For discussion
on 24 May 2019

FCR(2019-20)19

ITEM FOR FINANCE COMMITTEE

CAPITAL WORKS RESERVE FUND
HEAD 708 – CAPITAL SUBVENTIONS AND MAJOR SYSTEMS AND EQUIPMENT
Environmental Protection Department
New Subhead "Provision of a three-dimensional air pollution monitoring network using light detection and ranging technology for tracking pollution transport over Hong Kong"

Members are invited to approve a new commitment of $55 million for the provision of a three-dimensional air pollution monitoring network using light detection and ranging technology for tracking pollution transport over Hong Kong.

PROBLEM

We need to develop a three-dimensional (3-D) air pollution monitoring network to identify the trajectories of regional ozone and suspended particulates transport to improve the ability of the Environmental Protection Department (EPD) in air quality modelling and forecasting, enhance the understanding of the causes of regional ozone and particulate matters pollution problems, and facilitate the formulation of policy to tackle the issues.

PROPOSAL

2. The Director of Environmental Protection proposes to create a new commitment of $55 million to establish a 3-D air pollution monitoring network using light detection and ranging (LiDAR) technology for tracking pollution transport over Hong Kong.

/JUSTIFICATION …..

JUSTIFICATION

Need for a 3-D air pollution monitoring network

3. Apart from local pollution sources, the air quality in Hong Kong is also affected by emissions in the Pearl River Delta (PRD) Region, especially on ozone, respirable suspended particulates and fine suspended particulates (collectively referred to as "suspended particulates") which can be formed over the region through chemical reactions of pollutants in the atmosphere (e.g. ozone is formed by photochemical reactions of nitrogen oxides (NOx) and Volatile Organic Compounds (VOC) under sunlight; sulphate particulates and nitrate particulates are formed as secondary pollutants from sulphur dioxide (SO_2) or NOx, etc.). Ozone and suspended particulates are then transported by wind, affecting air quality in the PRD region including Hong Kong. In order to devise appropriate air 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 make reference to internationally recognised 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 air pollution levels to which members of the public are exposed. However, these traditional air quality monitoring stations can only measure air quality near ground level (a general air monitoring station is usually located on the roof of a low-rise building). They cannot monitor air pollution concentration at higher altitudes and their transportation pathways. EPD has been keeping abreast of the developments in air monitoring technology 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 and 3-D distribution of air pollutant concentration and wind profile up to several kilometres above ground. The data obtained from particulates, wind and ozone LiDAR systems can supplement the information gathered at near ground level, helping to identify the trajectories of regional ozone and suspended particulates transport, enhance the understanding of their sources as well as formation and transport processes. This would enhance EPD's air quality modelling and forecasting ability, and provide more robust scientific basis for formulating air pollutant emission control measures.

/LiDAR …..

LiDAR system

6. A 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. It mainly consists of a laser transmitter, a receiver, a scanner, a detector, a signal processor and a data display. Enclosure 1 is a schematic diagram of a typical particulate LiDAR system. Enclosure 2 shows some of the LiDAR systems available in the market.

Encl. 1
Encl. 2

7. Some LiDAR systems are equipped with all-sky scanners[1] capable of performing various scanning modes for different applications, including vertical scanning, horizontal scanning, conical scanning and mobile vertical scanning. Enclosure 3 shows some typical scanning options. The monitoring data can be displayed in charts such as those shown at Enclosure 4.

Encl. 3
Encl. 4

8. 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 the Mainland have also started deploying ozone LiDAR systems in recent years. For instance, the Guangdong Provincial Government is setting up a 3-D air pollution monitoring network in its province.

The proposed 3-D air pollution monitoring network and its benefits

9. EPD proposes to procure five sets each of the following three different LiDAR systems (15 sets of LiDAR systems in total) to establish a 3-D air pollution monitoring network –

- particulate LiDAR system with all-sky scanner;
- wind LiDAR system with all-sky scanner; and
- ozone LiDAR system.

/10. …..

[1] Due to technical limitation, the ozone LiDAR system cannot incorporate all-sky scanner for performing 3-D scanning. It can only perform vertical scanning.

10. There will be five monitoring sites in the 3-D air pollution monitoring network, each equipped with one ozone LiDAR system, one particulate LiDAR system and one wind LiDAR system. As regards locations, EPD plans to set up 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 at Encl. 5 Enclosure 5. EPD will invite university scholars and LiDAR specialists to help design the monitoring network and search for suitable monitoring sites. As particulate LiDAR system is relatively compact, EPD intends to install one set of particulate LiDAR system on a vehicle, so that, if necessary, it can be deployed at different locations in Hong Kong to monitor the real time distribution of suspended particulates at higher altitudes.

11. With the support of the LiDAR system data, EPD can better understand and analyse the sources of ozone and suspended particulates, as well as their formation and transport processes. This will complement the joint efforts of Hong Kong and Guangdong in developing VOC monitoring to tackle the ozone problem [2], and providing a more robust scientific basis for developing appropriate emission control strategies. In addition, the measured data from the LiDAR systems can be assimilated into EPD's existing air quality prediction system that is 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 explore how to combine the ground level monitoring data, 3-D monitoring data and modelling results for provision of 3-D pollutant distribution information to the public, and how to make the data available to universities and research institutes for developing and validating microclimate models.

FINANCIAL IMPLICATIONS

Non-recurrent Expenditure

12. 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** …..

[2] Ozone is not directly emitted by pollution sources. It is formed by photochemical reaction of NOx (including nitrogen monoxide and nitrogen dioxide) and VOC in the atmosphere under sunlight. They are transported by wind, affecting air quality in the PRD region including Hong Kong.

	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**

13. On paragraph 12(a) above, the estimate of $48,000,000 is for the procurement of 15 LiDAR systems in total for setting up five monitoring sites. Each site will be equipped with three LiDAR systems comprising a particulate LiDAR, a wind LiDAR and an ozone LiDAR.

14. On paragraph 12(b) above, the estimate of $2,000,000 is for the new site preparation works and setting up LiDAR systems, including delivery, installation, testing, commissioning and documentation of the LiDAR systems, and training for EPD staff.

15. On paragraph 12(c) above, the estimate of $5,000,000 represents a 10% contingency of the total cost estimate for the procurement of hardware and software as well as the new site preparation works and setting up LiDAR systems.

16. In compiling the cost estimate, EPD has obtained indicative quotes from potential suppliers for major cost items of LiDAR systems. If the funding is approved by the Finance Committee (FC), we shall proceed with the procurement of the LiDAR systems by open tender to worldwide suppliers in accordance with established government procurement procedures.

/**Recurrent** …..

Recurrent Expenditure

17. Following full implementation in 2021, the proposal will entail an indicative additional annual recurrent expenditure of $12.2 million from 2022 onwards to cover the operation costs including spare parts and other consumables, hire of services for maintaining the network, and EPD's staff cost[3]. EPD will absorb the recurrent expenditure from within its existing resources.

Other Proposals Considered

18. We have considered and assessed the alternative of procuring measurement data from a contractor, which means contracting out the setting up of the five monitoring stations as a service package, such that the contractor will provide all the LiDAR systems and be responsible for all the works in processing and reporting of measurement data. Based on a normal five-year lifespan of a LiDAR system, a rough comparison of the costs of the proposal and the alternative is at Enclosure 6. It shows that the expenditure of the alternative is slightly higher than the current proposal. Furthermore, relying on outsourcing the services will not be conducive to the development of in-house expertise in LiDAR monitoring technology within EPD. We do not recommend the alternative option.

Encl. 6

IMPLEMENTATION PLAN

19. Subject to FC's funding approval, we plan to implement the proposed monitoring network according to the following schedule –

	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

/PUBLIC …..

[3] Duties of EPD staff include daily operation of the 3-D air monitoring network, management of the data transmission and retrieval computer system, post-processing of the data including quality assurance, quality control and archive, and management of the outsourced maintenance service contract.

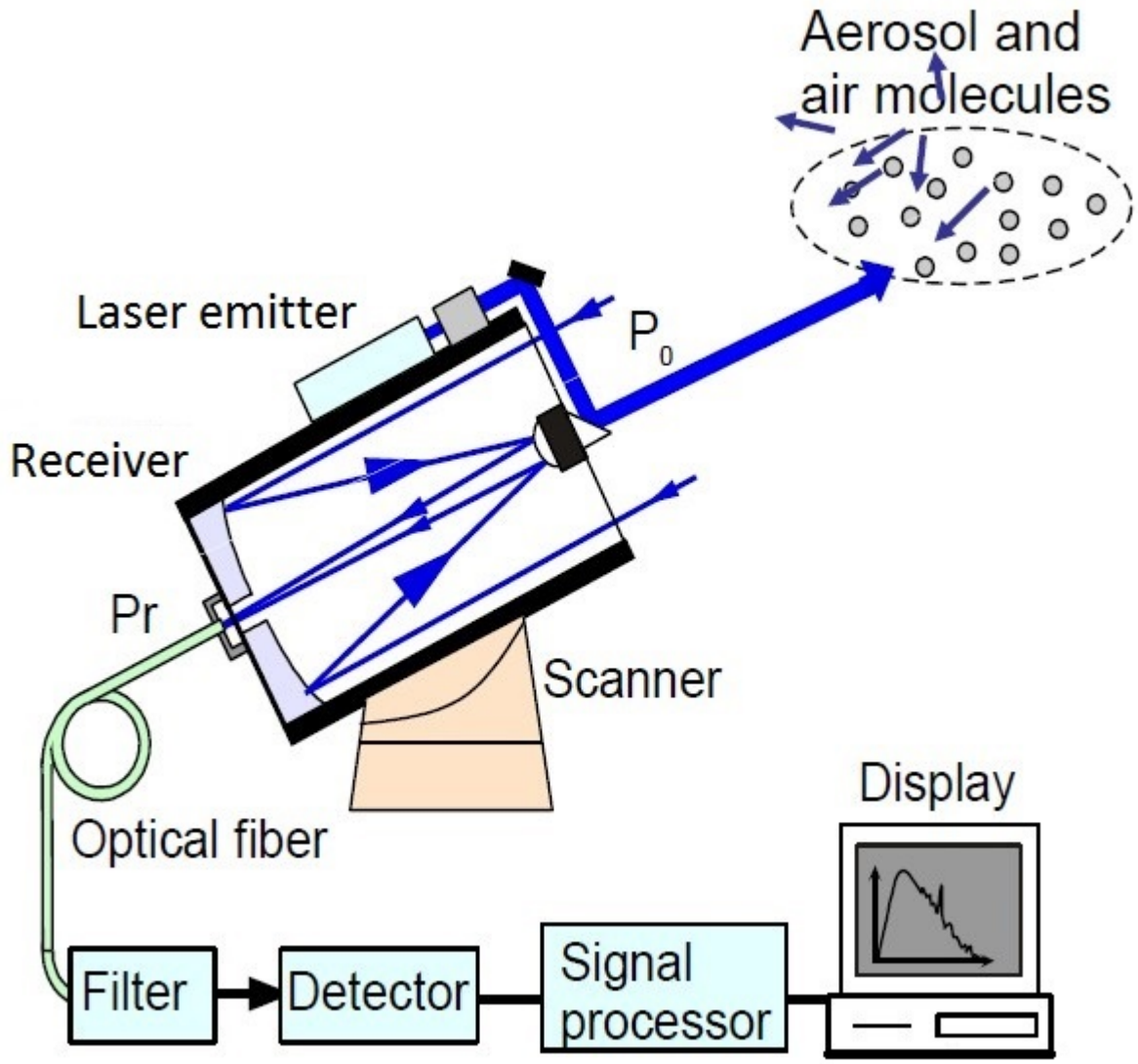
PUBLIC CONSULTATION

20. We consulted the Legislative Council Panel on Environmental Affairs on the proposal on 19 December 2018. Members supported the submission of the above proposal to FC for funding approval.

Environment Bureau
Environmental Protection Department
May 2019

Enclosure 1 to FCR(2019-20)19

Schematic Diagram of Particulate Light Detection and Ranging System



Enclosure 2 to FCR(2019-20)19

Commercial Grade Light Detection and Ranging (LiDAR) System

Ozone LiDAR

Particulate LiDAR

Particulate LiDAR

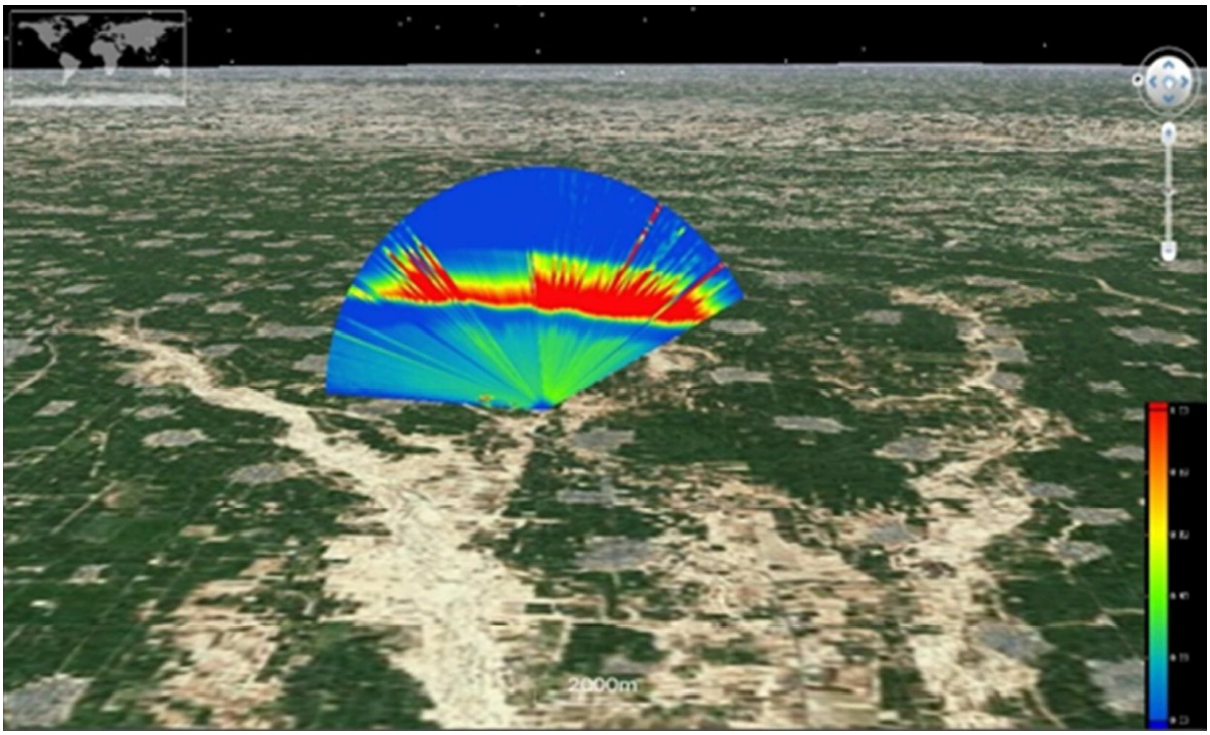
Portable Particulate LiDAR

Wind LiDAR

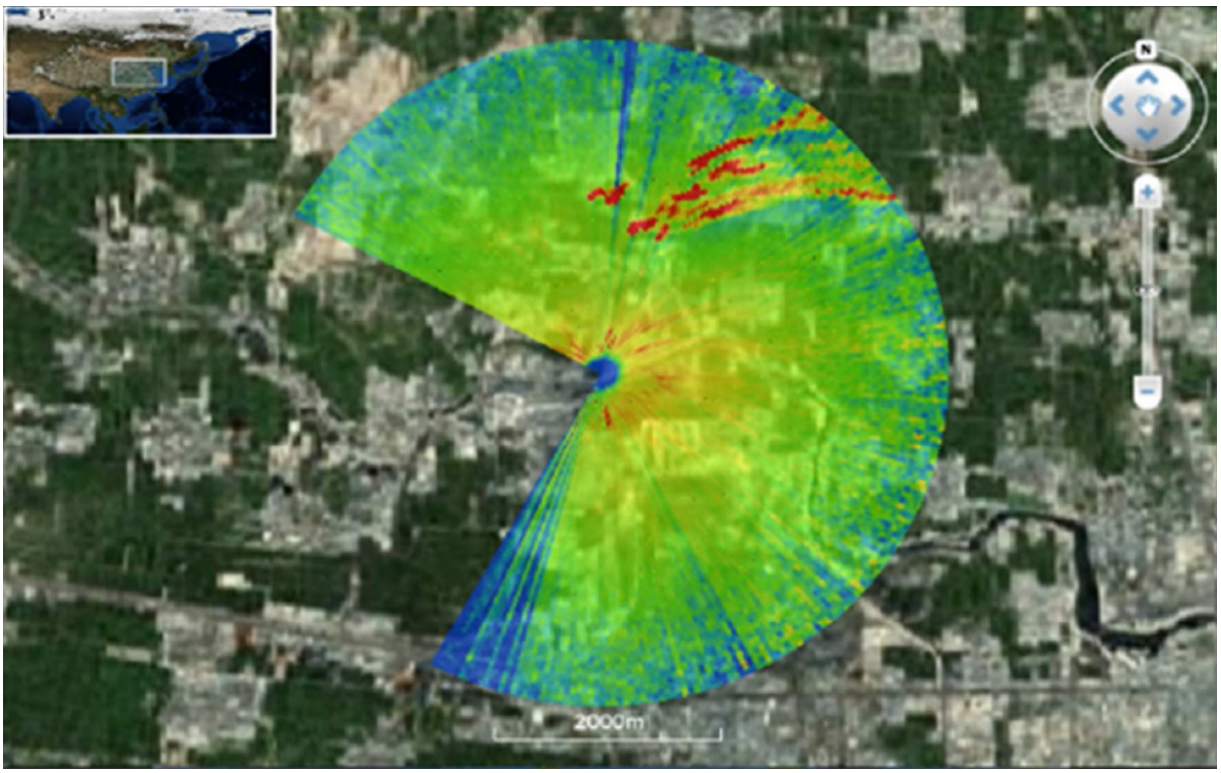
Wind LiDAR

Enclosure 3 to FCR(2019-20)19

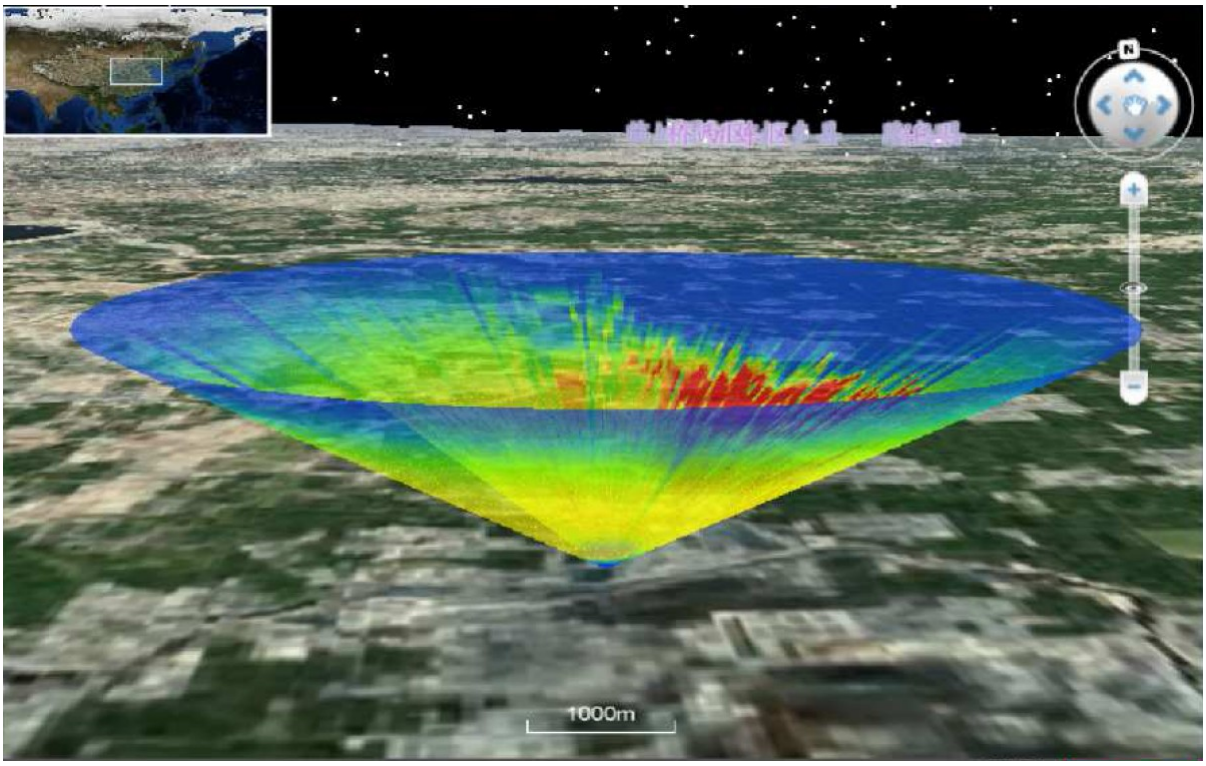
Scanning Mode of Light Detection and Ranging System



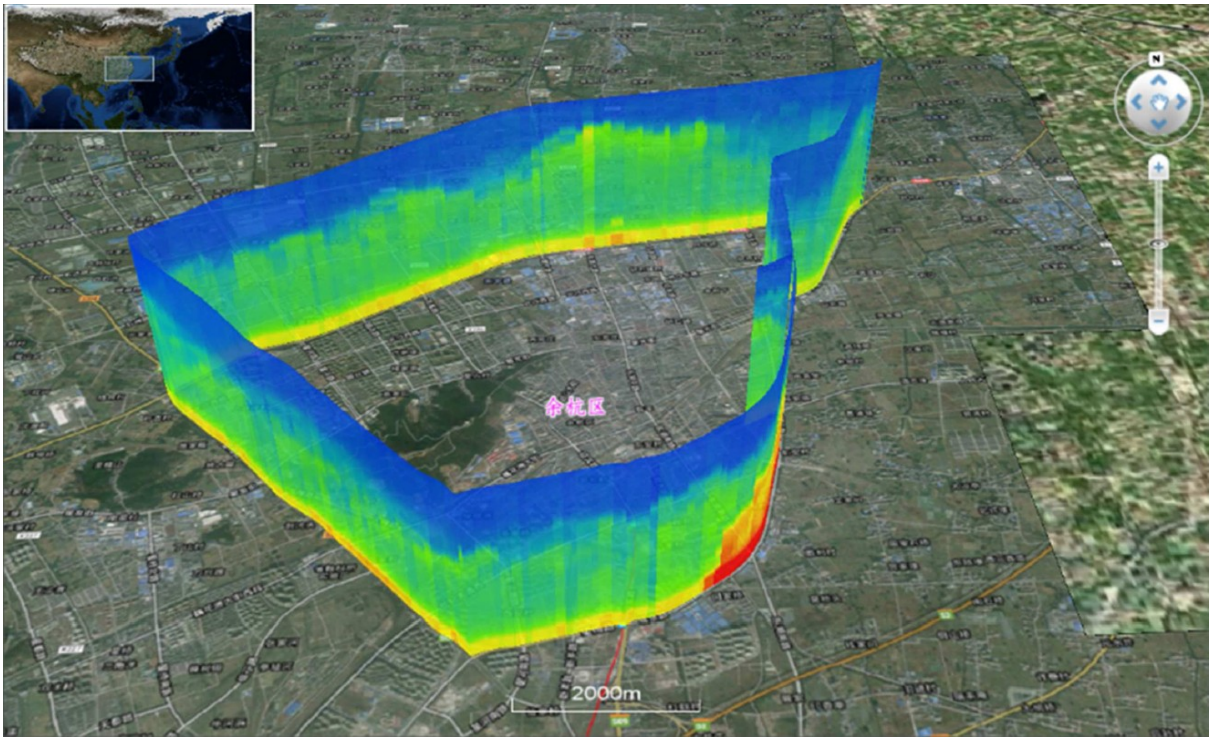
Vertical scanning



Horizontal Scanning



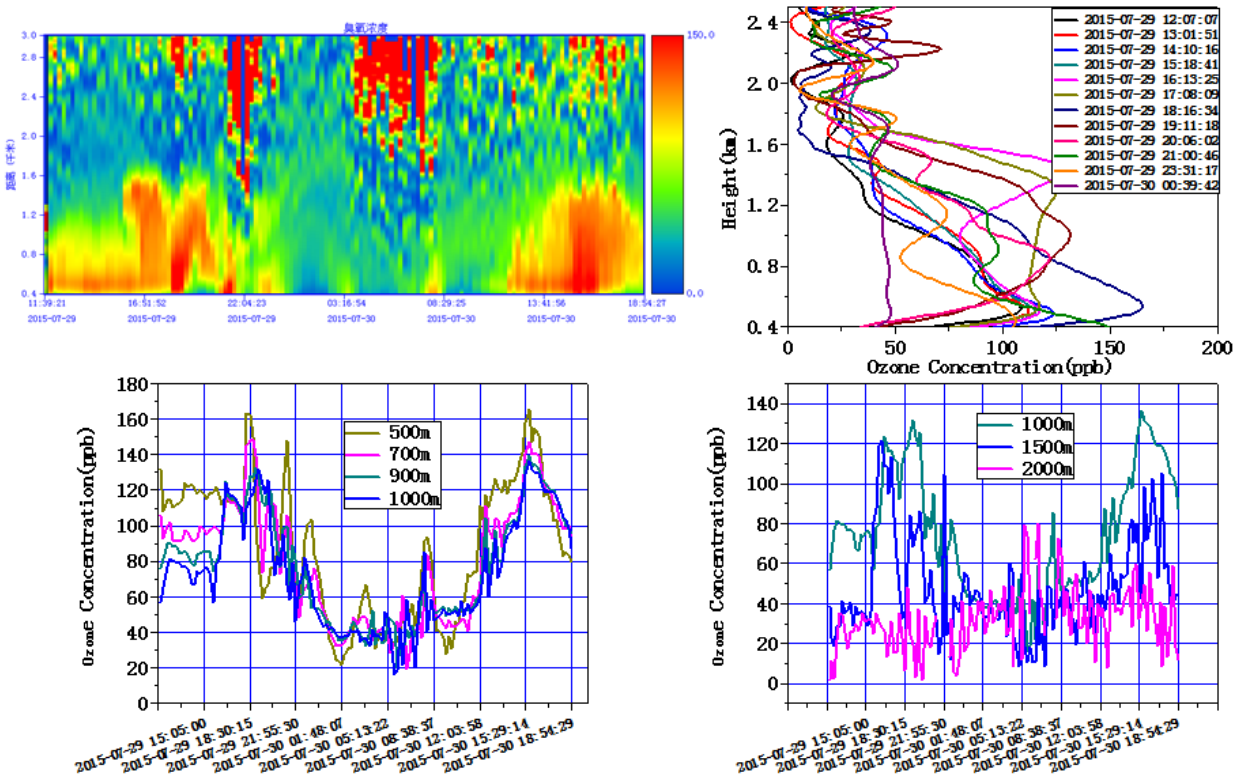
Conical Scanning



Mobile Vertical Scanning

Enclosure 4 to FCR(2019-20)19

Display of Monitoring Data



Enclosure 5 to FCR(2019-20)19

Concept Layout of the Three-dimensional Air Pollution Monitoring Network

Indicative LiDAR monitoring sites

Enclosure 6 to FCR(2019-20)19

Cost comparison of different options for three-dimensional (3-D) air pollution monitoring

	Cash flow ($'000)							
	2019-20	**2020-21**	**2021-22**	**2022-23**	**2023-24**	**2024-25**	**2025-26**	**Total**
Cost of the recommended proposal								
Capital expenditure	1,100	21,560	32,340	-	-	-	-	55,000
Recurrent expenditure								
1. Spare parts and consumables	-	-	-[1]	7,000	7,000	7,000	7,000	28,000
2. Hire of maintenance service	-	-	3,500	3,500	3,500	3,500	3,500	17,500
3. Environmental Protection Department (EPD)'s staff cost[2]	-	-	1,740	1,740	1,740	1,740	1,740	8,700
(A) Total cost of the proposal	**1,100**	**21,560**	**37,580**	**12,240**	**12,240**	**12,240**	**12,240**	**109,200**
Cost of the alternative option								
1. Procurement of measurement data[3]	-	-	21,000	21,000	21,000	21,000	21,000	105,000
2. EPD's staff cost[4]	-	-	1,050	1,050	1,050	1,050	1,050	5,250
(B) Total cost of alternative	**-**	**-**	**22,050**	**22,050**	**22,050**	**22,050**	**22,050**	**110,250**
(C) Net saving ((C) = (B) - (A))	**(1,100)**	**(21,560)**	**(15,530)**	**9,810**	**9,810**	**9,810**	**9,810**	**1,050**
Net cumulative saving	**(1,100)**	**(22,660)**	**(38,190)**	**(28,380)**	**(18,570)**	**(8,760)**	**1,050**	**1,050**

[1] It is within the first year after sales warranty period and therefore free of charge for parts and consumables.

[2] The work includes the daily operation of the 3-D air monitoring network, the management of the data transmission computer system, the post-processing of data including quality assurance, quality control and archive, and the management of the outsourced maintenance service contract.

[3] As a trial to enable EPD staff to have a basic understanding of the technology and operation of light detection and ranging (LiDAR) systems, EPD has awarded a one-year hire of services contract for provision of ozone measurement data at a cost of $1.4 million. The cost includes the rental cost for provision of an ozone LiDAR system and the works for processing and reporting of measurement data. Making reference to this contract and noting that the service charges for wind LiDAR and particulate LiDAR systems are roughly similar, the charge of outsourcing services for 15 sets of LiDAR systems is therefore roughly estimated to be $21 million.

[4] The work includes the management of the outsourced service contract for procurement of measurement data, the management of the data transmission computer system and the archive of data.
