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For Discussion
19 December 2018

LEGISLATIVE COUNCIL
PANEL ON ENVIRONMENTAL AFFAIRS

Establishing a Three-dimensional Air Pollution Monitoring Network

PURPOSE

The Hong Kong Special Administrative Region Government (SARG) intends to seek funding approval of $55 million from the Finance Committee in the first quarter of 2019 to establish a three-dimensional (3-D) air pollution monitoring network using light detection and ranging (LiDAR) technology for tracking pollution transport over Hong Kong. This paper briefs Members on the proposal.

BACKGOUND

2. The air quality in Hong Kong has been on an improving trend in recent years as a result of a wide range of local emission control measures implemented by the SARG and the collaboration with the Guangdong Provincial Government in reducing emissions in the Pearl River Delta (PRD) Region. Hong Kong's air quality monitoring data show that ambient concentrations of respirable suspended particulates (RSP), fine suspended particulates (FSP), nitrogen dioxide (NO_2) and sulphur dioxide (SO_2) have dropped by 26%, 29%, 26% and 38% respectively from 2013 to 2017. However, ozone level has been rising in recent years.

3. Apart from local pollution sources, air quality in Hong Kong is also affected by emissions from the PRD Region, especially on ozone, RSP and FSP (collectively referred to as "suspended particulates") which can be formed all over the region through converting various pollutants in the atmosphere (e.g. ozone is formed by photochemical reactions of nitrogen oxides (NOx) and Volatile Organic Compounds (VOC) under sunlight; SO_2 or NOx through reaction in the air may form sulphate or nitrate suspended particulates, etc.). Ozone and suspended particulates are then transported by wind, affecting air quality in the region including Hong Kong. In order to devise appropriate emission control measures, we need to better understand how ozone and suspended particulates are formed in the region, and how they are transported and affect Hong Kong.

4. There are currently 16 air quality monitoring stations in Hong Kong. The design, locations and quality control/quality assurance procedures of the stations made reference to internationally recognized standards, including United States Environmental Protection Agency's guidelines. The stations are set up in representative locations and collect air quality data over a long period, effectively monitoring the long-term air quality and the air pollution levels to which the public are exposed. However, these traditional air quality monitoring stations can only measure the air quality near ground level. They cannot provide air pollution concentration at higher altitude and pollution transport information. The Environmental Protection Department (EPD) has been keeping abreast of the monitoring technology development and adopting new technology in a timely manner to enhance the department's ability to monitor air quality.

5. LiDAR systems are capable of measuring real-time vertical, or 3-D, distribution of air pollutant concentration and wind profile up to several kilometres above ground. The LiDAR data can supplement the ground level information to provide better understanding on the pollutants' transport mechanism. The information will also help EPD identify the trajectories of regional ozone and suspended particulates transport, and improve its air quality modelling and forecasting ability. Wind LiDAR systems have been used by Hong Kong Observatory and Hong Kong Airport Authority to monitor wind speed and wind direction at Hong Kong International Airport. Particulate LiDAR systems have been used for research in some local universities. Wind and particulate LiDAR systems are widely used overseas. Some cities in Mainland have started deploying ozone LiDAR systems in recent years.

LiDAR SYSTEM

6. LiDAR system is a remote sensing instrument that sends laser beams of specific wavelengths into the atmosphere and then detects the backscattering signal to determine the distribution of pollutants or wind field in real time. A LiDAR system mainly consists of a laser transmitting system, a receiving system, a scanning system[1], a detector, a signal processor and a data display system. **Annex I** is a schematic diagram of a typical LiDAR system. **Annex II** shows some of the LiDAR systems available in the market.

7. Some LiDAR systems are equipped with all-sky scanners, which are capable of performing various scanning modes for different applications, including vertical

[1] Scanner is installed in particulate LiDAR and wind LiDAR systems to send out laser beams in three dimension and detect backscattering signal. Due to technical limitation, ozone LiDAR is unable to do 3-D scanning.

scanning, horizontal scanning, conical scanning and mobile vertical scanning. **Annex III** shows some typical scanning options. The monitoring data can be displayed in charts such as those shown in **Annex IV**.

THE PROPOSAL

8. The SARG proposes to procure five (5) sets of the following three (3) different LiDAR systems to establish a 3-D air pollution monitoring network:

- five (5) particulate LiDAR systems with all-sky scanner:
- five (5) wind LiDAR systems with all-sky scanner; and
- five (5) ozone LiDAR systems[2].

9. The 3-D air pollution monitoring network will have five monitoring sites, each equipped with one ozone LiDAR system, one particulate LiDAR system and one wind LiDAR system. EPD plans to have four sites at the periphery of Hong Kong to capture the properties of air plumes entering and leaving the territory. The fifth one will be located in the middle of the territory to monitor the impact of buildings in urban areas on microclimate and pollutant dispersion. A conceptual layout of the 3-D air pollution monitoring network with indicative site locations is shown in **Annex V**. EPD will invite university scholars and LiDAR specialists to help design the monitoring network and search for suitable monitoring sites. The particulate LiDAR system is also compact enough to operate inside a small vehicle to monitor the real time vertical distribution of pollutants in various parts of Hong Kong.

10. The systems will be able to provide good temporal and spatial resolution measurements for vertical distribution of wind speed, wind direction, concentrations of suspended particulates and ozone. As mentioned in para. 5 above, the LiDAR system data will help understand and analyse the sources of ozone and suspended particulates, their formation processes and transport. They will complement the joint efforts of Hong Kong and Guangdong in developing VOC monitoring to tackle the ozone problem[3]. The Guangdong Provincial Government is also setting up similar 3-D air pollution monitoring network in its province. The two sides can use the data obtained to support its policy formulation in the Study on Post-2020 Regional Air Pollutant Emission Reduction Targets and Concentration Levels. The study aims to help setting emission reduction measures and targets for the region after 2020. In addition, the

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2 Due to technical limitation, the ozone LiDAR cannot incorporate all-sky scanner.

3 Ozone is not directly emitted by pollution sources. It is formed by photo-chemical reaction of NOx and VOC in the atmosphere under sunlight. To tackle the ozone problem, it is necessary to jointly reduce VOC emission with the Guangdong Provincial Government. The two sides have already started to include VOC monitoring in the regional monitoring network and gradually have VOC monitoring as part of its routine.

analysed data can be assimilated into EPD's existing air quality prediction system that mainly based on meteorological and ground level air quality data to improve air quality prediction ability and accuracy, including prediction of the possibility of high pollution episodes. We will also develop method to combine the ground level monitoring data, 3-D monitoring data and modelling results to provide 3-D pollutant distribution information to the public. The 3-D monitoring data will also be available to universities and research institutes for developing and validating microclimate models.

FINANCIAL IMPLICATIONS

Non-recurrent expenditure

11. EPD plans to implement the proposed system over three years. The estimated non-recurrent cost of the project is around $55 million. The detailed breakdown is as follows –

	2019-20 $,000	**2020-21 $,000**	**2021-22 $,000**	**Total $,000**
(a) Hardware and Software	-	19,200	28,800	48,000
(b) Site preparation, delivery, installation, testing, commissioning, documentation and training	1,000	400	600	2,000
(c) Contingency (10% of (a)+(b))	100	1,960	2,940	5,000
Total	**1,100**	**21,560**	**32,340**	**55,000**

Recurrent expenditure

12. The proposal will entail an indicative additional annual recurrent expenditure of $7 million from 2021 onwards to cover the operation costs including light and power, communication lines, spare parts and consumables. EPD will absorb the recurrent expenditure from within its existing resources.

IMPLEMENTATION SCHEDULE

13. We plan to seek funding approval from the Finance Committee in the first quarter of 2019. A tentative implementation plan is set out below –

	Key deliverable	Target completion date
(a)	Tender preparation and invitation	September 2019
(b)	Contract award	February 2020
(c)	Site preparation works	July 2020
(d)	Delivery and installation	September 2020
(e)	Acceptance test	November 2020
(f)	Full commissioning of the system	May 2021

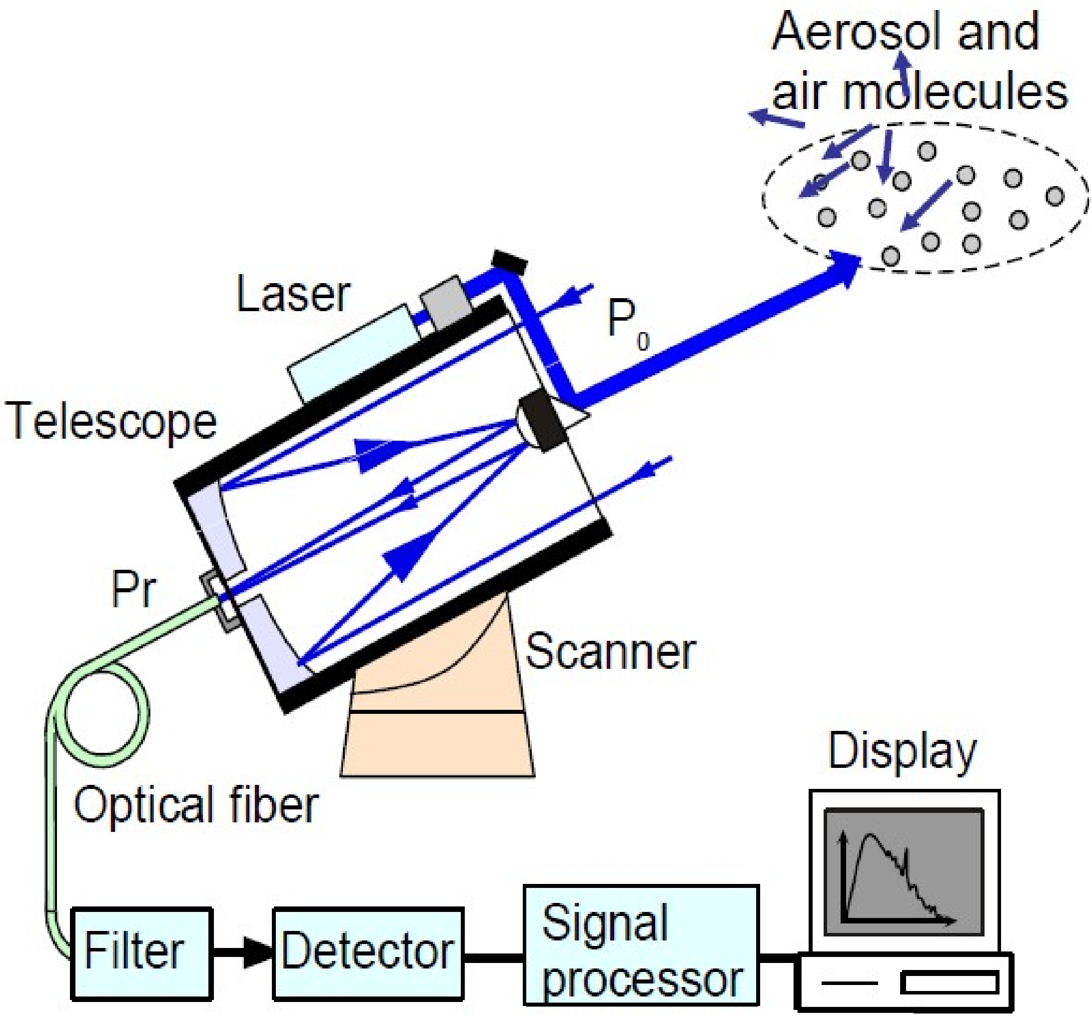
ADVICE SOUGHT

14. Members are invited to comment on and support the above proposal.

Environmental Protection Department
December 2018

Annex I

Schematic Diagram of LiDAR system

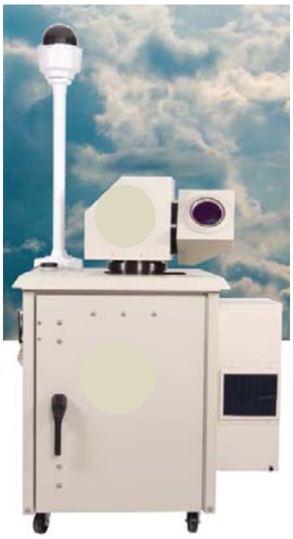


Annex II

Commercial Grade LiDAR System

Ozone LiDAR

Particulate LiDAR



Particulate LiDAR

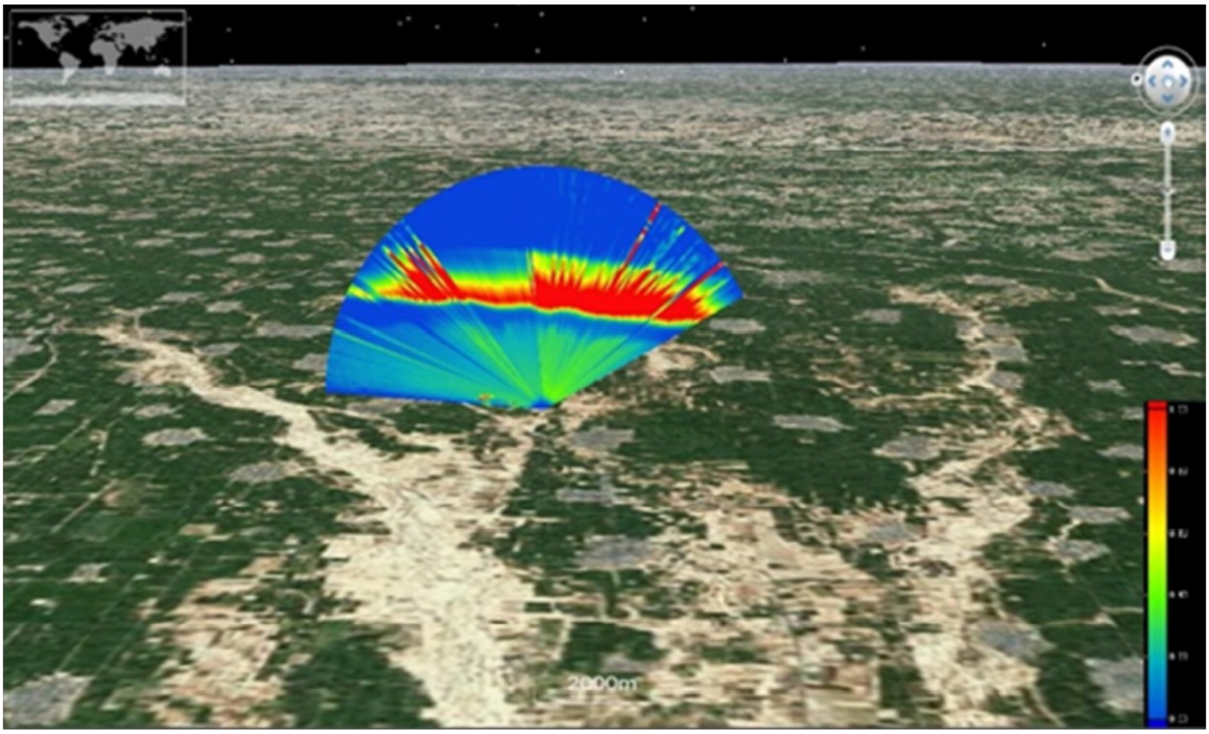
Portable Particulate LiDAR

Wind LiDAR

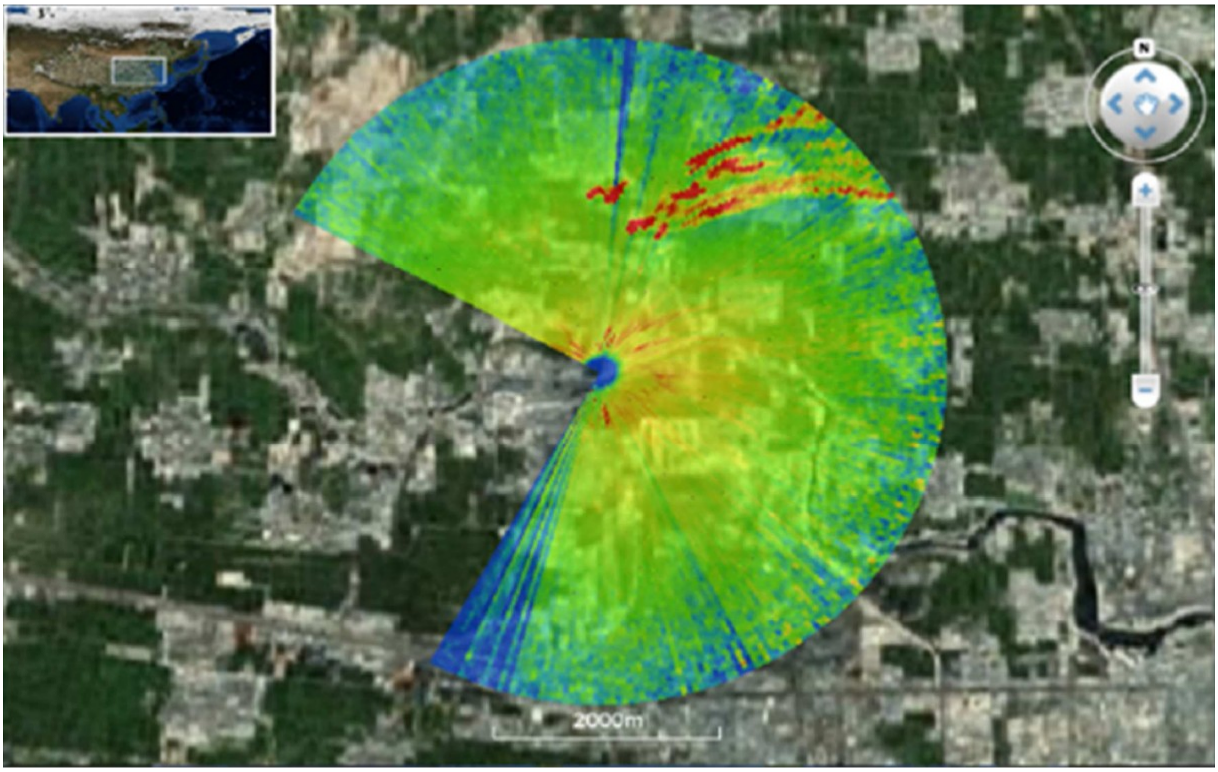
Wind LiDAR

Annex III

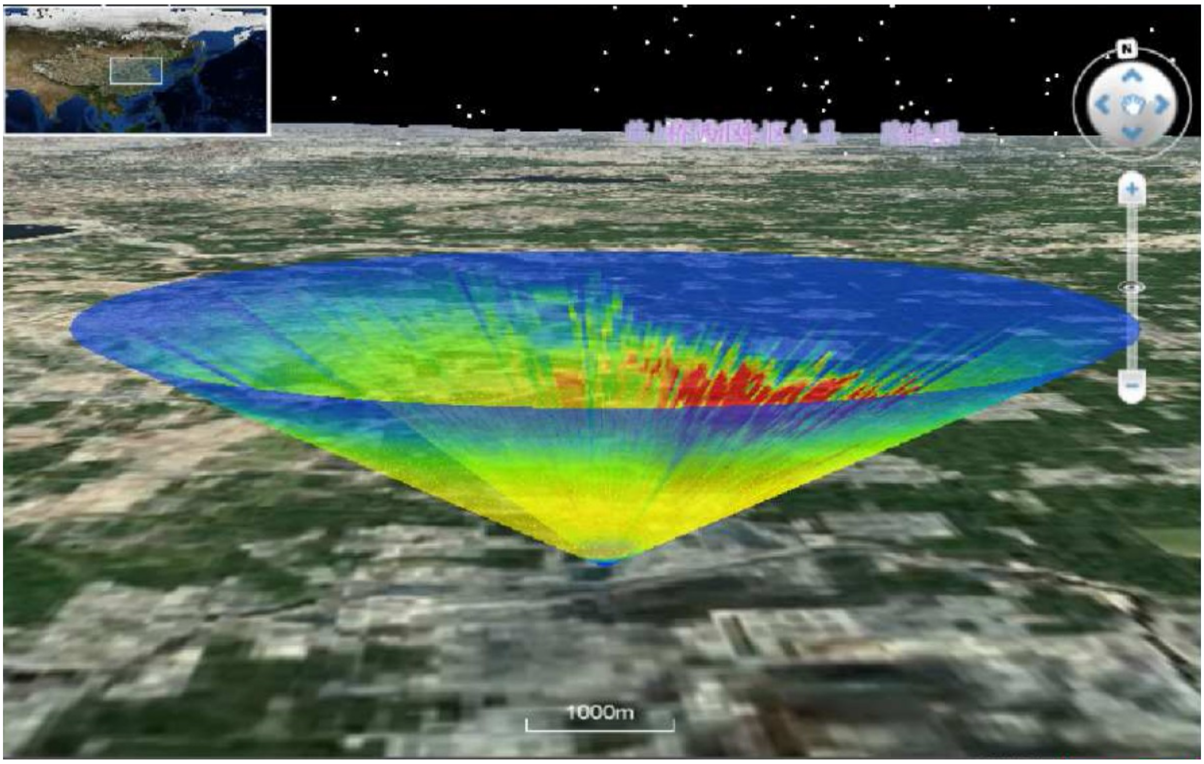
Scanning Mode of LiDAR System



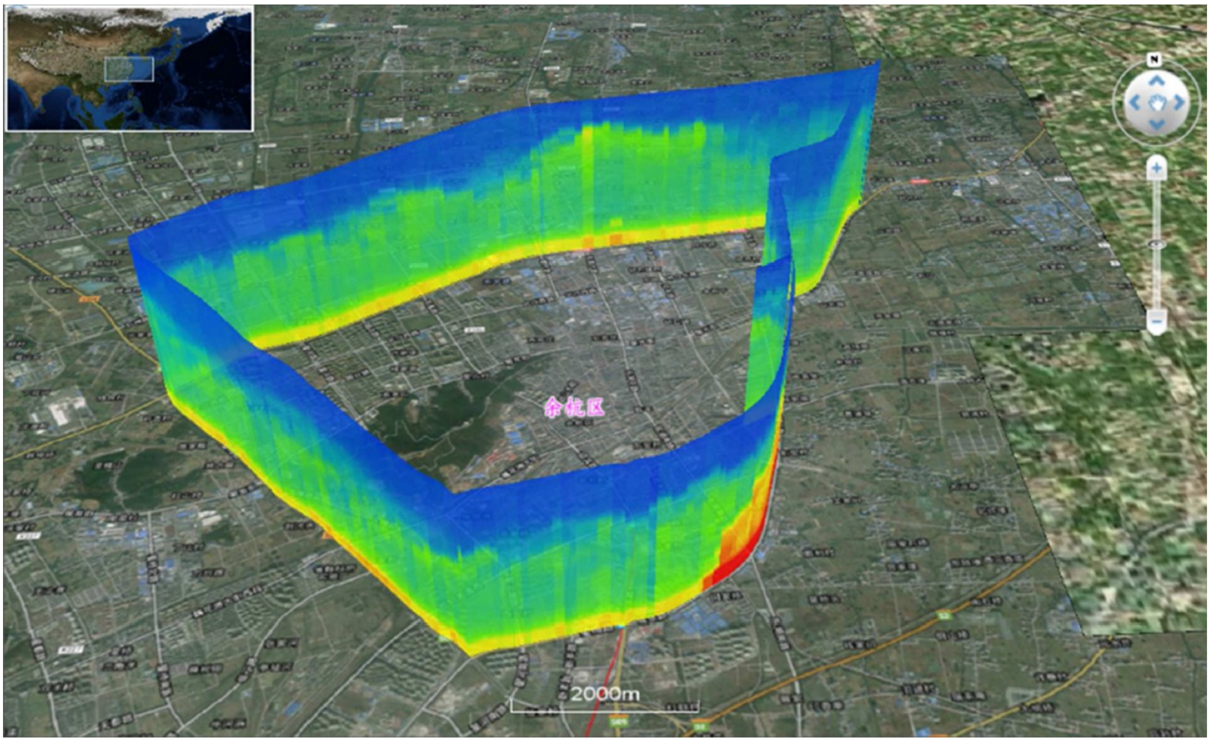
Vertical scanning



Horizontal Scanning

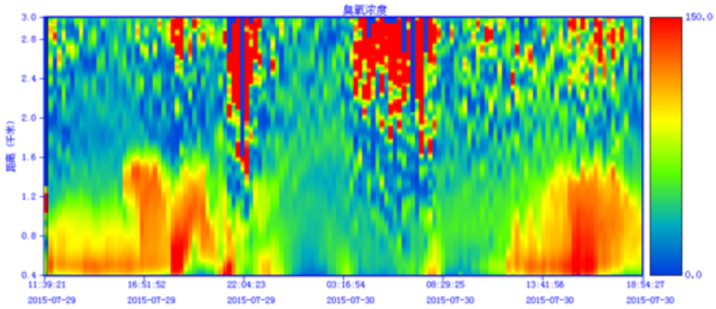


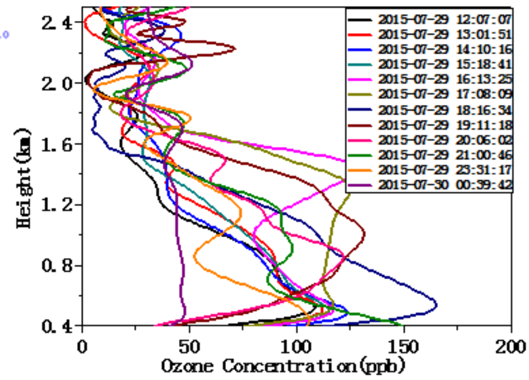
Conical Scanning

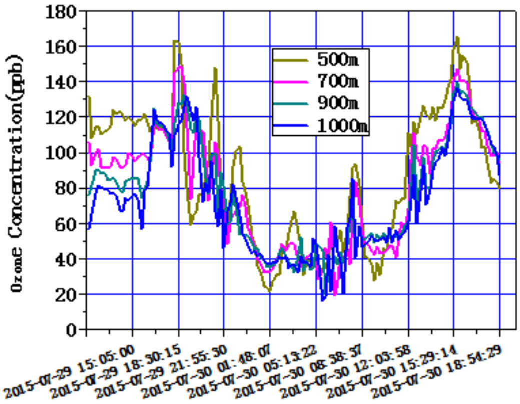


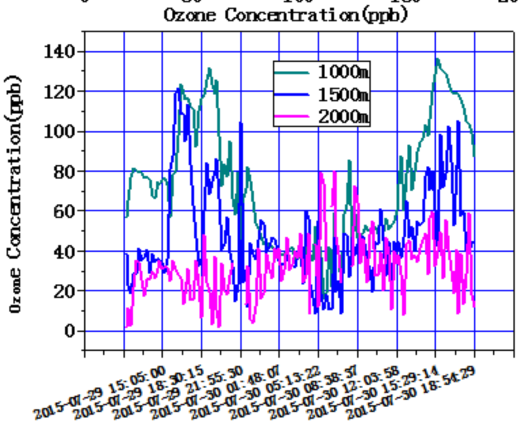
Mobile Vertical Scanning

Display of Monitoring Data



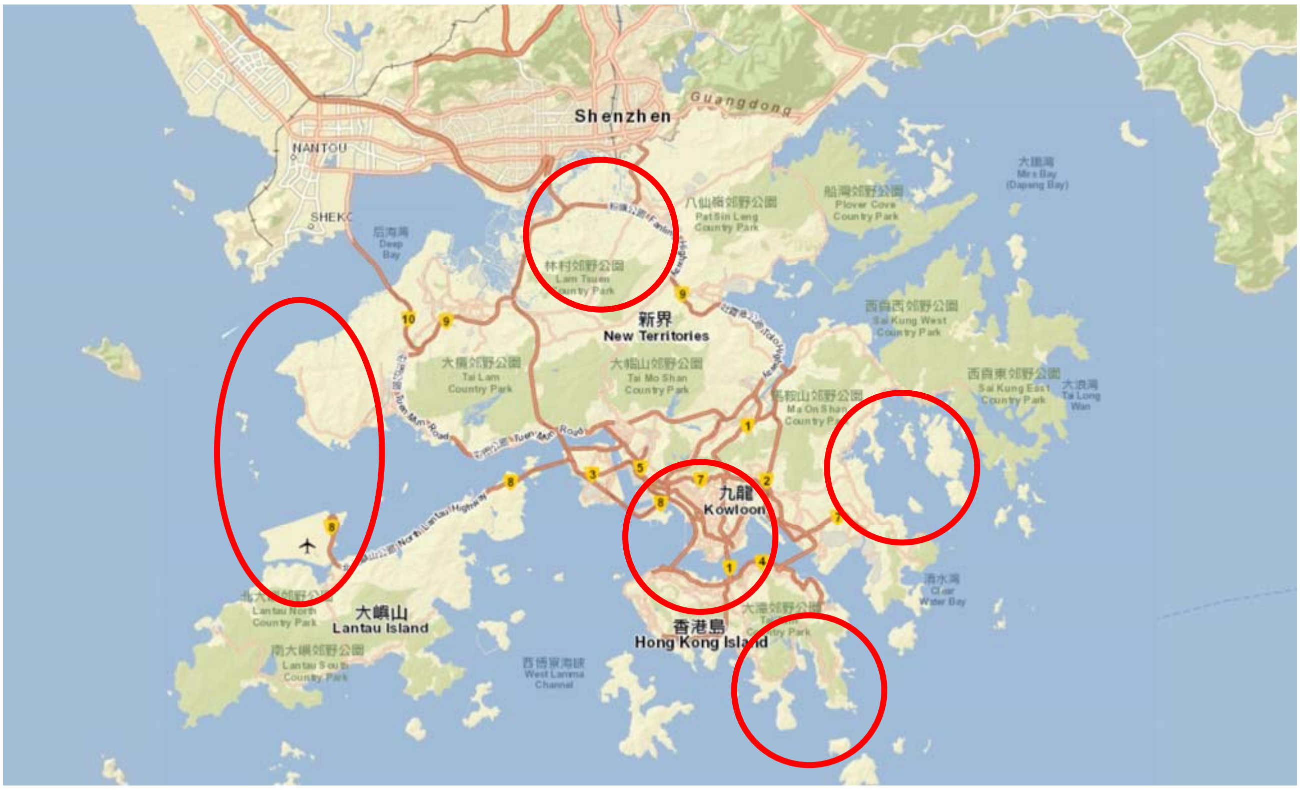






Annex V

Concept Layout of the 3-D Air Pollution Monitoring Network



Indicative LiDAR monitoring sites