SureFire: Smart Urban Resilience and Firefighting

Theme-based Research Scheme Project T22-505/19-N

Progress Meeting – Report to Partners

Agenda

16:30	Overview (AU, 5 min)
16:35	SureFire Architecture (XF, 10 min)
16:45	WP1 – Digital twins model (XY, 10 min)
16:55	WP2 – Communication Network and Sensors (QW, 5 min)
17:00	WP3 – Fire Simulation, Fire Test, AI , ML (XH / XF, 10 min)
17:10	Discussion
18:30	Close

HUAWEI

eHANG

ARUP

FIRE SERVICES HONG KONG

SKLFS 火灾科学国家重点实验室 STATE KEY LABORATORY OF FIRE SCIENCE

NIST National Institute of Standards and Technology

epcc The UK's leading supercomputing centre

SCFRI 四川消防研究所 Sichuan Fire Research Institute of MEM

清華大學 Tsinghua University

香港大學 THE UNIVERSITY OF HONG KONG

THE HONG KONG POLYTECHNIC UNIVERSITY 香港理工大學

UCL

THE UNIVERSITY of EDINBURGH

Deliverables (as in original proposal)

1. **Framework for developing a digital twin** of as-built buildings and selected infrastructure facilities using MicroGIS, BIM, IoT, and Computervision technologies.
2. **Data communication and computing framework** to be used before and during an emergency.
3. **Engineering tools** for data-assisted critical event forecasting in a fire emergency and the feasibility of their application to real-time emergency response strategies.
4. **Validation and technology transfer** through five virtual and two physical demonstrations.
5. **Report & roadmap** for a deployable prototype smart firefighting system for Hong Kong, and high-quality young researchers trained through the research programme.

Goals (as originally stated)

1. MicroGIS, Computervision, IoT, BIM and fire simulation tools will be used to generate data for real-time data analytics based on AI and machine learning techniques to provide **1st order rapid decision support information** to responders during an emergency.

2. Exploring data-driven simulation to generate more accurate and reliable predictions eventually enabling the provision of **2nd order decision support information based on critical event forecasting**.

3. Scaling up the critical event forecasting to large building spaces and civil infrastructure and **set up a perpetual physical demonstration of SureFire based on the 1st order methodology**.

Stage 1 deliverables expanded

Start date (Month / Year)*	Goals# as listed in Full Proposal	Deliverables to be achieved in each stage
January 2020	Goal 1 (30%) Goal 2 (10%) Goal 3 (10%)	1. Multiple fire tests with sensors at the full-scale road tunnel at SCFRI (Sichuan Fire Research Institute, Chengdu) and smoke tests at HKFASA (Hong Kong Fire and Ambulance Service Academy, Tseung Kwan O). 2. Apply conventional sensors in full-scale tests to identify critical fire event in tunnel and use experimental data to calibrate the computational fluid dynamics (CFD) model of tunnel fire. 3. Establish the digital twins for tunnel and the floor of a high-rise building with MicroGIS and BIM technologies. 4. Run a large number of CFD and structural response simulations to create big data repository for tunnel fire. 5. Plan the design and implementation of the on-site and off-site network prototypes. * Five FUFs: OFF – office floor (virtual); TUN – tunnel; MET – metro station (smoke test); HOS – hospital mockup; and SCH –school mockup (scale model)

Stage 2 deliverables expanded

Start date (Month / Year)*	Goals# as listed in Full Proposal	Deliverables to be achieved in each stage
November 2020	Goal 1 (50%) Goal 2 (30%) Goal 3 (20%)	1. Demonstrate the AI-based forecast for tunnel fire with big data and different algorithms to predict the simulated fire scenarios, and identify the critical data size for the accuracy of fire forecast 2. Establish the digital twins for all other proposed FUFs (e.g. primary school and MTR station) with MicroGIS and BIM technologies. 3. Implement the basic on-site networks for the full-scale tunnel and high-rise building at SCFRI (Sichuan Fire Research Institute, Chengdu) and conduct more full-scale fire tests. 4. Using experimental data to calibrate the CFD fire models for the office floor and high-rise building.

Stage 3 deliverables expanded

Start date (Month / Year)*	Goals# as listed in Full Proposal	Deliverables to be achieved in each stage
July 2021	Goal 1 (80%) Goal 2 (60%) Goal 3 (50%)	1. Demonstrate the AI-based forecast for compartment fire and traveling fire in the floor level to predict the simulated fire scenarios, identify the correlation between data size and forecast accuracy and optimize the AI algorithm. 2. Demonstrate the AI-based forecast for tunnel fire with real-time sensor-measured experimental data and identify critical time scale in operation. 3. Design and analyse the self-healing on-site network. 4. Ability to recognise changes in FUFs using IoT and Computer-vision technologies and update BIM models accordingly.

Stage 4 deliverables expanded

Start date (Month / Year)*	Goals# as listed in Full Proposal	Deliverables to be achieved in each stage
July 2022	Goal 1 (90%) Goal 2 (80%) Goal 3 (50%)	1. Demonstrate the AI-based forecast for different scenarios in all 5 FUFs with both CFD fire simulations and the real-time sensor-measured experimental data 2. Optimize AI algorithms based on different FUFs and identify critical time scale in the operation of sensor, communication, calculation and fire service. 3. Implement the self-healing on-site network prototype. 4. Design and analyse the 5G and/or edge computing off-site network.

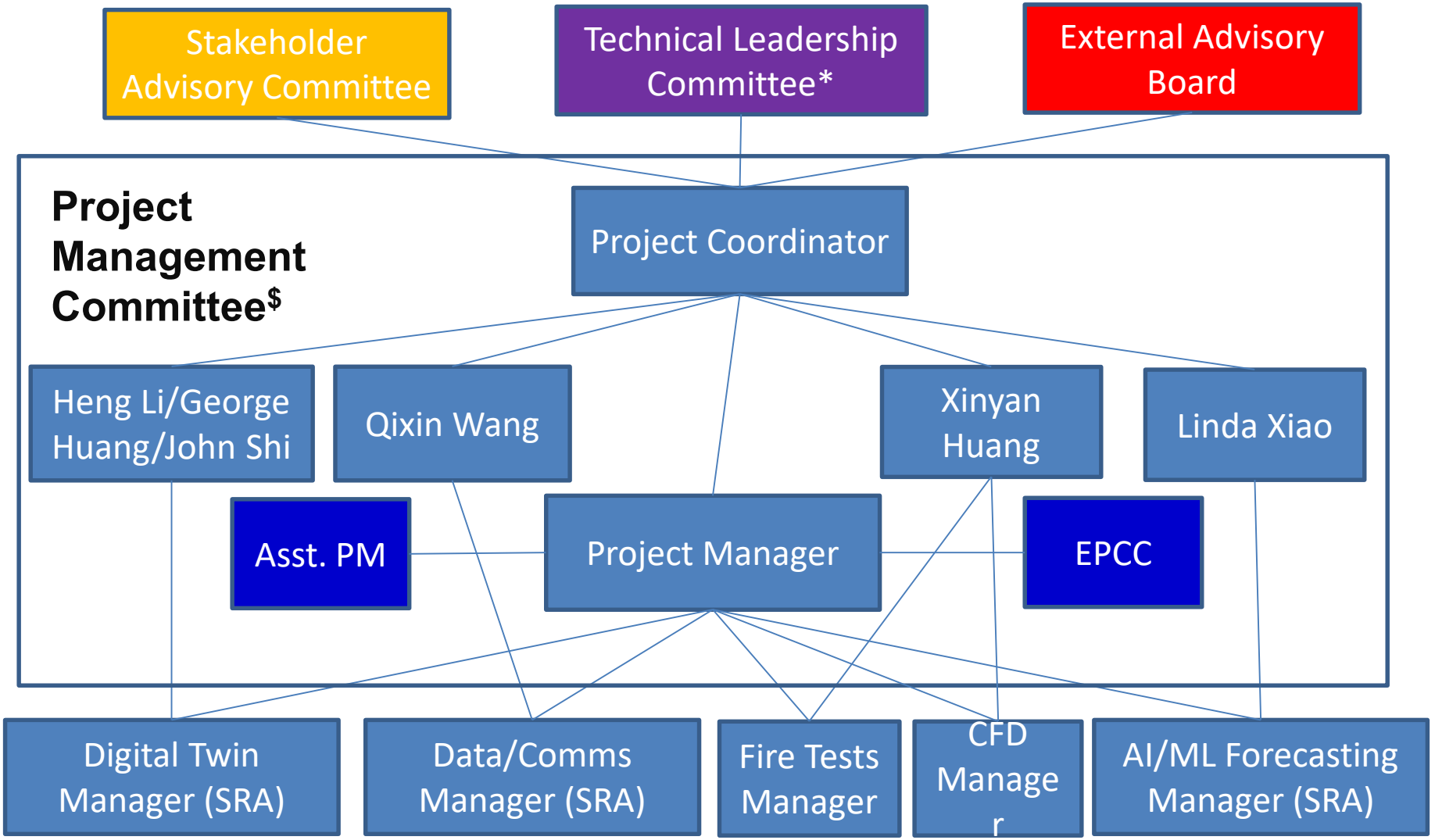
Stage 5 deliverables expanded

Start date (Month / Year)*	Goals# as listed in Full Proposal	Deliverables to be achieved in each stage
July 2023	Goal 1 (100%) Goal 2 (90%) Goal 3 (90%)	1. Implement the 5G and/or edge computing off-site network prototype. 2. Virtual demonstrations of the developed technologies and deliverables 3. Set up physical demonstrations of selected FUFs (Primary school mock-up in HKFASA and full-scale tunnel in SCFRI) with basic on-site and off-site networks and AI fire forecast for partners, public and other stakeholders 4. Roadmap for a deployable prototype SureFire smart firefighting tool for different building and urban environments and guidelines for technology transfer.

Stage 6 deliverables expanded

Start date (Month / Year)*	Goals# as listed in Full Proposal	Deliverables to be achieved in each stage
July 2024	Goal 1 (100%) Goal 2 (100%) Goal 3 (100%)	1. Development of fire-command training programme for Fire Service Department and public education programme. 2. Perfect the on-site and off-site network implementations. 3. Final reports

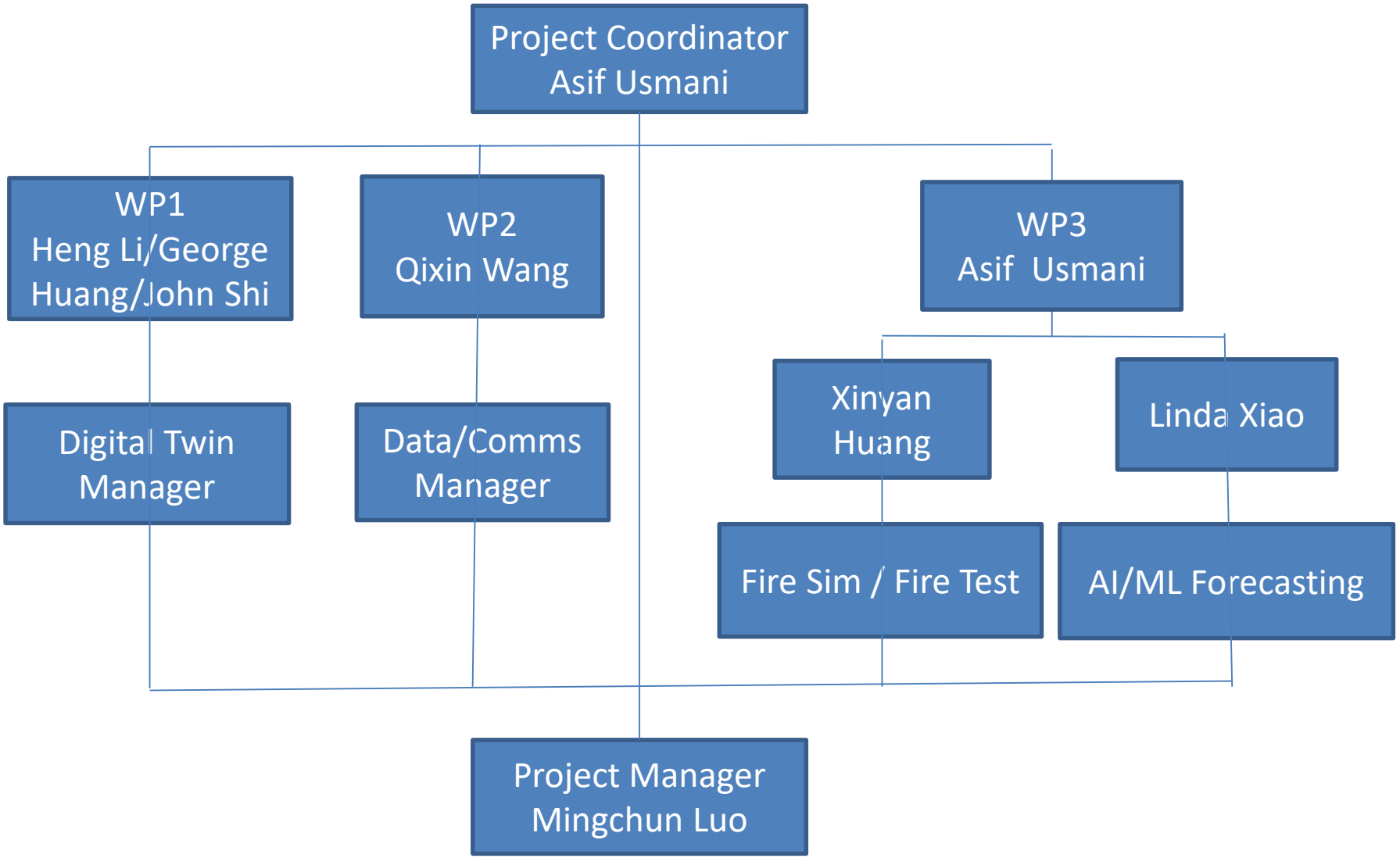
Management Structure



*__Technical Leadership Committee__ (TLC): comprises of all Co-Pis and Partners (it will be called upon individually or severally to assist on technical issues as and when required by the PC or PM)

$ __Project Management Committee__ (PMC): PC will chair this group for routine management of the project, with regular monthly meetings where the PM will present progress reports from all work package managers (occasionally WP managers may be invited)

Research Team Setup



Stakeholder Advisory Committee (SAC)

Convened by FSD
Building owners
Fire safety industry reps
Government departments
GBA Reps
District councillors
Media
Social/Healthcare sector

???

External Advisory Board (EAB)

Buildings Dept. Hong Kong

MTR, Hong Kong

Yi Wang
FM Global

Bart Merci
University of Ghent, Belgium

Yoshifumi Ohmiya
Tokyo University of Science

Lui Sha
UIUC, USA

Weicheng Fan
Tsinghua Univ., China

Jean-Marc Franssen
University of Liege, Belgium

Guoqing Zhu
CUMT, China

Overview

The deliverables for the first phase (1 January 2020 to 31 October 2020):

1. Multiple fire tests with sensors at the full-scale road tunnel at SCFRI and smoke tests at HKFASA.

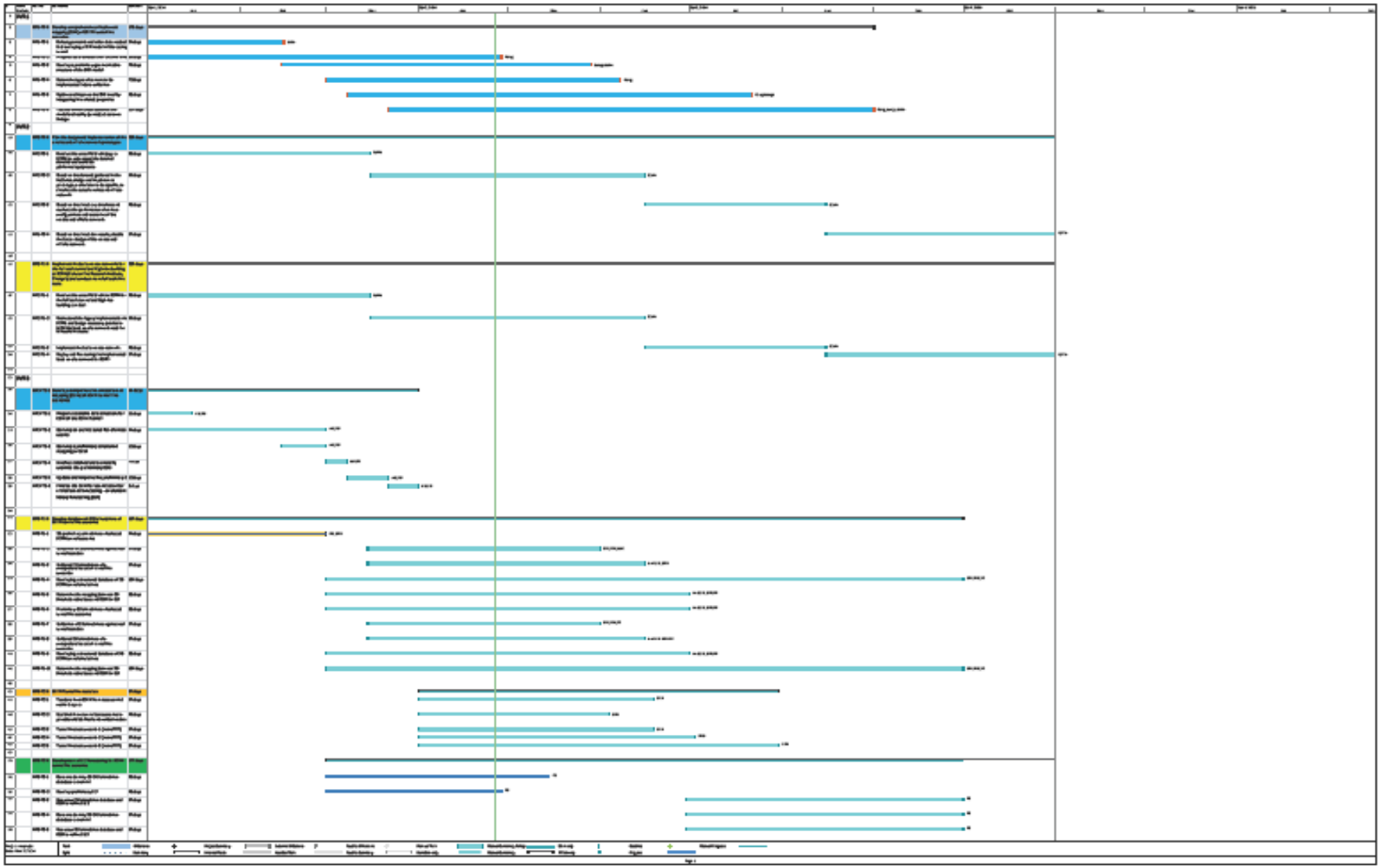
2. Apply the conventional sensors in full-scale tests to identify critical fire event in tunnel and use experimental data to calibrate the CFD model of tunnel fire.

3. Establish the digital twins for tunnel and *the floor of a high-rise building* with MicroGIS and BIM technologies.

4. Run a large number of CFD and structural response simulations to create big data repository for tunnel fire.

5. Plan the design and implementation of the on-site and off-site network prototypes.

SureFire：Proramme for 2020

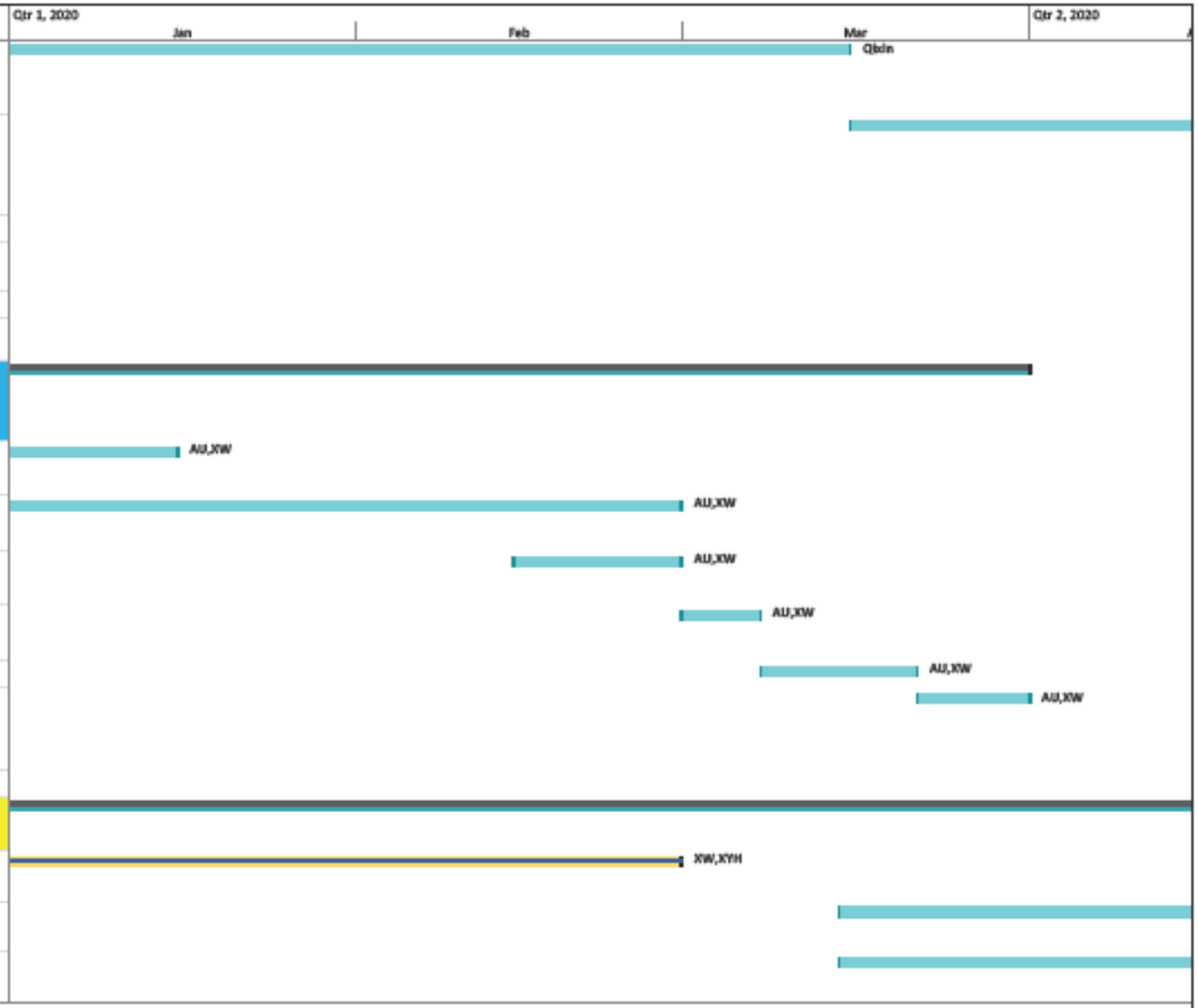


ID	Work Projects	Task ID	Task Name	Duration
1	**WP1**			
2		**WP1-T0-0**	**Develop comprehensive critical event mapping (CEM) of SCFRI tunnel fire**	**175 days**
3		WP1-T0-1	Collect geometric and other data needed for developing a BIM model of the testing	34 days
4		WP1-T0-2	Prepare a data strucutre for the BIM mod	86 days
5		WP1-T0-3	Develop a preliminary geometric data structure of the BIM model.	76 days
6		WP1-T0-4	Determine types of sensors to be implemented in data collection	72 days
7		WP1-T0-5	Update and improve the BIM moel by integrating fire-related properties	98 days
8		WP1-T0-6	Test the mirror effect between BIM model and reality (tunnel) via sensors	117 days
9	**WP2**			
10		**WP2-T0-0**	**Plan the design and implementation of the on-site and off-site network prototypes**	**220 days**
11		WP2-T0-1	Conduct the actual field visit (e.g. to SCFRI) to understand the detailed demand and available platforms/equipments	55 days
12		WP2-T0-2	Based on the demand gathered in the field visit, design and implement a prototype, a simulator to be specific, to simulate the actual on-site and off-site network.	66 days
13		WP2-T0-3	Based on the simulator, simulate and evaluate the performance of various configurations and scenarios of the on-site and off-site network.	45 days
14		WP1-T0-4	Based on the simulation results, decide the better design of the on-site and off-site network.	57 days
15				
16		**WP2-T1-0**	**Implement the basic on-site networks for the full-scale tunnel and high-rise building at SCFRI (Sichuan Fire Research Institute, Chengdu) and conduct more full-scale fire tests.**	**220 days**

Project: mspro11
Date: Mon 27/4/20

Task	Project Summary	Inactive Milestone	Manual Summary Rollup	Deadline
Split	External Tasks	Inactive Summary	Manual Summary	Progress
Milestone	External Milestone	Manual Task	Start-only	Manual Progress
Summary	Inactive Task	Duration-only	Finish-only	

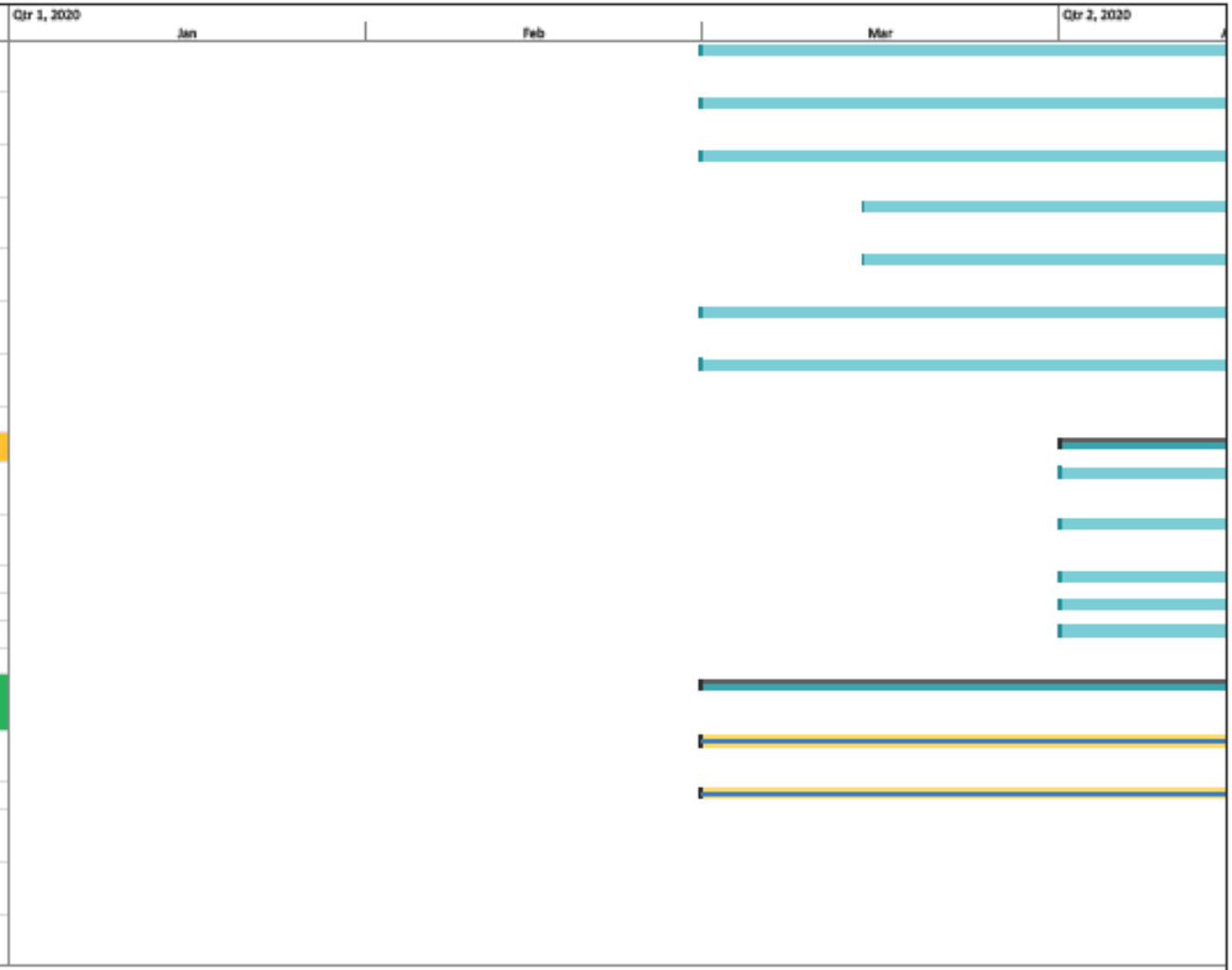
ID	Work Projects	Task ID	Task Name	Duration
17		WP2-T1-1	Conduct the actual field visit to SCFRI for the full-scale tunnel and high-rise building test bed.	55 days
18		WP2-T1-2	Understand the legacy implementation in SCFRI, and design necessary patches to fulfill the basic on-site network need for full-scale fire tests.	66 days
19		WP2-T1-3	Implement the basic on-site network.	45 days
20		WP2-T1-4	Deploy and fine tuning the implemented basic on-site network for SCFRI	57 days
21				
22	WP3			
23		WP3-T0-0	Develop comprehensive critical event mapping (CEM) of SCFRI tunnel fire scenarios	66 days
24		WP3-T0-1	Prepare a suitable data structure for CEM of the SCFRI Tunnel	11 days
25		WP3-T0-2	Develop an unstructured list of critical events	44 days
26		WP3-T0-3	Develop a preliminary structured mapping or CEM	12 days
27		WP3-T0-4	Involve stakeholders to critically examine the preliminary CEM	7 days
28		WP3-T0-5	Update and improve the preliminary C	12 days
29		WP3-T0-6	Finalise the CEM for use in 1st order critical event forecasting - or element library forecasting (ELF)	8 days
30				
31		WP3-T1-0	Develop database of CFD simulations of SCFRI tunnel fire scenarios	197 days
32		WP3-T1-1	2D preliminary simulations of selected SCFRI tunnel scenarios	44 days
33		WP3-T1-2	Validation of 2D simulations against real tunnel test data	57 days
34		WP3-T1-3	Validated 2D simulations of a comprehensive set of tunnel fire scenarios	67 days



Project: msproj11
Date: Mon 27/4/20

Task	Project Summary	Inactive Milestone	Manual Summary Rollup	Deadline
Split	External Tasks	Inactive Summary	Manual Summary	Progress
Milestone	External Milestone	Manual Task	Start-only	Manual Progress
Summary	Inactive Task	Duration-only	Finish-only	

ID	Work Projects	Task ID	Task Name	Duration
35		WP3-T1-4	Developing a structured database of 2D SCFRI tunnel simulations	154 days
36		WP3-T1-5	Determine the mapping between 2D Simulation database and CEM for ELF	88 days
37		WP3-T1-6	Preliminary 3D simulations of selected tunnel fire scenarios	88 days
38		WP3-T1-7	Validation of 3D simulations against real tunnel test data	57 days
39		WP3-T1-8	Validated 3D simulations of a comprehensive set of tunnel fire	67 days
40		WP3-T1-9	Developing a structured database of 3D SCFRI tunnel simulations	88 days
41		WP3-T1-10	Determine the mapping between 3D Simulation database and CEM for ELF	154 days
42				
43		WP3-T2-0	SCFRI Tunnel fire test data	87 days
44		WP3-T2-1	Test data from SCFRI from tests carried out in the past	57 days
45		WP3-T2-2	Establish three tunnel test scenarios to provide reliable first hand validation data	46 days
46		WP3-T2-3	Tunnel fire test scenario 1 (name????)	57 days
47		WP3-T2-4	Tunnel fire test scenario 2 (name????)	67 days
48		WP3-T2-5	Tunnel fire test scenario 3 (name????)	87 days
49				
50		WP3-T3-0	Development of ELF forecasting for SCFRI tunnel fire scenarios	177 days
51		WP3-T3-1	Generate dummy 2D CFD simulation database to train AI	55 days
52		WP3-T3-2	Develop preliminary ELF	43 days
53		WP3-T3-3	Use actual 2D simulation database and CEM to refine ELF2	67 days
54		WP3-T3-4	Generate dummy 3D CFD simulation database to train AI	67 days
55		WP3-T3-5	Use actual 3D simulation database and CEM to refine ELF3	67 days



Project: mspro|11
Date: Mon 27/4/20

Task	Project Summary	Inactive Milestone	Manual Summary Rollup	Deadline			
Split	External Tasks	Inactive Summary	Manual Summary	Progress			
Milestone	External Milestone	Manual Task	Start-only	Manual Progress			
Summary	Inactive Task	Duration-only	Finish-only				

Current Status

- Coronavirus crisis impacted the progress of the project;
- The research team has been set up and run;
- More PhD students and RA will join the team in Sep 2020;
- Experiments on desk top tunnel model and data collection with sensors are in progress;
- Database of Fire Simulation for SCFRI tunnel is established and developing the AI system to process the CFD data;
- SureFire Architecture is to be finalized;

SureFire Architecture

WP1: Digital Twin model

WP2: Communication Network and sensors

WP3: Fire simulation, fire test, AI/ML