Intelligent Assurance Management – A Smart Analytics Tool for Unparalleled Quality Assurance for Construction Industry

1. <u>Objective Setting</u>

The construction industry faces challenges in ensuring the quality of construction works, including the time-consuming and resource-intensive manual inspection process. To address these issues, this project aims to introduce a smart and groundbreaking tool that can perform fully automated, high-accuracy, and highly reliable quality assurance checks on construction projects. This innovative solution can reduce the cost, program, and safety risks associated with construction projects, maximizing the economic value for both the projects and the society.

It is a general practice that when the site work reaches a critical point, a formal inspection by a site inspector is required before the contractor can proceed to the next stage. The contractor submits a "Request for Inspection Survey Check" (RISC) form, and the site inspector conducts the inspection and records the inspection result (that may contain long paragraphs of texts) in the RISC form. Subsequently, the site supervisor/engineer and the Quality Assurance team manually review the RISC forms to ensure quality. However, this manual process is resource-intensive and subject to competency and human reliability issues.

- The construction industry faces a significant challenge in managing the large volume of RISC forms. During peak periods, a construction site can generate up to 2,000 RISC forms per day. Reviewing these forms is a time-consuming process, often taking 20-30 minutes or even a few hours, as the technical commentary can be lengthy, specialized, and non-specific. Additionally, the wide range of subject matters, including civil, building services, and E&M systems, requires the review team to have extensive knowledge across multiple engineering disciplines, which is both costly and impractical. Furthermore, the manual checking process is vulnerable to human factors, such as fatigue and lapses in attention, which can severely impact the accuracy and reliability of the results.

- The Construction Industry Council (CIC) in Hong Kong published the "Manpower Forecast for Hong Kong Construction Industry" in 2023, which forecasts that the shortage in site supervisory personal in Hong Kong will be around 1500 to 2000 in 2024 and increase to around 2000 to 2500 in 2027, whereas the shortage of professional staff in Hong Kong will be around 5000 to 6000 in 2024 and increase to around 6000 to 6500 in 2027. The expectation to engage more professional or site supervisory manpower to undertake a thorough and comprehensive quality assurance review on all RISC forms is unrealistic.

In 2018, the Chief Executive of Hong Kong proposed the "Construction 2.0" initiative, which advocates "Innovation," "Professionalization," and "Revitalization". The Hong Kong Development Bureau (DevB) has since spearheaded this initiative, aiming to increase productivity, enhance regulation and quality assurance, improve site safety, and reduce environmental impact. As part of this, DevB issued a Technical Circular (2020/3, Digital Works Supervision System "DWSS") in 2020, mandating the digitalization of the RISC form process for major government projects. This was further strengthened in 2023 under Technical Circular 2/2023, with the key objective of assuring construction quality through a robust RISC process with traceable inspection and assurance checking result.

Given the challenges, a smart solution is needed. While the DWSS can improve RISC form processing efficiency, it does not address the manual quality assurance checking process. Market intelligence and trials suggest that AI technology based on Natural Language Processing (NLP) can be used to automate the RISC assurance review process, with a much-improved outcome.

2. Design, Development and Execution

The project went through a multi-stage process from design through to production use of the AI Text Analytics Tool. The journey considered of 3 key stages, namely ideation and verification, then '0 to 1' development and finally '1 to N' development:

- **Ideation and Verification:** This stage involved market sounding, initial trials, funding approval, cyber security risk assessment, success metric definition, and end-user engagement. The team sampled 7,000 RISC forms, examined them using an untrained NLP model, and identified forms needing follow-up actions, as agreed by the project quality team. As revealed by end-users, the tool's ability to save time was a significant benefit. Manual inspection form checking had been a tedious and time-consuming process, typically done on a sampling basis due to the large volume. With end-user and TISC support, the team secured approval to start the project, targeting an 80% prediction accuracy for the initial model and a 95% stretch target for the enhanced model.

- **'0 to 1' Development:** This stage involved creating a proof-of-concept (PoC) model. The team conducted numbers of interviews with the site staff to understand the RISC form usage, patterns, and professional terms. They picked about 65,000 RISC forms from over 50 railway construction sites to train the prototype model to meet the target of 80% accuracy. While meeting the target, unexpected issues arose, such as unexpected form usage, complex expressions, and inconsistent requirements interpretation. The team then built dictionaries to capture professional terms and further developed AI models to handle different judgments. After rounds of improvements, they improved the tool to deliver 95%+ accuracy rate, and the tool was launched for formal user trial.

- **'1 to N' Development:** This stage involved developing the model into a "productized" system that is compatible with different brands of DWSS, operated with automated data pipeline, enhanced with continuous learning capability, and compliant with cyber security requirements. The team also developed application programming interfaces for interoperation between current suite of data analysis and visualization applications.

3. Creativity and Innovation

In this project, the team developed an AI Text Analytics Tool, based on NLP technique with a number of Machine Learning (ML) models, to automate the quality assurance checking process of the RISC forms. 60 ML models to replicate expert judgments for 9 highly specialized construction disciplines were built. The tool can examine the RISC forms without human error or bias, using various ML models. The AI Text Analytics Tool also offers the following competitive advantages to the organization:

- **Comprehensive, thorough and unbiased assessment**: The ML models have been trained to capture a wealth of industry-specific knowledge with over 100 years of real life construction experiences across 9 different construction disciplines (such as Building Services, Civil & Structure, Electrical, and Mechanical, etc.) that was collected through in-depth interviews with a number of professional and experienced construction colleagues. The analytics tool examines all textual input recorded in the RISC form deterministically and probabilistically, with the use of the 60 trained ML models. This ensures that the examination is comprehensive, thorough and unbiased.

- **Timely feedback that can prevent costly quality incidents**: poor construction quality can lead to major impacts on safety, project cost and project progress. In the worst case, quality risks can tarnish company reputation and the management team may also be subject to legal consequence. The analytics tool can take RISC forms directly from the DWSS, then run assurance assessment with high accuracy and flag up any concerns detected in no time! The assessment outcome can be fed to any dedicated party for attention so that immediate follow up actions can be triggered as required. The timely detection of concern and the opportunity to enable corrective action to be implemented in a timely manner can effectively mitigate quality risks.

- **Future proof**: The analytics tool is built with guided Machine Learning capability. The tool will learn to work smarter so that its ability (accuracy and reliability) to detect quality concerns will continuously improve. This smart feature ensures that the organization using the tool can stay ahead of the industry in quality performance.

Along with the continuous improvement feature, the tool is a groundbreaking innovation in the construction industry. It combines NLP, ML, and data analytics to transform the way to examine RISC forms. The examination is comprehensive and thorough with total elimination of human bias / errors. It takes no time at an affordable price. The tool has an immense potential for expanding into new industries, sectors, and communities outside of construction. It can be customizsed to the specific needs of different industries. Some examples of industries, sectors, and communities where the tool can be applied are:

- **Healthcare**: The healthcare industry generates a huge amount of data in the form of medical reports, patient records, and research papers. The NLP Text Analytics Tool can be tailored to review and analyze medical reports, providing healthcare professionals with valuable insights for informed decision-making regarding patient care.

- **Legal**: The legal industry produces large amounts of paperwork that require manual review and analysis. By tailoring the NLP Text Analytics Tool to process legal documents, legal professionals can benefit from efficient document review and gain insights that assist in making well-informed decisions in legal cases.

- **Government**: Governments handle a lot of paperwork, often requiring careful review and approval processes. By using the NLP Text Analytics Tool to process government documents, officials can simplify the review process, extract insights, and make informed decisions, especially for applications from the public.

All in all, the NLP Text Analytics Tool has a significant potential for extending into various industries, sectors, and communities beyond construction. Its adaptability and flexibility make it suitable for automating the review process of forms and documents, extracting valuable insights, and ultimately improving decision-making and productivity across multiple domains.

4. Sustained Outcomes, Benefits and Impact

The project delivers sustained outcomes:
- **Key Comment Identification:** The tool uses advanced AI algorithms and NLP models to find and extract important inspection comments from the RISC forms. This helps users to focus on critical areas of concern, enabling a more efficient review process.

- **Comment Examination and Assessment:** The tool carefully studies the details of inspection comments from the RISC forms, performing a level 2 checking to evaluate the quality of works. It verifies whether the RISC form has been approved or rejected by the Reviewer, providing insights into the result of level 1 checking. This in-depth analysis helps users to make informed judgments and decisions based on trustworthy data.

- **Discrepancy Detection and Third-Level Checking:** When a RISC form that is approved by level 1 checking is marked as negative by the AI Text Analytics Tool, it creates a discrepancy alert. This initiates a third-level checking process to be carried out by the Quality Assurance team. This extra level of oversight ensures that any possible issues or deviations are resolved quickly, reducing risks and maintaining high standards of quality control.

- **Key Term Extraction (Terminology):** The tool can extract key terms (terminology) from the RISC forms. This function serves two important purposes. Firstly, it enables the extraction of relevant terms for quality training, allowing the tool to continuously improve its accuracy through machine learning. Secondly, it

supports the standardization of terminology within the industry, enhancing consistency and clarity in the review process.

- **Financial Saving:** based on the projected data within MTR, with 7 railway projects to be delivered in the coming 6~8 years, the capital expenditure and operating expenditure of the tool in one year is about €312.5k. With an average of 1200 RISC forms generated per month per project and with an average of 30 mins review time per each RISC form, the staff cost incurred for running 100% assurance check on the RISC forms for 7 railway projects in each month is about €157.5k per month (average rate of QA Engineer is €37.5 per hour). All these staff cost incurring in running the quality assurance check on manual basis can be saved by adopting the AI text analytics tool. This means the project can be paid back in two months, or an annual saving of about €1.5M.

- **Manpower Released:** Again, based on the projected data within MTR, with 7 railway projects to be delivered in the coming 6~8 years. With an average of 1200 RISC forms generated per month per project and with an average of 30 mins review time per each RISC form, the manpower involved in running 100% assurance check on the RISC forms for 7 railway projects is about 50,400 hour per year. For about 1680 productive hours per QA engineer per year (52 weeks per annum, 4 weeks annual leave, 3 weeks public holiday, 1 week training, 2 weeks sick / causal leave. Leaving only 42 weeks per week. With 40 hours per week, this means 1680 working hours per year) it equates to 30 man-years per year. This amount of staff resources can be saved through the adoption of the AI text analytics tool. The manpower saved can be diverted to perform higher value tasks.

The project also provides the following benefits and impact for the organization and the industry:
- **A Game Changer to the Construction Industry:** thanks to the emerging technologies, the amalgamation of AI, NLP, ML, and Data Analytics transforms how unstructured textual data is analyzed. It processes large amounts of data efficiently, identifies anomalies, inconsistencies, and trends, and gives useful insights and judgments. The use of advanced technologies enables the industry to overcome challenges, such as competency issue, manpower shortage, human bias / errors, and sampling checks. The tool's ability to pin-point potential problems, prevent quality incidents, and improve project outcomes marks a significant change in the industry's quality assurance standard.

- **Effective and Efficient Assurance:** The tool helps project delivery teams and assurance teams to perform their assurance role effectively and efficiently. The assurance check takes no time. Anomalies detected will be flagged up to draw immediate attention. It significantly reduces risks and maximizes value.

- **Enhanced Quality Assurance Regime:** The tool strengthens the quality assurance regime for site inspection activities. Every RISC form will be subject to a comprehensive and thorough quality assurance check without human bias / errors, ensuring higher dependability and accuracy while lowering the overall costs.

- **Scalability for Augmented Benefits**: The tool can accommodate various quality inspection processes besides construction works, offering scalability and the potential to increase benefits across different works and work supervision systems. Additionally, the tool can be improved to extract useful insights from work supervision modules, further extending its usefulness.

5. Exceptional Merits

The project has exceptional merits in the following aspects:

- The project is fully consistent with the MTR "Go Smart Go Beyond" campaign, which expresses the organization's commitment to making the MTR journeys safer and smoother, and towards a more connected future. The solution demonstrates the organization's dedication to excellence, safety, and sustainability, as well as its social responsibility to society and the environment. It is also in line with the corporate innovation strategy that the tool is purpose-driven, focusing on creating value for the organization and its stakeholders.

- The project has boosted the innovation culture and teamwork in the organization. The idea of applying AI/ML and NLP technique to examine unstructured textual data came from the working teams, instead of a top-down initiative. The working teams, including the data team, the site team, the designers, and the Quality Assurance team, applied for a special funding from the corporate Technology and Innovation Steering Committee (TISC) and worked collaboratively to build this tool. This invention was well appreciated by the TISC, and became a showcase in the Corporation that encourages colleagues to embrace technologies and be more innovative. The efforts of the project team have been recognized by the Corporation formally with the granting of the "**MTR Grand Award 2024**".

- The adoption of AI technology to address a critical pain-point in the construction industry has led to the winning of a **Gold Award and a Grand Award in the 2023 HKICT Awards**, strengthening the organization's position as a leader in innovation within the industry. The tool is also well recognized by the DevB.

- The transformational change in the way to deliver quality assurance check on site quality documents as achieved by the tool has also been recognized by the Hong Kong Management Association (HKMA). The tool has been shortlisted by HKMA as one of the **Top 10 Finalists** under **HKMA / HKT Global Innovation Award 2024**. The final award to be granted will be announced by 23 Jan 2025.