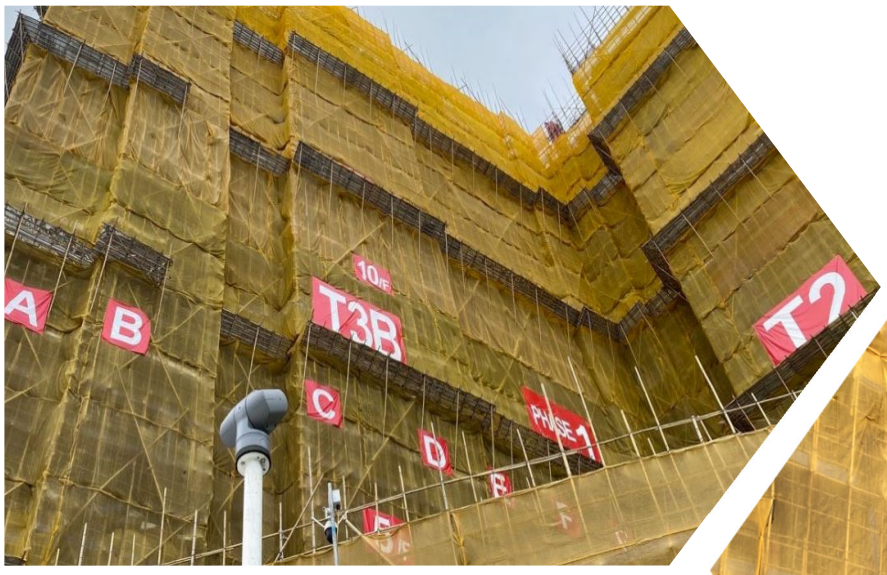
CONSTRUCTION
INDUSTRY COUNCIL
建造業議會





# Reference Materials - Sample Specification for Provision of Site Safety Monitoring Services Using Artificial Intelligence

www.cic.hk

September 2021

## DISCLAIMER

This publication is prepared for general reference only. The publication may include (and is not limited to): (a) content prepared using information from various sources contributed by third parties, (b) information provided by third parties, and (c) links to third party information on internet websites. Whilst reasonable efforts have been made to ensure the accuracy of the publication, readers should make direct reference to the original sources of information and the legal requirements referred to by the publication or seek appropriate independent advice from professional advisors before taking action. Readers should not treat or rely on this publication as a substitute for professional advice. The publication is subject to change without notice. No statement, representation or warranty (express or implied) is made as to the reliability, completeness, accuracy or fitness for any particular purpose of the publication. The Construction Industry Council shall not have any liability under the law of contract, tort or otherwise howsoever for any loss, expense, damage, or injury which may arise from or be incurred or suffered by any party relating to or in connection with any information in or any omission from the publication.

## ACKNOWLEDGEMENTS

Public works departments (in particular the Drainage Services Department and Lands Department), the Hong Kong Science and Technology Parks Corporation AIR Platform and Precision Engineering Department, the Office of the Chief Government Information Officer, Members of the CIC Committee on Construction Safety and companies with relevant experience (in particular EBSL, KartaX Technology, Kong Chun Construction Machinery Services Centre Limited, viAct and Nexplore Hong Kong Limited, etc.) have provided useful information and helpful assistance in the preparation of this publication[1]. These contributions are gratefully acknowledged.

## ENQUIRIES

Enquiries on the Reference Material may be made to the CIC Secretariat:

CIC Headquarters

38/F, COS Centre, 56 Tsun Yip Street

Kwun Tong, Kowloon

Tel: (852) 2100 9000

Fax: (852) 2100 9090

Email: enquiry@cic.hk

Website: www.cic.hk



[1] *Cover photos credit to China State Construction International Holdings Limited and the Civil Engineering and Development Department.*

# CONTENTS

## PREFACE

The Construction Industry Council (CIC) is committed to seeking continuous improvement in all aspects of the construction industry in Hong Kong. To achieve this aim, the CIC forms Committees, Task Forces and other forums to review specific areas of work with the intention of producing Alerts, Reference Materials, Guidelines and Codes of Conduct to assist participants in the industry to strive for excellence.

The CIC appreciates that some improvements and practices can be implemented immediately whilst others may take more time for implementation. It is for this reason that four separate categories of publication have been adopted, the purposes of which are as follows:

| | |
|---|---|
| Alerts | The Alerts are reminders in form of brief leaflets produced quickly to draw the immediate attention of relevant stakeholders to the need to follow some good practices or to implement some preventive measures in relation to the construction industry. |
| Reference Materials | The Reference Materials are standards or methodologies generally adopted and regarded by the industry as good practices. The CIC recommends the adoption of the Reference Materials by industry stakeholders where appropriate. |
| Guidelines | The Guidelines provide information and guidance on particular topics relevant to the construction industry. The CIC expects all industry stakeholders to adopt the recommendations set out in the Guidelines where applicable. |
| Codes of Conduct | The Codes of Conduct set out the principles that all relevant industry participants should follow. Under the Construction Industry Council Ordinance (Cap. 587), the CIC is tasked to formulate codes of conduct and enforce such codes. The CIC may take necessary actions to ensure compliance with the codes. |

If you have read this publication, we encourage you to share your feedback with us. Please take a moment to fill out the Feedback Form attached to this publication in order that we can further enhance it for the benefit of all concerned. With our joint efforts, we believe our construction industry will develop further and will continue to prosper for years to come.

## ABBREVIATIONS

| | |
|---|---|
| AI | Artificial Intelligence |
| IP | Internet Protocol |
| PPE | Personal Protective Equipment |
| API | Application Programming Interface |

# 1. INTRODUCTION

A site safety monitoring system using artificial intelligence (AI) can help to identify potential hazards in a construction site in a more cost effective manner than traditional site safety supervision methods. It allows timely action to be taken to improve safety performance.

This publication presents sample specification clauses that can be adopted/adapted for the procurement of services to monitor site safety using AI. It is written to provide reference materials for competent professionals in the preparation of contracts.

The sample specification clauses should be modified or added, where necessary, for the preparation of a particular specification, to suit the requirements of each individual project. Notes are given in italics against some of the clauses on the issues to be considered or factors to be taken into account in finalising the contract requirements.

Practitioners are encouraged to apply to the CIC to seek funding support under the Construction Innovation and Technology Fund (CITF[2]). Reference should be made to the CIC's CITF website on the pre-approved lists of technologies under the different categories (http://www.citf.cic.hk/?route=search). The website provides details of technological solutions that may be applicable in construction projects as well as information on relevant service providers.

As technologies advance rapidly, it is crucial to consult service providers on their latest technological solutions when preparing specifications. In particular, the italicised text in the specification clauses of this publication should be reviewed and updated, where appropriate. Appropriate functional requirements should be included in the specifications to meet the needs of the project and to derive value for productivity improvement and cost effectiveness.

[2] *The CITF was established by the HKSAR Government to encourage wider adoption of innovative constructive methods and new technologies in the construction industry. The CITF provides funding support to consultants, levy paying contractors, registered specialist trade contractors and registered subcontractors to adopt new technologies in their Hong Kong construction projects. For details, please refer to the CITF website at www.citf.cic.hk. Please note that applications for CITF should be made before committing expenses. Technology will only be approved where it is found to meet the objectives of the CITF after assessment by the relevant Vetting Sub-Committee.*

## 2. SAMPLE SPECIFICATION CLAUSES FOR PROVISION OF SITE SAFETY MONITORING SERVICES USING ARTIFICIAL INTELLIGENCE

2.010 General Requirements

(1) The Contractor shall provide the services required himself or employ a competent service provider with AI expertise to provide the service.

(2) The Contractor shall provide and install *x number of* Internet Protocol (IP) cameras and associated AI processors with protective casings and sensor systems to collect videos that can cover all areas of the Site for real-time monitoring of site conditions. A single monitoring system shall be provided to manage all IP cameras, sensors and related video recordings.

(*Note: Since the provision of IP cameras has cost implications, the Client should consider the project need and site conditions, and determine how many IP cameras are required to provide effective site safety monitoring services. The need for frequent movement of the cameras should be avoided. Besides, the locations of the cameras can affect performance of the site monitoring system. Consultation should be made with experienced service providers.*)

(3) Within *2 weeks* after commencement of the Contract, the Contractor shall submit a proposal on the usage, locations and number of the IP cameras, associated infrastructure and network arrangement, and cost, for approval by the Architect/Engineer. After approval, the proposal shall be reviewed and updated at regular intervals, or at any time as directed by the Architect/Engineer, to suit the progress of the construction works.

(*Note: The term "Architect/Engineer" may be changed to other terms to suit different project situations. For example, "Supervising Officer", "Contract Manager", and "Appointing Party", etc., may be used as appropriate.*)

(4) The proposed AI detection and video analytics shall pass an accuracy test with a testing dataset. The Contractor shall conduct a live test with the pre-built AI engine modules to achieve an AI detection accuracy of *at least 70% (true positive)* for each type of specified unsafe scenario requiring detection. The testing dataset shall comprise *not less than 10,000 images/videos* and it shall be split into half between image*/videos* data with and without the proposed object of detection (or event) in those images*/videos*.

(*Notes: The types of unsafe scenario requiring detection should be clearly specified for contract acceptance, such as:*

*(a) Workers not wearing a safety helmet or safety vest or safety belt, and*

*(b) Unauthorised access/entry to a danger zone.*

*The specified accuracy can be achieved by proven "pre-trained" AI models. For new or "custom-trained" models, potential tenderers should be asked to provide a live trial to prove the effectiveness and accuracy of the AI engine modules for the unsafe scenarios required to be detected*).

(5) Within *4 weeks* after deployment of AI detection, the Contractor shall provide the Architect/Engineer with an AI improvement plan (including any re-training and proposed use of other methodology, with input from AI

expertise) to achieve the required accuracy of AI detection.

(6) Between the *4th week* and *12th week* after the deployment of AI detection, the Contractor shall provide the Architect/Engineer with a *bi-weekly* AI improvement plan (including any further re-training and proposed use of other methodology) to achieve the required accuracy of AI detection.

(7) Between *3 months* from the date of commencement of the Contract and the end of the Contract, the Contractor shall provide the Architect/Engineer with a monthly AI improvement plan (including any further re-training and proposed use of other methodology) to achieve the required accuracy of AI detection.

(8) After 4 weeks from the deployment of AI detection until the end of Contract, the Contractor shall maintain an AI detection accuracy of *at least 80%* on average, covering all types of unsafe scenarios required to be detected.

(9) The Contractor shall provide a suitable power supply and connections to a broadband network and/or a 5G network for use of the site monitoring system.

(*Notes: Use of a cloud AI server instead of installing an on-site AI processor can reduce installation works on site and require less coordination.*).

(10) The Contractor shall provide all necessary computer hardware, including a CPU and/or all other related hardware, which can support the functions and the performance requirements specified for the site monitoring system based on the proposal accepted by the Architect/Engineer.

(11) The Contractor shall maintain and repair/replace (*within 72 hours* as necessary at his own cost) all the required hardware and software for the site monitoring system to ensure continuous video coverage throughout the Contract.

(12) Upon approval of the submitted proposal by the Architect/Engineer, the Contractor shall implement appropriate security controls and measures to protect the confidentiality, integrity and availability of all data and information obtained, stored, processed or transmitted through the site monitoring system throughout the Contract. The Contractor shall make reference to the prevailing best practices, review regularly the adequacy of the security control and protection measures, and implement additional measures where necessary.

(*Note: The Contractor shall be responsible for IT security if the site monitoring system provided is connected to the Client's IT system. For government projects, the Contractor shall comply with the relevant Government IT security regulations, policies and guidelines.*)

(13) The Contractor shall provide a total of *two (2)* on-site technical training courses (*4 hours* for each course) for implementing the site monitoring system using AI. The details are as follows:

- The content of each course shall cover aspects of data acquisition and preparation work, in particular labelling of dataset, processing and detection analysis for different types of unsafe scenarios relevant to

the AI engine modules required at different stages, as defined in Clause 2.020 below.

- The trainer shall possess extensive knowledge and practical experience in deploying IP cameras for surveillance and analysing data collected from site videos by appropriate AI engine modules.
- Each training course shall be arranged within *x weeks* from the date of instruction given by the Contractor.
- The content of each course, the experience and qualifications of the trainer, an organisation chart showing the post and contact details of the Contractor's site staff requiring training to operate the monitoring system as well as their duties and responsibilities in the monitoring, shall be submitted to and agreed by the Architect/Engineer prior to commencement of the training course.

(14) The Contractor shall ensure that all requirements under the Personal Data (Privacy) Ordinance (Cap. 486) have been duly complied with in relation to the data/information collected.

2.020 Site Monitoring System

(1) The videos shall be recorded and analysed in real-time by AI engine modules designed to detect, identify and classify the following types of unsafe scenarios:

(*Note: The scenarios to be specified should take into account the project needs, the site conditions and availability of suitable technologies to cover such scenarios. Consultation should be made with experienced service providers on the types of unsafe scenarios that can practically be included in the site monitoring system.*)

- *unauthorised access to restricted zones, danger zones, lifting zones and no-parking zones (detection zones and alerts should be configurable);*
- *workers and other personnel not wearing the required personal protective equipment (PPE), including safety helmet and safety vest;*
- *an excessive number of dump trucks and materials (or debris) on dump trucks not properly covered (the number of dump trucks shall be captured by the site monitoring system; a predefined number shall be provided by the Contractor beyond which alerts will be triggered);*
- *potential collisions between workers and site vehicles or other plant;*
- *workers entering the danger zone near site vehicles or plant (e.g. within the operating radius of moving plant or equipment) as designated by the Contractor;*
- *heights or range of lifting in excess of the authorised limits;*
- *entry into vehicles during loading or movement by personnel not authorised by the Contractor;*
- *parking in unauthorised areas; and*
- *workers working at height without wearing a safety belt attached to an independent lifeline, or wearing a safety belt but not fixing it to a*

*proper anchorage point, or without a proper access or working platform.*)

(2) Continuous video recording shall be offered if available, in particular when new customised AI models have been developed for monitoring other unsafe activities that are not listed above. Detailed requirements shall be defined with mutual agreement between the Contractor and Architect/Engineer.

(3) The Contractor shall implement the site monitoring system in the following stages as required by the Architect/Engineer*:*

| Stage | On-Site Activities | Tentative Duration | AI Engine Modules |
|---|---|---|---|
| 1 | *(List the major on-site activities relevant to each stage)* | *(Indicate the duration in month/year for each stage)* | *(List the AI engine modules for detection of unsafe scenarios relevant to each stage)* |
| 2 | *(A longer list with more activities than at Stage 1 is preferred, so that more details can be obtained for tender analysis.)* | | |
| 3 | *(expand the table as necessary)* | | |

(4) The site monitoring system shall allow restricted zones, danger zones and lifting zones to be defined on the screen either by the user or by recognition of a series of plastic barriers placed on site.

(5) When unsafe scenarios are detected, warning signals/alerts shall be immediately sent to nearby workers and plant operators inside machine cabins by means of a local sound/light alert system according to specified requirements. Simultaneously, the warning signals/alerts shall be sent to the Contractor's Safety Officer, Safety Supervisors, and the Architect's/Engineer's resident site staff designated by means of SMS, email, or in-app pop-up notification for appropriate follow up. The AI engine shall be able to detect multiple physical events at the same time. (*Note: The duties of each party upon receipt of the warning signals/alerts shall be clearly defined by the Contractor and the Architect/Engineer).* For AI detection related to a potentially fatal hazard (or as required by the user), the local sound/light alert system shall be triggered within a period that can allow timely action to be taken to prevent fatality or serious injury after the physical event has been detected. A practice drill shall be conducted once every 6 months to test the effectiveness of the alarm/alert system.)

(6) The Contractor shall record the response time of the follow-up actions triggered by each warning signal/alert.

(7) The videos, data, warning alerts/signals and response times collected by the site monitoring system shall be live-streamed to a management platform at the Site for viewing by authorised staff and accepted by the Contractor and the Architect/Engineer. The display format for the management platform shall be defined by mutual agreement between the Contractor and the Architect/Engineer. All videos or image data shall be encrypted.

(8) The duration of the recorded videos of unsafe practices (including unsafe behaviours and scenarios) shall commence *1 minute* before and finish *1 minute* after the identified unsafe practice. The images shall be captured and stored for future analysis. The same dataset shall also be available for integration by an Application Programming Interface (API) with the centralised management platform procured by the Contractor. The data shall be stored for a period agreed by the Architect/Engineer. The Contractor shall attend workshops organised by theArchitect/Engineer on the centralised management platform regarding the API requirements.

(9) The Contractor shall develop a dashboard with a unique website link based on the data collected from the IP cameras. The format, report and presentation details of the dashboard shall be submitted to the Architect/Engineer for approval before implementation.

(10) The Contractor shall create sufficient administration and standard user accounts with login names and passwords for generating and viewing the dashboard and associated reports at each stage.

(*Note: Viewing the dashboard is not a confidential action and may not need password protection*).

2.030 Deliverables

(1) The Contractor shall provide the Architect/Engineer with a summary report on each case of identified unsafe practice or behaviour, the warning signals/alerts issued, and the response times.

(2) The Contractor shall provide the Architect/Engineer with a *monthly* site monitoring and analysis report on the unsafe practices/behaviours detected on site, the warning signals/alerts issued, and proposed rectification measures with a view to improving the safety management system for the Site. The proposed measures shall be submitted to the Architect/Engineer for review and agreement.

(3) One year after commencement of the Contract, the Contractor shall provide the Architect/Engineer with an interim report summarising the findings, evaluation and review of the application of AI on site safety, any constraints/difficulties encountered, and recommendations for further enhancement.

(4) Within *1 month* after the completion of the Contract, the Contractor shall provide the Architect/Engineer with a final report summarising the findings, evaluation and review of the application of AI on safety, constraints and difficulties, and recommendations for future use of AI in other construction projects of a similar nature.

(5) *Monthly, interim* and final reports shall be endorsed by the Site Safety Officer, the Contractor and the Architect/Engineer.

(6) The various reports submitted by the Contractor shall be deliberated at the regular site safety meetings held between the Contractor and his workers, and at the regular site safety management meetings held between the Contractor and the Architect/Engineer.

## Enquiries

Enquiries on this Reference Material may be made to the CIC Secretariat:

CIC Headquarters
38/F, COS Centre,
56 Tsun Yip Street,
Kwun Tong, Kowloon.

Tel : (852) 2100 9000
Fax : (852) 2100 9090
Email : enquiry@cic.hk
Website : www.cic.hk