of the project

The Network Licensee should state any changes to its planned methodology and describe why the planned approach proved to be inappropriate. Please confirm if no changes were required

1. The existing Smart Hammer had a very reliable plug-in battery pack utilising a high quality push-in microwave coaxial connector to carry the DC power from the battery pack in the shaft up to the sensor electronics capsule on the head. Introducing Bluetooth, however, for data transmission to the phone, required the radio module to be within the battery tube, as it would not withstand high levels of mechanical shock. This required either a three-way push- in connector or a complicated scheme allowing power and data to share the existing two wires down the shaft. Neither proved practical or reliable, hence the decision was taken that since reliability was paramount, a three-wire system would be employed and the connector omitted, resulting in battery replacement being a factory operation.

2. At a late stage in the project, it was decided that displaying battery state and 2-digit strike data on the face of the electronics capsule was superfluous. This enabled all components within the capsule to be mounted on a single printed circuit board solidly mounted on the capsule floor, reducing cost and increasing reliability.

3. On commencing the project the previous practice of employing three 1.2 Volt nickel metal hydride batteries in series was followed to provide a 750 mAh supply. This was changed mid-project to a single 3.6 V, 2,600mAh lithium-ion battery, greatly increasing battery life between charges, at the expense of having to take additional safety measures such as fusing and venting, and great care in handling during build.

4. The project proposal allowed for the build of 15 development models in three stages of 5 off each X, A and B models, followed by 10 off pre-production models. In addition to this work a small-scale production run of a further 50 models were implemented. All of the afore-mentioned models were fitted with a two-digit numeric display of basic strike data and a 10-segment display of battery state. A further 10 production standard models were then supplied in which the two-digit display was omitted but the battery indicator retained.

Following the above, a further three models were supplied with both the 2-digit display and the battery indicator omitted, allowing the capsule length to be reduced by 6 mm. Although a relatively small amount, this made a considerable improvement to the appearance of the tool and operator “feel”. The feel factor was further improved in these models by removing the PVC sheath covering the bought-in hammer shaft and replacing with high quality bicycle handlebar tape neatly retained by heat shrink tubing. Although “low tech”, such features are very important in producing a tool of this nature which users are happy to use over long time periods.

6. Lessons learnt for future projects

Describe how the project (methodology, stakeholder engagement etc.) changed, or provided opportunities, from your expectation at the start of the project and therefore could be useful for a future project. In addition, please discuss the effectiveness of the research development or demonstration undertaken.

The project proposal consisted of 20 pages of technical discussion, including a section containing 5 areas which were considered at the time to be of technical risk. The first two such areas related to component and constructional reliability in the presence of very high levels of mechanical shock repeated at rapid intervals over a design lifetime of 5 years. By careful choice of components and build methods, shock has not so far proved to be a problem, and we now have a reasonable degree of confidence that the target operating life may be achieved.

A third area was the risk associated with the original plan to transmit power and data along the same pair of wires in the hammer shaft. As previously mentioned, this risk was averted by reluctantly conceding that a hard-wired battery pack was the only safe option.

The fourth area of risk concerned our inexperience at the time of integrating one of our products with a Smartphone application. As mentioned in the proposal, this risk was mitigated by sub-contracting to a company whom we at least had worked with before as a supplier to them of radio frequency hardware. We had also budgeted for a second round of development of the phone app., which would have been adequate for what we thought at the time would be the endpoint of the project. Changing and more ambitious requirements from our sponsor later resulted in the phone software development becoming at least as great a task as development of the hardware and its internal firmware. Fortunately, this was funded directly by SSEN out with our initial contract with the sub-contractor.

At the start of the project analysis of data gathered by the hammer in the field had been envisaged as being carried out by an engineer using a PC into which the accumulated strike data had been downloaded. This was abandoned when the idea of a web portal was introduced and funded again directly by SSEN.

The fifth area of risk listed in our proposal concerned the consequences of parts and components becoming obsolescent over the duration of the project. In practice, obsolescence has not been a problem, but temporary unavailability of components most certainly has been an issue. We were first affected by a world-wide shortage of the STM32F microprocessor chip, and more recently by deliveries exceeding one year of the sensor device in the hammer capsule. The lesson to be learnt here is to buy everything likely to be required at the outset, in quantities which will enable the work to be carried over into production should the project outcome be successful. In today's world this policy must be maintained over the production lifetime; there is no possibility for small-scale production (by consumer product standards) reaching a “just in time” arrangement with a semiconductor chip manufacturer. For future projects the lesson learned would be to understand the risk profile of availability on all parts at the outset of the project and understand if actions had to be taken to mitigate future availability issues before it impacted on the project timeline.

Hence, to ensure commercial success, it is necessary to decide in advance how many units will be sold, buy all critical parts for these up-front, and be prepared to do a re-design thereafter. Obviously, where expensive non-second sourced parts are involved, this entails considerable financial risk for small manufacturing enterprises.

7. The outcomes of the project

When available, comprehensive details of the Project’s outcomes are to be reported. Where quantitative data is available to describe these outcomes it should be included in the report. Wherever possible, the performance improvement attributable to the Project should be described. If the TRL of the Method has changed as a result of the Project this should be reported. The Network Licensee should highlight any opportunities for future Projects to develop learning further.

The results of the project were very positive, the Smart Hammer has been found to outperform the current traditional method of inspecting a wood pole using a lump hammer. After destructive tests of wood poles the Smart Hammer was found to have identified rot in poles that had been missed by the traditional testing method. The project was successful in raising the TRL of Smart Hammer from a TRL 5 to TRL 8 ready for BAU implementation. It is the intention to implement Smart Hammer into the BAU process for the testing of wood poles. A funding application was made to the Storm Arwen re-opener to fund the deployment of Smart Hammer. It is the intention to provide a further additional close down report detailing the Smart Hammer development and the validation activities that were carried out during the project.

8. Data Access & Quality Details

A description of how any network or consumption data (anonymised where necessary) gathered in the course of the Project can be requested by interested parties. Please include a link to the publicly available data policy.

For information on how to request data gathered in the course of this project, see Network Innovation Competition (NIC) and Network Innovation Allowance (NIA) Data Sharing Procedure at https://ssen-innovation.co.uk/innovation-strategy/.

9. Foreground IPR

A description of any foreground IPR that have been developed by the project and how this will be owned.

The technology employed in the original “Electronic Pole Sounding Hammer” as existing in advance of the Project discussed herein falls into the category of “Background IPR, and remains the sole property of the inventors.

The ownership of Foreground IPR relating to work funded under the contract with SSEN is shared jointly between parties and SSEN, under the terms of the contract. We cannot make any definite statement at this stage as to whether any arrangement will be made whereby future buyers of the Smart Hammer will be able to gain access to software developed out with our present contract with SSEN.

The foreground IPR to which we have joint ownership, i.e. the Smart Hammer hardware design and the Smart Phone App. until the stage where our sponsor started to work with the sub-contractor directly comprises the following techniques:

(a) The design of an integrated battery pack and bluetooth module which can be inserted into the hammer shaft.

(b) The methods of adapting a standard commercially available hammer to accommodate the battery / bluetooth pack and the electronics capsule, such that the overall hardware is as waterproof as possible.

(c) The electrical and mechanical design and configuration of the present electronics capsule.

(d) The technique employed to cope with the DC offset voltage of the sensing device.

10. Planned implementation, recommendations or next steps

Please describe the next steps to implement this innovation project. What policies and standards need to be updated or created as part of this implementation.

It is the intention to deploy the Smart Hammer to business as usual. The SSEN policy and standards team are identifying the internal policies that require to be changed to accommodate Smart Hammer implementation. In addition, funding for deployment has been applied for through the Storm Arwen re-opener.

11. Other comments

One of the main benefits of the Smart Hammer is that it can be used by a wide range of field staff, once they have had the necessary introductory training. Testing wood poles without this tool relies on qualified and specially trained asset inspectors, who inspect and test a range of asset types. Other benefits include reduced pole failures during storms and weather events which increase network resilience, a reduction in Customer Interruptions (CI) and Customer Minutes Lost (CML), the increase in data quality about our assets also allows us to drive better network investment decisions.

12. Standards Documents

Identify any industry standards that may require updating due to the outcomes or understanding developed from this innovation project. If no standards will need to be updated, please state - not applicable

N/A