For discussion
on 19 November 2019

Legislative Council
Panel on Commerce and Industry

Four-Year Progress Report on Research & Development ("R&D") Centres and Funding Proposal to Extend the Operation of the R&D Centres

PURPOSE

This paper briefs Members on the operation of the five R&D Centres under the purview of the Innovation and Technology Commission ("ITC") between 2015-16 and 2018-19 (a four-year period) and seeks Members' views on the funding proposal to extend the operation of four of the R&D Centres beyond 31 March 2021 for another four years to 31 March 2025.

BACKGROUND

2. Since 2006, the Government has set up five R&D Centres to drive and coordinate applied R&D in selected focus areas. The five Centres are –

(a) Automotive Platforms and Application Systems R&D Centre[1] ("APAS");
(b) Hong Kong Applied Science and Technology Research Institute[2] ("ASTRI");
(c) Hong Kong Research Institute of Textiles and Apparel ("HKRITA");
(d) Logistics and Supply Chain MultiTech R&D Centre [3] ("LSCM"); and
(e) Nano and Advanced Materials Institute ("NAMI").

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[1] Renamed in August 2019 and formerly known as the "Automotive Parts and Accessory Systems R&D Centre".

[2] ASTRI was established in 2000 and designated as the R&D Centre for Information and Communications Technologies ("ICT") in 2006.

[3] Renamed in May 2018 and formerly known as the "R&D Centre for Logistics and Supply Chain Management Enabling Technologies".

3. In December 2015, the Finance Committee ("FC") of the Legislative Council ("LegCo") approved an additional allocation of $677.6 million from the Innovation and Technology Fund ("ITF") to support the operation of four of the R&D Centres up to 31 March 2021 (except ASTRI since its operating expenditure is met separately from Government's annual recurrent subvention). Since 2006, a total commitment of $1,696.6 million has been approved to fund the operation of the four R&D Centres.

4. The R&D Centres play an important role in creating a vibrant innovation and technology ("I&T") ecosystem. They act as a focal point for technology collaboration among the Government, industry, academia and research sectors. The R&D Centres not only contribute to the applied research in key areas, but also work closely with the industry to encourage private investment in R&D in Hong Kong and drive the commercialisation of R&D results.

5. In addition, the R&D Centres actively participate in the Public Sector Trial Scheme ("PSTS")[4] and promote the adoption of local technology products and services by public sector organisations. Throughout the years, the R&D Centres have also nurtured a pool of research talents and received numerous international awards for their innovations, making significant contribution in consolidating the capabilities of local scientific research teams.

OVERVIEW OF THE OPERATION OF THE R&D CENTRES BETWEEN 2015-16 AND 2018-19

6. The ensuing paragraphs provide an overview of the operation of the R&D Centres between 2015-16 and 2018-19 on the following areas -

(a) operating expenditure and staffing situation;
(b) level of industry income;
(c) R&D projects and expenditure; and
(d) commercialisation,

with an emphasis on their performance in 2018-19. The work of the R&D Centres in the past three years were reported to the LegCo Panel on Commerce and Industry

[4] The PSTS is a funding scheme under the ITF which supports the production of prototypes/samples and conducting of trials in the public sector to facilitate and promote the realisation and commercialisation of R&D results under the ITF projects or those developed by incubatees and graduate tenants of the Hong Kong Science and Technology Parks Corporation and Cyberport.

at its meetings on 21 June 2016, 20 June 2017 and 19 June 2018 respectively. Members may refer to the relevant papers[5] for details.

(A) Operating Expenditure and Staffing Situation

7. The operating expenditure and staffing situation of the R&D Centres are summarised as follows –

Table 1: Operating Expenditure ($ million) and Staffing Situation

	Operating Expenditure ($ million)									Number of Staff as at 31 Mar 2019
	First 5 Years of Operation (2006-11) (A)	4-year Period (2011-15) (B)	2015-16	2016-17	2017-18	2018-19	4-year Period (2015-19) (C)	% change [(C)-(B)] /(B)	13-year Cumulative (2006-19) [(A)+(B)+(C)]	
APAS	70.4	60.4	15.8	17.7	16.4	18.3	68.2	+13%	199	28
ASTRI	526.3	505.4	145.8	144.8	139.6	156.9	587.1	+16%	1,618.8	660
HKRITA	47.0	80.3	29.6	31.4	34.3	37.1	132.4	+65%	259.7	75
LSCM	64.3	85.2	25.1	27.1	29.5	37.2	118.9	+40%	268.4	124
NAMI	84.5	183.2	54.3	52.7	65.6	73.6	246.2	+34%	513.9	236
Total	**792.5**	**914.5**	**270.6**	**273.7**	**285.4**	**323.1**	**1,152.8**	**+26%**	**2,859.8**	**1 123**

8. Between 2015-16 and 2018-19, the operating expenditure of the R&D Centres was $1,152.8 million, averaging $288.2 million per year. This represents an increase of 26% as compared with the average annual operating expenditure of $228.6 million between 2011-12 and 2014-15. Some of the Centres have hired additional R&D personnel and rented additional laboratory space for enhancing their in-house research capability. Some of the Centres have allocated additional resources in commercialisation work, maintenance of their intellectual property ("IP") portfolio and maintenance of equipment, etc.

[5] 2015-16: LC Paper No. CB(1)1045/15-16(05) (https://www.legco.gov.hk/yr15-16/english/panels/ci/papers/ci20160621cb1-1045-5-e.pdf); 2016-17: LC Paper No. CB(1)1144/16-17(03) (https://www.legco.gov.hk/yr16-17/english/panels/ci/papers/ci20170620cb1-1144-3-e.pdf); and 2017-18: LC Paper No. CB(1)1097/17-18(04) (https://www.legco.gov.hk/yr17-18/english/panels/ci/papers/ci20180619cb1-1097-4-e.pdf).

(B) Level of Industry Income

9. As the R&D Centres are platforms for coordinating applied research and facilitating technology transfer to the industry, it is important to gauge the level of support of the industry in their work. A new indicator on the level of industry income of the R&D Centres, which covers the industry contribution for their R&D projects, income arising from licensing/royalty and contract services, etc., has been adopted with a target of 30%[6] from 2017-18 onwards.

10. The level of industry income of the R&D Centres in 2018-19 and 2017-18 is tabled as follows –

Table 2: Level of Industry Income (Note)

	2017-18	2018-19	Difference (Percentage points)
APAS	47%	49%	+2
ASTRI	33%	36%	+3
HKRITA	30%	34%	+4
LSCM	40%	46%	+6
NAMI	53%	55%	+2

Note: The level of industry income is calculated as follows –

$$\frac{\textit{Industry Contribution Pledged + Other Sources of Financial Contribution Pledged + Commercialisation Income Received}}{\textit{Approved Project Expenditure}} \times 100\%$$

11. In both 2017-18 and 2018-19, the level of industry income of all R&D Centres met the 30% target. We consider the performance of the Centres satisfactory.

[6] A target of 20% was set for the level of industry contribution before 2017-18.

(C) R&D Projects and Expenditure

12. The number of new projects commenced and the relevant project cost of the R&D Centres are as follows –

Table 3: Number of New Projects Commenced

	Nubmer of New Projects Commenced *(Figures in brackets denote the numbers of new collaborative projects with the industry)*						
	4-year Period (2011-15) (A)	2015-16	2016-17	2017-18	2018-19	4-year Period (2015-19) (B)	% change [(B)-(A)/(A)]
APAS	34 (13)	13 (6)	16 (3)	13 (3)	16 (3)	58 (15)	+71%
ASTRI	141 (11)	42 (4)	38 (4)	45 (2)	39 (0)	164 (10)	+16%
HKRITA	83 (22)	21 (5)	18 (5)	21 (5)	23(4)	83 (19)	-
LSCM	48 (7)	16 (2)	18 (3)	21 (3)	25 (2)	80 (10)	+67%
NAMI	94 (32)	45 (27)	45 (33)	41 (20)	43 (26)	174 (106)	+85%
Total	**400 (85)**	**137 (44)**	**135 (48)**	**141 (33)**	**146 (35)**	**559 (160)**	**+40%**

Table 4: Project Cost of New Projects Commenced ($ million)

	Project Cost of New Projects Commenced ($ million) *(Figures in brackets denote the project costs of new collaborative projects)*						
	4-year Period (2011-15) (A)	2015-16	2016-17	2017-18	2018-19	4-year Period (2015-19) (B)	% change [(B)-(A)/(A)]
APAS	146.9 (99.5)	70.1 (54.7)	45.3 (18.1)	69.1 (48.0)	65.5 (21.2)	250.0 (142.0)	+70%
ASTRI	1,087.7 (99.5)	334.2 (27.5)	292.4 (36.4)	410.6 (13.0)	333.4 (0)	1,370.6 (76.9)	+26%
HKRITA	208.7 (73.0)	66.9 (24.1)	71.3 (20.1)	100.5 (14.7)	93.5 (8.9)	332.2 (67.8)	+59%
LSCM	214.9 (18.9)	79.0 (3.2)	78.1 (5.2)	117.1 (7.3)	123.9 (2.6)	398.1 (18.3)	+85%
NAMI	267.5 (146.6)	110.9 (60.6)	125.2 (83.1)	141.9 (62.9)	151.3 (90.6)	529.3 (297.2)	+98%
Total	**1,925.7 (437.5)**	**661.1 (170.1)**	**612.3 (162.9)**	**839.2 (145.9)**	**767.6 (123.3)**	**2,880.2 (602.2)**	**+50%**

13. Between 2015-16 and 2018-19, the total number of new projects commenced by the R&D Centres was 559, averaging about 140 per year. This represents a 40% increase as compared with the average annual number of new projects of 100 between 2011-12 and 2014-15. The total project cost of newly commenced projects between 2015-16 and 2018-19 was $2,880.2 million, averaging $720.1 million per year. This represents a substantial increase of 50% as compared with the average project cost of $481.4 million per year between 2011-12 and 2014-15. In 2018-19, while the number of new projects commenced slightly increased over 2017-18, the total project cost of these projects was slightly below that in 2017-18 due to the increase in the number of new projects of relatively smaller scale.

14. The Centres have commenced a total of 160 collaborative projects (which require industry contribution of at least 30% of the total project cost) between 2015-16 and 2018-19, averaging 40 per year, a substantial increase of 90% as compared with around 21 projects on average per year between 2011-12 and 2014-15. In 2018-19 alone, the number of collaborative projects commenced was 35, a 6% increase as compared with 2017-18. The total project cost of collaborative projects commenced between 2015-16 and 2018-19 was $602.2 million, an increase of 38% over the period between 2011-12 and 2014-15. This reflected the confidence of the industry in the work of the Centres. The industry sponsors of these projects will be entitled to utilise the IP arising from the projects exclusively for a defined period or own the project IP.

15. With healthy growth in the number of new projects, the number of on-going projects of the Centres each year has also increased steadily as follows –

Table 5: Number of On-going Projects

	Number of On-going Projects *(Figures in brackets denote the numbers of on-going collaborative projects)*			
	As at 31 Mar 2016	As at 31 Mar 2017	As at 31 Mar 2018	As at 31 Mar 2019
APAS	36 (15)	44 (16)	47 (15)	51 (16)
ASTRI	69 (8)	62 (7)	63 (6)	71 (2)
HKRITA	62 (17)	59 (15)	52 (13)	54 (10)
LSCM	35 (3)	37 (4)	38 (5)	45 (2)
NAMI	82 (40)	86 (51)	78 (41)	67 (40)
Total	**284 (83)**	**288 (93)**	**278 (80)**	**288 (70)**

16. Many of the on-going projects involve industry contribution (both in cash or in kind) and participation, demonstrating the relevancy of the projects to the industry. The number of on-going projects involving industry participation and the number of companies participating in on-going projects are as follows –

Table 6: Number of On-going Projects involving Industry Participation and Companies participating in On-going Projects

	No. of On-going Projects involving Industry Participation *(Percentage changes in brackets)*				Number of Companies participating in On-going Projects *(Percentage changes in brackets)*			
	As at 31 Mar 2016	As at 31 Mar 2017	As at 31 Mar 2018	As at 31 Mar 2019	As at 31 Mar 2016	As at 31 Mar 2017	As at 31 Mar 2018	As at 31 Mar 2019
APAS	25	23 (-8%)	24 (+4%)	21 (-13%)	49	38 (-22%)	41 (+8%)	23 (-44%)
ASTRI	34	33 (-3%)	42 (+27%)	47 (+12%)	86	69 (-20%)	91 (+32%)	151 (+66%)
HKRITA	38	39 (+3%)	41 (+5%)	41 (0%)	90	93 (+3%)	89 (-4%)	81 (-9%)
LSCM	15	17 (+13%)	15 (-12%)	13 (-13%)	48	55 (+15%)	56 (+2%)	64 (+14%)
NAMI	52	64 (+23%)	51 (-20%)	46 (-10%)	63	81 (+29%)	68 (-16%)	56 (-18%)
Total	**164**	**176 (+7%)**	**173 (-2%)**	**168 (-3%)**	**336**	**336 (0%)**	**345 (+3%)**	**375 (+9%)**

17. The R&D expenditure of the R&D Centres each year is as follows -

Table 7: R&D Expenditure ($ million)

	First 5 Years of Operation (2006-11) (A)	4-year Period (2011-15) (B)	2015-16	2016-17	2017-18	2018-19	4-year Period (2015-19) (C)	% change [(C)-(B)]/(B)	13-year Cumulative (2006-19) (A)+(B)+(C)
APAS	89.9	92.6	54.6	34.2 (-37%)	47.6 (+39%)	45.8 (-4%)	182.2	+97%	364.7
ASTRI	1,114.0	1,030.4	243.7	268.0 (+10%)	315.3 (+18%)	346.9 (+10%)	1,173.9	+14%	3,318.3
HKRITA	98.0	157.6	51.1	41.8 (-18%)	65.1 (+56%)	96.5 (+48%)	254.5	+61%	510.1
LSCM	139.4	164.1	67.4	83.3 (+24%)	90.6 (+9%)	82.0 (-9%)	323.3	+97%	626.8
NAMI	89.5	185.8	63.2	92.4 (+46%)	105.5 (+14%)	112.3 (+6%)	373.4	+101%	648.7
Total	**1,530.8**	**1,630.5**	**480.0**	**519.7 (+8%)**	**624.1 (+20%)**	**683.5 (+10%)**	**2,307.3**	**+42%**	**5,468.6**

18. Between 2015-16 and 2018-19, the total R&D expenditure of the five R&D Centres was $2,307.3 million, averaging $576.8 million per year. This represents an increase of 42% as compared with the average annual R&D expenditure of $407.6 million between 2011-12 and 2014-15. The increase in R&D expenditure showed that the R&D Centres have been gaining momentum in their R&D work. In 2018-19, despite some fluctuation in the R&D expenditure of LSCM and APAS, the total R&D expenditure of the R&D Centres increased by 10% as compared with 2017-18.

(D) Commercialisation

19. The performance of the R&D Centres in terms of commercialisation income is as follows –

Table 8: Commercialisation Income ($ million)

	First 5 Years of Operation (2006-11) (A)	4-year Period (2011-15) (B)	2015-16	2016-17	2017-18	2018-19	4-year Period (2015-19) (C)	% change [(C)-(B)]/ (B)	13-year Cumulative (2006-19)
APAS	0.8	0.9	0.75	1.57 (+109%)	1.19 (-24%)	1.87 (+57%)	5.38	+498%	7.08
ASTRI	29.6	96.2	20.06	29.27 (+46%)	28.23 (-4%)	21.16 (-25%)	98.72	+3%	224.52
HKRITA	5.3	3.3	1.05	0.89 (-15%)	1.24 (+39%)	10.98 (+785%)	14.16	+329%	22.76
LSCM	17.8	0.9	0.43	0.97 (+126%)	4.27 (+340%)	10.09 (+136%)	15.76	+1651%	34.46
NAMI	2.7	17.4	5.86	15.85 (+170%)	14.05 (-11%)	17.11 (+22%)	52.87	+204%	72.97
Total	**56.2**	**118.7**	**28.15**	**48.55 (+72%)**	**48.98 (+1%)**	**61.21 (+25%)**	**186.89**	**+57%**	**361.79**

20. In recent years, the R&D Centres have received more and more income other than industry sponsorship for ITF projects, including contract service income, licensing fees and royalties. Between 2015-16 and 2018-19, the total commercialisation income received by the R&D Centres was $186.89 million, averaging $46.7 million per year, which represented a 57% increase as compared with the average annual commercialisation income of $29.7 million between 2011-12 and 2014-15. Some of the R&D Centres have recorded significant growth in the commercialisation income during the four-year period. In 2018-19, the total amount of commercialisation income increased by 25%, from $48.98 million in 2017-18 to $61.21 million in 2018-19.

21. It should be noted that while the figures for a particular year could reflect the work of the R&D Centres, year-on-year variations are also affected by various factors including –

(a) short-term fluctuations in market demand and economic situation which may affect the negotiations/discussions of the R&D Centres with their industry partners/sponsors; and

(b) the need of the R&D Centres to deliver public missions, such as the application of their technologies in the public sector, which may affect their short-term income.

REPORT ON INDIVIDUAL R&D CENTRES

22. This section highlights the key activities of each R&D Centre during the period from 2015-16 to 2018-19 and their highlights of future development between 2021-22 and 2024-25.

APAS

23. During the four-year period from 2015-16 to 2018-19, the total number of new projects grew to 58, which represented an increase of 71% as compared with 34 projects in the four-year period from 2011-12 to 2014-15. APAS also achieved an overall industry income level of 47% in 2017-18 and 49% in 2018-19. Major recent R&D achievements of APAS include –

(a) *Robot System for Placement and Collection of Traffic Cones and Lanterns in Road Works* – APAS has jointly developed the first mobile road robot with the Automotive and Electronics Division ("AED") of the Hong Kong Productivity Council ("HKPC") for the Highways Department of the HKSAR Government to automate high risk operations in road works. The robot won the Honourable Mention Prize of the Chinese Delegation for Invention & Innovation and the Gold Medal with the Congratulations of the Jury at the 47th International Exhibition of Inventions of Geneva in 2019. The robot system also won a Gold Award in the Smart Transportation category of the Hong Kong ICT Awards 2019; and

(b) *Bus Infotainment System* – the system enables the linking up of a server with hundreds of display terminals and integrates attractive features to enhance passenger experience.

24. A number of APAS' technologies have been successfully commercialised or deployed for use in the public sector. Examples include –

(a) *Multi-standard Mobilised Smart Charger for Electric Vehicle ("EV")* – it provides the city's first emergency roadside charging service for battery-drained EVs. The second generation mobilised charger is being developed for use in the Hong Kong International Airport in 2020; and

(b) *New Generation Advanced Motorcycle Electronic Fuel Injection System* – the system fulfils the National IV standard. About 300 units have been sold to the local industry for use in Mainland China.

25. Since the launch of PSTS in 2011, APAS has commenced a total of 24 PSTS projects, of which 16 were commenced during the past four years. The application of such technologies has received positive feedback from the users. Two examples are -

(a) *Smart Vehicle-to-Home ("V2H") System for EV Trial* – the system facilitates EV batteries to function as energy storage devices for households. It saves electricity cost and helps relieve the high power consumption situation in peak load hours. This V2H system supports the Smart Energy Programme launched by the China Light and Power Hong Kong Limited in 2017; and

(b) *Intelligent eBus* – the intelligent eBus is an electric bus with lightweight body structure and a high efficiency traction motor system. The Airport Authority Hong Kong ("AAHK") will use one sample eBus to provide transportation services for its staff within the airport. The other sample will be provided to the Hong Kong Anti-Cancer Society.

26. APAS has been actively promoting its R&D results for adoption by the industry as well as Government/public bodies. For example, APAS organised the "APAS Showcase 2018", which attracted about 300 guests from different sectors including Government departments, universities, motor

companies, telecommunication companies, automobile parts and accessories companies. There was also a number of media coverage on APAS' autonomous driving technology and EV charging system. APAS also signed two Memorandums of Understanding in 2018-19, one with AAHK to forge long-term collaboration on the development of autonomous vehicles and smart airport solutions, and another one with Zhaoqing Municipal Science and Technology Bureau to jointly develop vehicle-to-infrastructure communication technology and autonomous vehicles.

Highlights of Future Development

27. In terms of the number of new projects, APAS expects that it will increase from 23 in 2021-22 to 30 in 2024-25. The R&D expenditure for 2021-22 to 2024-25 is around $361 million, which represents an average annual expenditure of about $90 million.

28. The rapid growth of the automobile industry provides tremendous business opportunities for the local automotive and component industry. APAS will explore new projects relating to automotive technologies with business partners. APAS will also continue to devote efforts to contribute to the policy direction of the Government to promote smart city in terms of the development and adoption of EVs with automated technologies in Hong Kong. To further promote smart mobility, APAS will put extra efforts on autonomous vehicles, as well as traffic control through vehicle-to-everything ("V2X") systems with high level of automation. Moreover, APAS will promote and adopt the application of various sensing technologies for safety, driving automation and data collection. On green transportation, APAS will continue to focus on the development of new energy vehicles for both mass public transportation and commercial use, as well as higher power chargers, superfast EV charging methods and recycling retired batteries for energy storage purpose. APAS will also explore the adoption of 5G technology, artificial intelligence ("AI"), vehicle connectivity and big data as well as the development of intelligent systems and human-machine interfaces for the automotive industry to improve driving experience.

29. For more details of the work of APAS during the four-year period from 2015-16 to 2018-19 and its plans between 2021-22 and 2024-25, please refer to **Annex A**.

ASTRI

30. ASTRI is a Government-subvented organisation established in 2000 with the mission to enhance Hong Kong's competitiveness in technology-based industries through applied research. During the four-year period from 2015-16 to 2018-19, ASTRI had signed 87 licensing agreements and received commercialisation income of around $98.7 million. 246 patents had been filed and 261 patents were granted[7]. ASTRI identified five focuses in its applied research work and some significant examples are highlighted below -

(a) *Intelligent Manufacturing* – ASTRI combined its core competence in robotic vision, integrated power systems and communications to provide solutions for developing robotics intensive or unmanned fully automatic manufacturing factories. For example, it had developed a deep learning machine vision software platform for industrial automatic defects inspection to support product quality control and manufacturing efficiency enhancement, which was adopted by a leading manufacturing enterprise for wafer defects inspection. Besides, ASTRI and its Hong Kong partner jointly developed the Collaborative Mobile Manipulator for handling the magnetic heads in clean rooms for manufacturing in a fully automated manner;

(b) *Financial Technologies* – ASTRI mainly focused on network security, big data analytics, and mobile platform technologies. In collaboration with the Hong Kong Monetary Authority and the Hong Kong Association of Banks, ASTRI has developed a Cyber Intelligence Sharing Platform to enable timely intelligence sharing to combat cyber-attacks, which was fully deployed last year. ASTRI has also developed an AI-enabled Chinese handwritten recognition and optical character recognition automatic form processing system and a mixed languages chatbot supporting Cantonese for banking applications in 2018. It also collaborated with a local property development company in 2018 to create Hong Kong's first property-purchase blockchain platform, which helps save time and resources in the property-buying process;

[7] The 261 patents also included those filed prior to 2015-16 but were granted during the four-year period.

(c) *Health Technologies* – ASTRI focused on health electronics devices, medical imaging (e.g. endoscope and laryngoscope) and big data analytics. Riding on the miniaturised Raman spectroscopy-based technology, ASTRI developed a compact device prototype with programmable spectral range and analysis solution for enhancing safety control on everyday food stock in Hong Kong. The prototype had been initially tested for multi-pesticide measurement. Leveraged on deep learning technologies, ASTRI developed the Cervical Cancer Screening Management System which is a convenient, effective, accurate and scalable computer-aided diagnostic platform, and was used by a large diagnostic service provider in Hong Kong;

(d) *Smart City* – ASTRI had migrated its R&D efforts from 4G to 5G, focusing on small cell, core network, Internet of Things ("IoT"), and applications platform for enhancing Hong Kong's competitiveness in next generation networks ("NGN"). Its NGN technology had been widely adopted by its clients. In addition, ASTRI carried out the world's first city-wide trial of Cellular Vehicle-to-Everything ("C-V2X") technology in Wuxi last year, demonstrating significant progress in enhancing traffic safety and efficiency. As the only institute in Hong Kong participating in the international 5G standardisation meetings, ASTRI also worked with the Office of the Communications Authority and telecom stakeholders to study the 5G spectrum interference in Hong Kong, and completed the first study trial in 2018, which serves as a reference for deploying outdoor 5G base stations in restricted zone; and

(e) *Application Specific Integrated Circuit ("ASIC")* – ASTRI developed IPs for Narrowband IoT devices and Electrostatic Discharge for 16nm Fin Field Effect Transistor technology, which were licensed to multiple integrated circuit companies. Through its collaboration with a local electronics strategic partner, ASTRI's naked eye 3D technology has been adopted by some commercial products for ultra-high-definition 4K video content, making significant development in multi-media technology.

Highlights of Future Development

31. ASTRI expects to commence around 47 new projects in 2024-25. The R&D expenditure for 2021-22 to 2024-25 is around $1,600 million, which represents an average annual expenditure of about $400 million.

32. Looking forward, ASTRI will continue to leverage its existing know-how to develop intelligent systems for smart city applications, for example, Industrial IoT, 5G base station and 5G core system, C-V2X networking and traffic management, intelligent home, etc. On financial technologies, ASTRI will develop a smart wealth management platform, which can provide dynamic monitoring and analyses based on big data and AI. ASTRI will also focus on AI and robotics, with a view to upgrading manufacturing technologies and reliability, assisting the industry to reduce production cost and making production process more intelligent and efficient. In the coming years, ASTRI will also be engaged in medical image diagnosis/data analytics and healthcare solutions. On ASIC, ASTRI will continue to devote R&D resources in microelectronics, integrated circuits and systems in the fields of systems/IPs and applications and packaging. This would include next generation wireless IoT technologies and/or system on chips, library/module co-design technologies for advanced semiconductor manufacturing technologies, and smart power conversion systems.

33. For more details of the work of ASTRI during the four-year period from 2015-16 to 2018-19 and its plans between 2021-22 and 2024-25, please refer to **Annex B**.

HKRITA

34. HKRITA continued to collaborate with local research institutes to develop new materials and advanced production technologies for the textiles and apparel industry, as well as to conduct more multi-discipline and industry-driven research projects. It started 23 new projects in 2018-19, and the level of industry income also increased from 30% in 2017-18 to 34% in 2018-19, demonstrating growing support from the industry and good progress in commercialisation and technology transfer.

35. In the past four years, HKRITA continued to build on its research competence in textile recycling and high-performance textile technologies, with a focus on sustainable development and environmental protection that can not only enhance the competitiveness of Hong Kong's textile industry but also benefit society as a whole. Examples of HKRITA's R&D work include –

(a) *Garment to Garment System – A Mini Mill in Retail Space* – HKRITA set up a mini production line in a retail shop at the Mills, Tsuen Wan to recycle post-consumer garment into clean and wearable clothes. The whole process takes place in a 40ft glass-walled container. The production line won the Red Dot Award: Production Design 2019; and

(b) *Highly Efficient Far Infrared ("FIR") Functional Textile* – Conventional production of FIR fibre involves expensive chemical treatment to achieve heat preservation, which degrades the yarn properties and quality. This award-winning project defines the cross-sectional profile of fibre and modifies its parameters ideally for fibre spinning. This cost-competitive and eco-friendly technology provides permanent FIR function for preserving heat, increasing blood oxygen and circulation, facilitating fatigue recovery, and improving metabolism and sleep quality.

(c) *Clean and enclosed industrial system for recycling old clothes to fibres* – Through sanitisation and mechanical means, the system up-cycles old clothes to fibres so that the good physical properties of the fibres can be kept for producing yarn and fabric. The up-cycling process makes use of a high degree of automation through the use of automated guided vehicles and intelligent control of conveyors. Colour-sorted fibres can be used directly for spinning without the need for dyeing and finishing. A local company has adopted this new technology and set up an environmentally-friendly yarn production line in Tai Po Industrial Estate in September 2018.

36. On commercialisation, between 2015-16 and 2018-19, HKRITA signed a total of 27 licensing agreements and the total commercialisation income received was $14.2 million. In 2018-19 alone, HKRITA signed seven licensing agreements with the industry, and received commercialisation income amounting to around $11 million, a nearly eight-fold increase from 2017-18. In 2018-19, HKRITA also initiated or facilitated 30 technology transfer activities to local companies, a government department and non-governmental organisations.

37. HKRITA also continued to promote the adoption of its R&D outcomes in the public sector. Between 2015-16 and 2018-19, HKRITA conducted 17 projects under the PSTS. These included production of duty uniform and extreme condition gear for disciplinary forces such as the Fire Services Department. HKRITA will also develop high performance sportswear

and devices with improved ergonomic designs for Hong Kong elite athletes to enhance their performance at the 2020 Olympic Games. Moreover, HKRITA collaborated with LSCM and ASTRI to develop a smart wear system by integrating different tracker technologies to help elderly homes prevent the elderly from wandering off. The smart wear system has been adopted in 11 Tung Wah Group of Hospitals' elderly centres.

38. In the past four years, HKRITA organised, supported or participated in a series of conferences and technology seminars to share the results of its work, facilitate knowledge transfer and forge closer ties with its stakeholders. They included the Innovation and Technology Symposium, Fashion Week, Business of Design Week, Copenhagen Fashion Summit, Textile Exchange Forum, Techstyle Conference and Product Innovation Apparel. HKRITA also won 42 international and local awards, which demonstrated the international peers' and the industry's recognition of its R&D results. At the 47th International Exhibition of Inventions of Geneva this year, HKRITA won six awards including three gold medals, one silver medal and two bronze medals. Apart winning the gold medal, the new technology of Highly Efficient FIR Functional Textile also received a special prize from The National Research Council of Thailand.

Highlights of Future Development

39. HKRITA expects that the number of new projects will increase gradually to 29 in 2024-25. The R&D expenditure between 2021-22 and 2024-25 is around $502 million, which represents an average annual expenditure of about $126 million.

40. At present, Hong Kong's textiles and apparel industry is transforming and putting more emphasis on promoting corporate social responsibility. HKRITA has been actively conducting R&D on textile recycling and high-performance textile technologies, and studying how to mitigate the environmental impact of textile and garment manufacturing. For example, HKRITA has developed a waterless dyeing process that addresses water scarcity and wastewater production problems, two environmental issues long associated with fabric dyeing. The protection of precious natural resources will also be a key focus in HKRITA's framework of R&D.

41. For more details of the work of HKRITA during the four-year period from 2015-16 to 2018-19 and its plans between 2021-22 and 2024-25, please refer to **Annex C**.

LSCM

42. The performance of LSCM has improved considerably between 2015-16 and 2018-19. The level of income received from the industry was 40% in 2017-18 and 46% in 2018-19. During the four-year period from 2015-16 to 2018-19, LSCM had signed 79 licensing agreements and received total commercialisation income of around $15.8 million. 86 patents had been filed.

43. Some significant examples of the Centre's work on R&D and technology adoption include –

(a) *Logistics & Supply Chain and Trading* – LSCM has developed an Online Dispute Resolution Cloud Services Platform for e-Arbitration / Mediation for the legal sector, which provides a cost effective, speedy and convenient way to resolve disputes. It will complement the Belt and Road and Greater Bay Area initiatives and consolidate Hong Kong's position as an international legal and dispute resolution services centre.

Leveraging the latest blockchain technology, LSCM has developed an Entrusted Decentralised Exchange platform for businesses to manage documents and carry out due diligence, which would help enhance cost effectiveness and competitiveness of business transactions involving multiple exchanges among business parties.

Furthermore, LSCM is developing the e-Trade Facilitation Platform to facilitate faster customs declaration between Hong Kong and Zhuhai/west Pearl River Delta region.

(b) *Smart Government* – The Transport Department has deployed the Smart Traffic Control System developed by LSCM at Tai Tam Road to collect real-time traffic information for the adjustment of road signals to reduce traffic congestion. In collaboration with the Housing Authority, LSCM and the University of Hong Kong developed an IoT-based just-in-time prefabrication housing construction management system, which provides real-time construction data and enhances prefabrication logistic and supply chain management, thereby improving the efficiency of the housing construction life cycle.

(c) *E-Warehouse Automation* – LSCM developed an autonomous guided vehicle ("AGV") suitable for use in local warehouses, factories and mass retail shops to enhance the efficiency in

warehouses and mitigate the problems arising from high labour and land rental costs in Hong Kong. The technology has been licensed to two system integrators; and

(d) *Community Service* – LSCM has developed a service logging and information kiosk system, an infrared thermal safety system, a Radio Frequency IDentification ("RFID")-tagged vest and a gate door system as well as GPS tracking technologies to serve elderly care centres and attention homes. LSCM has worked with the Hong Kong Housing Society, Pok Oi Hospital, Tung Wah Group of Hospitals and other non-governmental organisations to apply the technologies in their centres.

LSCM also developed the use of Ultra-wide Band and signal processing technologies for monitoring the condition of solitary elderly. The system provides a low-cost activity analysis solution to measure movement and location of solitary elderly in the living room, allowing the elderly to live at their own place.

LSCM developed a RFID Blind Cane Navigation System which provides guidance to the visually impaired and leads them to the destination. The system was adopted by the Hong Kong Society for the Blind, Yuen Long Home for the Aged Blind and West Kowloon Cultural District. A social enterprise has also licensed the technology to offer related service solutions in the market.

Highlights of Future Development

44. LSCM expects to commence about 27 new projects in 2024-25. Apart from ITF-funded R&D projects, the Centre expects there will be more projects arising from technology consultancy services and collaboration with local companies and other R&D institutes. It is estimated that the R&D expenditure between 2021-22 and 2024-25 is around $519 million, which represents an average annual expenditure of about $130 million or an annual increase of around 15%.

45. LSCM will continue its efforts to develop technologies to offer comprehensive support for trade disputes resolution for the logistics and supply chain industry, especially on e-commerce, smart contract, blockchain for transactions and AI of virtual meeting transcription, etc.

46. For more details of the work of LSCM during the four-year period from 2015-16 to 2018-19 and its plans between 2021-22 and 2024-25, please refer to **Annex D**.

NAMI

47. Between 2015-16 and 2018-19, NAMI placed strong emphasis on collaborative projects, proactively aligned research objectives with market needs, which successfully enabled the continuous growth of NAMI's research revenues and commercialisation income as well as an increase in the numbers of licenses, awards and products launched by the industry sponsors.

48. The number of new projects commenced increased to 43 in 2018-19, of which 26 were collaborative projects with project costs amounting to $90.6 million. The level of income received from the industry in 2017-18 and 2018-19 was 53% and 55% respectively, exceeding the target of 30%.

49. Between 2015-16 and 2018-19, NAMI signed 66 licensing agreements, a significant increase as compared with 19 licensing agreements signed during the period from 2011-12 to 2014-15. The total commercialisation income received by NAMI was around $52.9 million. NAMI also filed 217 patents during the period from 2015-16 to 2018-19, and was granted 132 patents.

50. NAMI had put much emphasis on commercialisation of project results. Up to March 2019, a total of 19 new products have been launched, including Multifunctional High Efficiency Particulate Air ("HEPA") media for air purification, germ-repellent medical breathing tubes and food packaging materials, and ultra-lightweight thermal insulation panels. Moreover, between 2015-16 and 2018-19, NAMI had conducted a total of 10 projects under the PSTS.

51. NAMI's technologies received more than 40 international awards, including RD100 and Consumer Electronics Show ("CES") Innovation Awards in USA, and the International Exhibition of Inventions of Geneva. NAMI's breakthrough technologies include -

(a) *Printed Electronics and Battery Technologies* – NAMI has developed printed lithium ion batteries and printed ink for flexible electronics, for application in wearable electronics and IoT markets; and

(b) *Nanofibre Technologies* – NAMI's Nanofibre has high pollutant removal efficiency. The industry sponsor has set up a production facility in Hong Kong. The Nanofibre technologies were also used in water filtration, beauty products and battery separators, etc.

Highlights of Future Development

52. NAMI expects that the number of projects will be about 57 in 2024-25 with more than half being industry-sponsored projects. The R&D expenditure in the four-year period from 2021-22 to 2024-25 is around $780 million, which represents an average annual expenditure of $195 million or an annual increase of around 5%.

53. For more details of the work of NAMI during the four-year period from 2015-16 to 2018-19 and its plans between 2021-22 and 2024-25, please refer to **Annex E**.

PROPOSED EXTENSION OF THE OPERATION OF THE R&D CENTRES TO 31 MARCH 2025

54. Among the five R&D Centres, the operating expenditure of four of them, namely APAS, HKRITA, LSCM and NAMI, is funded by the ITF while the operating expenditure of ASTRI is funded separately by the Government.

(A) Additional Funding for R&D Centres

55. Since 2005, the LegCo FC has approved a total funding commitment of $1,696.6 million to support the operating expenditure of the above four R&D Centres up to 31 March 2021. As shown at Table 1 above, as at 31 March 2019, the four R&D Centres have incurred a total of $1,241 million in operating expenditure and the remaining funding commitment stood at $455.6 million. It is estimated that as at 31 March 2021, the remaining funding commitment will be $63.6 million.

56. As the four R&D Centres have shown sustained improvements in their overall performance and their continued operation would be conducive to promoting the I&T upgrading in their respective industrial sectors, we propose to extend their operation for four more years until 31 March 2025. This will involve an additional funding commitment of $1,015.1 million from the ITF to support the operating expenditure of the four R&D Centres.

APAS

Funding Commitment	**Amount (in $ million)**
Funding commitment approved by FC in June 2005, June 2009, May 2012 and December 2015 for APAS's operation up to 31 March 2021	299.7
Proposed additional funding for extending APAS's operation for four years (up to 31 March 2025)	84.5
Proposed total funding commitment for APAS for a 19-year period (1 April 2006 – 31 March 2025)	**384.2**

HKRITA

Funding Commitment	**Amount (in $ million)**
Funding commitment approved by FC in June 2005, June 2009, January 2014 and December 2015 for HKRITA's operation up to 31 March 2021	344.5
Proposed additional funding for extending HKRITA's operation for four years (up to 31 March 2025)	214.3
Proposed total funding commitment for HKRITA for a 19-year period (1 April 2006 – 31 March 2025)	**558.8**

LSCM

Funding Commitment	**Amount (in $ million)**
Funding commitment approved by FC in June 2005, June 2009, May 2012, January 2014 and December 2015 for LSCM's operation up to 31 March 2021	362.4
Proposed additional funding for extending LSCM's operation for four years (up to 31 March 2025)	276.8
Proposed total funding commitment for LSCM for a 19-year period (1 April 2006 – 31 March 2025)	**639.2**

NAMI

Funding Commitment	Amount (in $ million)
Funding commitment approved by FC in June 2005, June 2009, May 2012 and December 2015 for NAMI's operation up to 31 March 2021	690.0
Proposed additional funding for extending NAMI's operation for four years (up to 31 March 2025)	439.5
Proposed total funding commitment for NAMI for a 19-year period (1 April 2006 – 31 March 2025)	**1,129.5**

Financial Implications

Operating Expenditure

57. The indicative breakdown of the proposed additional allocation is as follows –

Table 9: Operating Expenditure ($ million)

	Estimated Remaining Funding Commitment as at 31 Mar 2021	2021-22	2022-23	2023-24	2024-25	Proposed Additional Funding Commitment
APAS	51.7	29.0	32.2	35.6	39.4	84.5
HKRITA	0.0	50.6	50.8	54.6	58.3	214.3
LSCM	0.0	84.0	71.4	58.4	63.0	276.8
NAMI	11.9	96.1	109.0	117.7	128.6	439.5
Total	**63.6**	**259.7**	**263.4**	**266.3**	**289.3**	**1,015.1**

R&D Project Expenditure

58. The R&D expenditure of the R&D Centres will be funded separately out of the ITF on a project basis. The latest estimates of the R&D expenditure of the R&D Centres are summarised below –

Table 10: R&D Expenditure ($ million)

	Actual R&D Expenditure ($ million)		Indicative R&D Expenditure ($ million)	
	First Nine Years of Operation (2006-15)	Four-year Period (2015-19)	2019-21	2021-25
APAS	182.5	182.2	112.0	361.0
HKRITA	255.6	254.5	209.0	501.8
LSCM	303.5	323.3	176.5	519.2
NAMI	275.3	373.4	330.0	780.0
Total	**1,016.9**	**1,133.4**	**827.5**	**2,162.0**

59. The total estimated additional funding requirements for the operating expenditure of the R&D Centres for the period from 2021-22 to 2024-25 and their estimated R&D expenditure will be met by the uncommitted balance of the ITF[8].

(B) Review and Control Mechanism

Performance Monitoring

60. We will monitor closely the operation and performance of the R&D Centres. As a standard practice, the Centres are required to submit the following for approval by their respective Boards of Directors and the ITC every year –

(a) an annual plan on the Centre's R&D programme, including the annual expenditure budget and performance indicators;

(b) quarterly reports on their operation, covering the staffing position, major activities and expenditure position; and

(c) annual audited accounts of the Centre's operation and its R&D projects.

61. We will continue to submit progress reports on the performance of the R&D Centres to this Panel annually.

[8] The LegCo FC approved on 13 July 2018 a further injection of $10 billion into the ITF to provide sustained and comprehensive support for the development of I&T in Hong Kong.

Level of Industry Income

62. The R&D Centres have been able to achieve the industry income target of 30% since the indicator was promulgated in 2017-18 and are gradually building up stronger client base and industry reputation. We are optimistic that their performance in industry collaboration will continue to improve.

63. We suggest that the same industry income target of 30% to apply. This should encourage the Centres to proactively reach out to the industry and solicit sufficient sponsorship to embark on market relevant R&D while at the same time allow the Centres to initiate seed projects which are more forward-looking and exploratory in nature.

Commercialisation

64. To promote the commercialisation of R&D outcomes by the Centres, the LegCo FC approved on 13 July 2018 for the Centres to retain their commercialisation incomes earned for use in strategic activities (such as technology and market analyses, R&D infrastructure, staff development or experimental projects etc.), instead of returning such incomes to the Government.

65. In fact, the number of licensing deals and commericalisation income received by the R&D Centres have in general been increasing in recent years. These included income generated from licensing fees, royalty and contract services. However, such income still only constituted a small proportion of their total industry income and could fluctuate significantly due to a number of factors such as the economic situation, market reaction and technological developments. We would continue to monitor the progress of commercialisation of the Centres and review whether there is a need to set other performance indicators as and when appropriate.

(C) Expected Benefits

66. The R&D Centres have contributed to the development of I&T in Hong Kong since their establishment and particularly in the past four years –

(a) their total R&D expenditure rose from $600 million in the previous four-year period (2011-15) to $1,133.4 million;

(b) they have been performing satisfactorily in serving as the focal point to facilitate collaboration among the Government, industry, academia and research sectors in conducting R&D in their respective focus areas and applying technologies in the industry as well as in the community;

(c) they have been able to encourage greater industry participation in applied R&D in Hong Kong, their level of industry contribution has continuously improved and the number of collaborative projects has significantly increased;

(d) they have been providing training and employment opportunities for university graduates and technical personnel. In 2018-19, the four R&D Centres have engaged a total of about 1 500 R&D personnel[9] in their R&D projects; and

(e) they have been able to strengthen their links with stakeholders, e.g. enterprises, trade associations, academia, etc. through various channels like seminars, exhibitions, etc. both locally and overseas.

67. The R&D Centres will continue to step up their collaboration with stakeholders to support the industry and bring wider benefits to the community as a whole.

ADVICE SOUGHT

68. Members are invited to note the latest progress of the R&D Centres and to offer views on the proposed extension and funding proposal for the four R&D Centres.

Innovation and Technology Bureau
Innovation and Technology Commission
November 2019

[9] Including researchers of the four R&D Centres and those from the universities, research institutes and other parties participating in the relevant ITF-funded R&D projects.

Annex A

Automotive Platforms and Application Systems R&D Centre ("APAS")

PART 1 - General Background

1. Mission and vision

Vision

To become a leading automotive platforms and application systems R&D centre in the region and assist Hong Kong's foundation industries to enter into or expand in the automotive market. The three major focus areas of APAS' technology roadmap are –

(a) green transportation;
(b) smart mobility; and
(c) intelligent systems.

Mission

(a) develop R&D competencies in selected core technical areas;
(b) establish related networks in the Mainland and overseas;
(c) collaborate with Mainland and overseas R&D partners;
(d) promote R&D services and expand user base; and
(e) support HKSAR Government's initiatives of smart city and re-industrialisation.

2. Institutional set up

APAS was established in 2006 as a subsidiary company of the hosting organisation, the Hong Kong Productivity Council ("HKPC"). In November 2012, APAS was merged with HKPC as a new internal division of HKPC. HKPC oversees the operation and development of APAS. To fulfil industry expectations and tie in with the technology trend, APAS is renamed from "Automotive Parts and Accessory Systems R&D Centre" to "Automotive Platforms and Application Systems R&D Centre" (汽車科技研發中心) in August 2019.

APAS has in place an Internal Audit ("IA") mechanism with IA reports submitted to the HKPC Audit Committee for review. APAS is also required to prepare annual plans, mid-term reports and annual reports on its operation for submission to the Commissioner for Innovation and Technology for approval. Annual audited accounts also have to be submitted to the Innovation and Technology Commission ("ITC") every year.

3. Organisation

As at 31 March 2019, the staff strength of APAS is 28[1], against an establishment of 33 posts including the General Manager. The organisation chart is at the Appendix.

PART 2 - Highlight of Operation in 2018-19

I. New R&D Projects and Industry Contribution (in $million)

	2017-18			2018-19		
	No. of New Projects	Project Cost	Industry Contribution	No. of New Projects	Project Cost	Industry Contribution
Platform[2]	3	9.1	1.2	1	7.4	1.3
Collaborative[3]	3	48.0	24.3	3	21.2	10.8
Seed[4]	2	5.1	n/a	8	18.8	n/a
Total:	8	62.2	25.5	12	47.4	12.1
Public Sector Trial Scheme	5	6.9	n/a	4	18.1	n/a

II. Operating Expenditure (in $million)

	2017-18	2018-19
Staffing	9.7	10.7
Accommodation	2.7	2.9
Equipment	0.9	1.0
Others	3.1	3.7
Total:	16.4	18.3

[1] Excluding 4 project-based staff & 2 interns who are outside the establishment of 33 posts.

[2] Platform projects require industry contribution of at least 10% of the total project cost.

[3] Collaborative projects require industry contribution of 30-50% of the total project cost.

[4] Seed projects are projects which are more forward-looking and exploratory in nature. No industry contribution is required.

III. Industry Income (in $million)

	2017-18	2018-19
Industry Contribution	25.5	12.1
Licensing/Royalty	0	0.01
Contract Services	0.7	0.8
Others	0.5	1.1
Total:	26.7 (26.7)	14.0 (14.0)
Project Cost	62.2 (57.1)	47.4 (28.6)
Level of Industry Income:	47%	49%

Note: *Figures in brackets only include projects requiring sponsorship for the purpose of calculating the level of industry income.*

IV. Other Performance Indicators

	2017-18	2018-19
Number of Organisations Benefitting from the Public Sector Trial Scheme	16	17
Number of Interns Engaged	21	25
Number of Patents Filed	5(5)	10(5)

Note: *Figures in brackets denote the numbers of patents granted.*

PART 3 – Evaluation of the Performance of the R&D Centre from 2015-16 to 2018-19

1. R&D Achievements

The performance of APAS in the four-year period of 2015-16 to 2018-19 has improved in terms of solicitation of industry contribution, level of industry income and number of projects conducted. During the four-year period between 2015-16 and 2018-19, the total number of new projects approved and commenced (excluding Public Sector Trial Scheme ("PSTS") projects) grew to 42, which represented an increase of 61.5% as compared with 26 projects in the four-year period between 2011-12 and 2014-15. In the same period of 2015-16 to 2018-19, the total pledged industry contribution to approved projects amounted to $74.2 million, which represented a 41% increase when compared with the amount of $52.6 million in the period between 2011-12 and 2014-15. APAS also achieved an overall industry income level of 47% in 2017-18 and 49% in 2018-19, exceeding the original target of 30% as set by the ITC.

APAS has strong performance in terms of R&D achievements in its focused technical areas of green transportation, smart mobility technologies and materials and manufacturing, based on the technology roadmap updated in 2014 and 2016. A summary of some significant R&D achievements is as follows –

(a) Robot System for Placement and Collection of Traffic Cones and Lanterns in Road Works

APAS has jointly developed the first mobile road robot with the Automotive and Electronics Division of HKPC for the Highways Department ("HyD") of the HKSAR Government to automate high risk operations in road works and minimise the exposure of workers to live traffic. The robot system can efficiently place both traffic cones and lanterns in any laying shapes and forms;

(b) Smart Safety Seat Belt

Drowsy driving, a common cause of traffic accidents, can cause serious casualties. To address the problem, APAS developed the award-winning "Smart Safety Seat Belt" embedded with sensors to monitor the driver's physiological signals and drowsiness level throughout the journey for transmission to smart devices such as smart phone or smart watch. If drowsiness is detected, alarms will be triggered in the form of sound, voice, flash light or vibration to alert the driver until he or she is awakened to ensure safety;

(c) Bus Infotainment System

The Bus Infotainment System links up a central server with hundreds of display terminals and integrates attractive features to enhance passenger experience. The first generation system was installed on over 80 buses in Hong Kong and Guangdong, while the upgraded second generation system is being installed on 400 cross-border buses by the industry partner;

(d) Hybrid-electric Coach ("e-coach")
APAS developed the first 12m coach equipped with dual energy sources designed and assembled in HK. In hybrid-electric drive mode, the coach can operate continuously without stopping for recharge. It can also offer more than 30% fuel saving and more than 50% emission reduction as compared with the ordinary diesel coach. The e-coach is equipped with a high quality, safer and fast-charging lithium titanate battery pack. APAS expects to obtain the type approval from the Transport Department (TD) in the third quarter of 2019-20; and

(e) Autonomous Electric Tractor for the Hong Kong International Airport
By making use of advanced autonomous driving technology, the tractor would increase the effectiveness and efficiency of the baggage or cargo conveyance service. The tractor could travel from cargo apron to passenger apron automatically in a 2.1 km route of the airfield. The Airport Authority Hong Kong ("AAHK") will use the autonomous electric tractor in the Hong Kong International Airport.

Number of patents – Over the years, APAS has filed 73 patent applications with 44 patents granted, of which 21 were granted during the last four years. The total number of patents granted is very stable every year.

Awards – APAS has developed a number of technologies that won local and international awards in the past four years. Such achievement proves the success of APAS's R&D results at an international level. As at 31 March 2019, APAS has won two international awards and three local awards for its R&D achievements. For example, at the 46th International Exhibition of Inventions of Geneva in 2018, APAS won a Gold Medal with Jury's Commendation for its smart safety seat belt. In April 2019, the robot system for placement and collection of traffic cones and lanterns in road works received the Honourable Mention Prize of the Chinese Delegation for Invention & Innovation and a Gold Medal with the Congratulations of the Jury at the 47th International Exhibition of Inventions of Geneva in 2019. The robot system also won a Gold Award in the Smart Transportation category at the Hong Kong ICT Awards 2019.

2. Commercialisation and Technology Transfer to the Industry

In commercialisation and technology transfer, APAS has put a strong emphasis on collaborative projects to achieve tangible results and commercial outcomes in the relatively new industry in Hong Kong. The summary below shows the R&D outcomes which have been successfully deployed in commercial applications by small and medium enterprises ("SMEs") and other companies and in the public sector in Hong Kong –

(a) New Generation Advanced Motorcycle Electronic Fuel Injection System – The system fulfils the National IV standard. About 300 units of the system have been sold for industry adoption and the first royalty income of $10,000 was received in 2018-19;

(b) Electric Bus ("e-bus") – The project sponsor obtained the type approval from the TD in September 2017 and more than 60 e-buses have been sold in the Mainland market. The aluminium bus body is 13% lighter than that of existing electric buses. The optimised drivetrain is fit for use in HK's typical road and traffic conditions;

(c) Multi-standard Mobilised Smart Charger for Electric Vehicles ("EV") – APAS worked in collaboration with the Hong Kong Automobile Association (HKAA) in providing a mobilised charging service to Hong Kong. A mobilised EV charger with pre-charged batteries is placed on a van and this mobile charging unit offers emergency charging services to EV drivers around Hong Kong. The second generation mobilised charger is being developed for use in the Hong Kong International Airport in 2020; and

(d) Advanced Driver Assistance Systems ("ADAS") application – APAS developed many ADASes such as pedestrian warning and protection system, integrated lane assist system, monitoring system by vision and collision avoidance system. These sensing technologies have been applied in different areas such as the robot system for placement and collection of traffic cones and lanterns in road works, and the autonomous driving development.

Between 2015-16 and 2018-19, the total commercialisation income received grew to $5.38 million as compared with $0.86 million between 2011-12 and 2014-15, representing a 526% increase. The increase in commercialisation income received indicates growing industry interest in adopting APAS's R&D results and technologies.

3. Application of R&D Outcomes in the Public Sector and Benefits to the Community

Since the inception of the PSTS, APAS has been an active participant to transfer its R&D efforts to the community. So far, APAS has commenced a total of 24 PSTS projects. Among all, 16 trial projects were conducted during the period from 2015-16 to 2018-19. APAS aims to bring not only new automotive technologies but also a safer working environment to the society. The following shows several key public sector trials and their benefits –

(a) **Smart Vehicle-to-Home ("V2H") System for EV Trial –** the system facilitates EV batteries to function as energy storage devices for households. It helps lower electricity cost and helps relieve the high power consumption situation in peak load hours. This V2H system supports the Smart Energy Program launched by the China Light and Power Hong Kong Limited ("CLP") in 2017;

(b) **Integrated Battery System ("BMS") for Limited Production EV Trial –** a PSTS project developed a BMS for Tsing Yi Institute of Vocational Education ("IVE")'s solar car "Sophie VI", which won the 4th place at the 2017 World Solar Challenge competition held in October 2017 in Australia. The competition not only created a track record for the battery system but also provided a training ground for IVE students. The project was a great implementation of STEM[5] education that created a wider impact on society;

(c) **Fast EV Charger Trial –** APAS's Dual Channel Fast Charging Station for EVs has been installed for trials at the Hong Kong International Airport, Water Supplies Department, Hong Kong Police Force and Hong Kong Housing Society ("HKHS") to encourage commercial adoption of EVs in Hong Kong and help support Hong Kong as a smart city in collaboration with the Government; and

(d) **Intelligent eBus –** Two eBus samples will be produced for two organisations. The AAHK will use one eBus sample to provide transportation services to its staff within the airport. The other sample is being used by the Hong Kong Anti-Cancer Society for their roadshows and community service for the public.

4. Promotion Activities and Liaison with Stakeholders, including Local and International Collaboration

(a) Promotion and Publicity

APAS organised and participated in more than 260 promotional and industry events and activities during the period from 2015-16 to 2018-19. These activities involved a wide range of industry stakeholders, Government departments and agencies, universities and research institutions.

Annual APAS Showcase – Since 2015, APAS has been organising the Annual APAS Showcase that has attracted over a thousand industry participants so far. There were speakers from different industries to share their views. Concurrent exhibitions at the Showcase displayed APAS's R&D results to the guests. Apart from business networking opportunities, the event has generated new project ideas and collaboration opportunities for APAS.

(b) Engaging the Local Industry and the Government/Public Bodies

With a focus on autonomous driving and EV technologies, APAS has actively engaged with the local industry and government departments to support the technology development in Hong Kong. A number of Memorandum of Understandings ("MOUs") were also signed with different organisations in the past years including the AAHK for collaborations.

[5] Science, technology, engineering, and mathematics.

Government Departments – APAS developed in conjunction with another division in HKPC the first roadworks robot system for the HyD to help improve road works efficiency and safeguard lives. APAS also worked with the Electrical and Mechanical Services Department and the Environmental Protection Department ("EPD") of the HKSAR Government and property developers to enhance the healthy development of EVs, charger infrastructure and requirement.

AAHK – In order to cope with the shortage of tractor drivers and prepare for the increase in demand from the coming construction of the 3rd runway, APAS also served as an independent advisor to the AAHK to develop the autonomous electric tractor in 2018-19.

EV Steering Committee – Over the past two years, the General Manager of APAS has provided assistance to policy makers and key stakeholders in the local automotive industry to promote the development of the automotive industry in Hong Kong. For instance, he served as a Technical Expert of the EV Steering Committee hosted by the Financial Secretary; and an Honorary Advisor to the Council of the Hong Kong Automobile Service Industry Association and Hong Kong E-Vehicles Business General Association. To showcase the technology of autonomous vehicle, he also presented "Mobilising for Smarter Cities" at the "Federation of International Automobile ("FIA") Smart Cities Forum" co-organised by FIA and the HKAA at the FIA Formula E Championship held on 9 March 2019 at Central Harbourfront.

HKHS – For the past two years, 13 smart EV Charging Station Load Management Systems had been demonstrated at the sites of CLP and the Hong Kong Housing Society. The HKHS produced a promotional video on the system to promote the technology to the public.

HKAA – A mobilised charger was developed and fabricated for the HKAA to provide the city's first emergency roadside charging service.

Hong Kong Auto Parts Industry Association – APAS has developed a strategic partnership with it with membership of over 130 companies to explore new business opportunities.

Stakeholder Clusters and Special Interest Groups – During the period from 2015-16 to 2018-19, APAS and HKPC jointly established the Electric Vehicle Stakeholders Interest Group (電動車持份者小組會議) and the Hong Kong Connected Vehicles Cluster (香港智能網聯汽車產業聯盟). APAS conducted regular meetings with these entities to gauge industry demand, explore possible collaboration, and promote APAS's R&D capabilities to the industry.

(c) Collaboration with Local and Overseas Research Institutions

APAS has maintained a good relationship with a number of universities in Hong Kong, the Mainland and overseas. The co-operation does not only enhance the local R&D technology capability but also help the industry upgrade its competitiveness.

Local

APAS has initiated projects in EV with super capacitor energy storage system and its management system in collaboration with the City University of Hong Kong. APAS collaborated with the Hong Kong Polytechnic University ("PolyU") on projects related to EV charging technology and EV components. APAS has also worked with the Chinese University of Hong Kong on developing a micro hybrid powertrain system.

Mainland

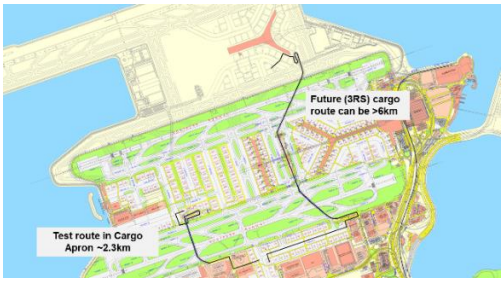
APAS maintained co-operative relationships with Mainland universities such as Jilin University (吉林大學), Jiaotong University (交通大學), Sun Yat-Sen University (中山大學) and Tsinghua University (清華大學) to enhance APAS's ability to develop new energy vehicles and intelligent transportation.

International

At the international level, APAS acquired its first autonomous vehicle development platform from Streetdrone in the United Kingdom in 2018. The vehicle is being used as an R&D platform for local development and application of autonomous technologies. This will also help strengthen APAS' innovative and scientific techniques and expertise in autonomous driving. As another example, APAS has set up partnership with The University of Sheffield of the UK, which has over 10 years' experience in developing fault tolerant systems for fly-by-wire application in the aerospace industry. The partnership will enable APAS to tap the university's experience and technical know-how in developing safety critical applications for autonomous driving.

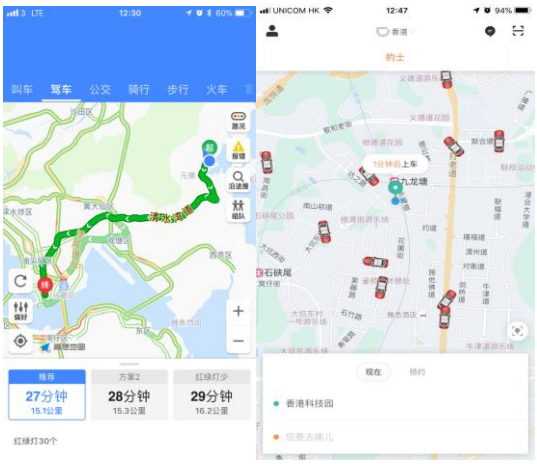
PART 4 - Progress of Selected Projects on R&D, Commercialisation and Use of R&D Outcomes in the Public Sector from 2015-16 to 2018-19

Project / Technology	Status / Progress
1. Robot System for Placement and Collection of Traffic Cones and Lanterns in Road Works  	The system makes use of sensors fusion real-time processing algorithm to automate high risk operations in road works to minimise the exposure of workers to live traffic. The system can efficiently handle both traffic cones and lanterns and can place cones in any laying shapes and forms. With an extensible design, the system can be applied in different forms of road works to suit the local environment. System reliability is also proven as the system can work under different weather conditions. Awards won: 1. HK ICT Awards 2019 Smart Mobility Award (Smart Transportation Stream) - Gold Award 2. 47th International Exhibition of Inventions of Geneva in 2019 - Gold Medal with the Congratulations of the Jury 3. 47th International Exhibition of Inventions of Geneva in 2019 - Honourable Mention Prize of the Chinese Delegation for Invention and Innovation

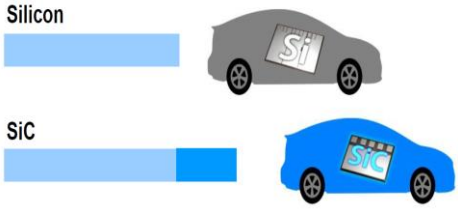
Project / Technology	Status / Progress
2. Autonomous Electric Tractor for the Hong Kong International Airport  	The Hong Kong International Airport is one of the busiest airports in the world, and the third runway is now under construction in order to cope with the increasing demand of passengers. However, shortage in tractor driver becomes the major hurdle of providing high quality service and increasing service capability. To solve this problem, HKPC co-operated with UISEE technology Inc. and developed the autonomous electric tractor. By making use of advanced autonomous driving technology, the tractor will increase the effectiveness and efficiency of the baggage and cargo conveyance service. The autonomous electric tractor can travel automatically in a 2.1 km route of the airfield and deliver cargo from cargo apron to passenger apron automatically. Pilot run was carried out from Aug 2018 to Mar 2019 and the accumulated autonomous travelling distance is now up to 1 500 km. For commercialisation, the AAHK will introduce the autonomous electric tractor service to improve the service quality of the Hong Kong International Airport and make effort to promote the blue print of Smart Airport.

Project / Technology	Status / Progress
3. Swappable Battery Pure Electric Minibus  	Co-operating with a local automotive company, APAS developed and designed this brand new 7-meter minibus. It has several first-of-the-kind features fulfilling the unique, tough and busy operational needs in Hong Kong or other metropolitan cities. The minibus has a low-floor height of 300 mm only. It enables passengers to get on/off easily and safely by one entry step. The electric minibus is equipped with two swappable battery packs. When the minibus runs out of power, the full-powered batteries can be swapped-in within 10 minutes. It eliminates the long recharging time and makes this zero-emission e-minibus capable of taking up busy public transportation operation in Hong Kong. The e-minibus has 20 passenger seats fulfilling the high passenger capacity demand. It also has smart features like remote reporting of the current status of the minibus (e.g. the number of passengers, vehicle speed, battery utilisation and other in-vehicle information) so that minibus operators can optimise their fleet operation arrangement. The e-minibus is planned to be launched in the Hong Kong market in the first quarter of 2020 upon completion of the type approval process.

Project / Technology	Status / Progress
4. Development of Pantograph High Power Charging ("HPC") Solution   	Long battery recharging time has always been a factor hindering the adoption of EVs in public transportation. In this collaborative project, a 300kW pantograph HPC plus a modular HPC vehicle platform kit will be developed. The HPC delivers 6-8 times charging speed faster than common 50kW quick chargers. Electric commercial vehicles can charge at terminus and top-up 20kWh power in five minutes. This enables the electric commercial vehicles to sustain a continuous operation without stopping for long time recharging.

Project / Technology	Status / Progress
5. Development of the HK Taxi Smart System  	Hong Kong taxi system has long history and a reputation around the world for its efficiency and safety. However, many of the hardware facilities are outdated and provide only limited functions. This is obviously not competitive enough as compared with the worldwide standard. To strengthen the service quality and competitiveness, a smart taxi system is introduced. Our solution consists of a new taxi meter, a telematics system, application software and a backend cloud to provide novel functionalities. These include online ride-hailing, journey cost and time estimation, real-time monitoring of driver's behavior, electronic payment, passengers feedback on service quality, broadcast emergency alert and data analysis to enable better management of the operational efficiency of the fleet. These functions benefit all the stakeholders in the taxi industry – taxi drivers, taxi operators as well as passengers. The project is now in the phase of system hardware and software design, and our team is working closely with a local taxi company to develop a usable and flexible system based on their needs. The project's ultimate goal is to introduce safe, fair, and convenient services to the passengers and improve the quality of Hong Kong's taxi service.

Project / Technology	Status / Progress
6. Development of Hybrid Refrigerated E-Truck with Aluminium-air and Lithium Titanate ("LTO") Batteries 	The main objective of this project is to develop a viable solution for the energy hungry refrigerated electric truck. A hybrid energy storage system comprising Aluminum-air ("Al-air") and Lithium-ion ("Li-ion") batteries for powering electric refrigerated trucks is under development. On average, the energy density of Al-air batteries is around 6 times higher than contemporary Li-ion batteries. However, Al-air batteries can only deliver constant power inherently and are primary (non-rechargable) cells. The innate characteristics hinder Al-air batteries as becoming a standalone power source for EV applications. Li-ion batteries can tolerate high charging/discharging current. However, they have a relatively low specific energy. Combining both Al-air and Li-ion batteries can produce a complementary effect, while demonstrating their intrinsic advantages. The project is still ongoing and the following deliverables have been achieved: 1) the prototype of Li-air battery has been delivered; 2) BMS for Li-air battery has been delivered; 3) vehicle chassis has been identified; and 4) technical specifications of Li-ion battery pack have been worked out pending procurement. We have approached the food transportation industry for future trial and promotion. The success of the project will prove that even the energy-hungry refrigerated truck can be entirely powered by electricity. Since commercial vehicles are the biggest contributor of road-side emission in HK, electric commercial vehicles will definitely help improve air quality of urban areas. It will be helpful to realise the green transportation under the blue print of Smart City of HK.

Project / Technology	Status / Progress
7. R&D of High Power Density and High Efficiency Motor Drives for EVs  	APAS R&D team has developed a high efficiency 150kW intelligent motor drive with advanced control algorithm for EVs successfully. Applying the latest advanced Silicon Carbide technology, the efficiency is increased to 99%, the size is reduced by half, and the whole EV's driving range will be prolonged by around 10%. This technology has been regarded as a breakthrough in next generation propulsion system for EVs. The success of this project has raised a lot of interest from the industry and universities. A trial based on this technology is under preparation for the PolyU electric race car to participate in the 2019 Formula Student Electric China competition organised by SAE-China.

PART 5 – Future Plan of the R&D Centre from 2021-22 to 2024-25

1. Technology Roadmap and R&D Programme

A. Smart city and smart mobility

The rapid growth and development of the automotive industry in the Mainland provides tremendous business opportunities for the local automotive and component industry. Under the Chief Executive's 2018 Policy Address and the 2019-20 Budget, the Smart City Blueprint underscores the forthcoming technology focuses for I&T development, which include enhancing charging facilities for EVs in Hong Kong. In the light of the potential of EV-related technologies and products, APAS will pursue development of artificial intelligence ("AI") technologies and data sharing platforms. The goal is to achieve better transport management for smarter and greener living in Hong Kong.

B. Market driven technology roadmap

With the set up of APAS to support automotive parts R&D in the past decade, significant progress has been made in upgrading the local industry's capabilities such that local industry players could transform from original equipment manufacturers (OEMs) which produce electronic and mechanical automotive components to those designing and building automotive platforms in the areas of green transportation and automotive safety-advisory work.

In the past few years, APAS has also strengthened the industry's technology know-how. For example, in respect of EV charging and battery management systems, APAS developed the first multi-standard mobilised fast EV charger in Hong Kong which provides fast charging solutions under emergency situations.

Market demand is always a driving force to call for future development directions of innovation and technology. For example, recent concerns of the community on the automotive industry are the shortage and mis-matched locations of EV charging facilities, occurrence of critical road fatalities due to human inattention or reckless driving etc. APAS recognised that there are pressing needs for the I&T industry to react and make changes so as to keep up with the rapid changes in the society.

To assist the industry in coping with the above challenges, APAS will transform its R&D capabilities and focuses from the relatively downstream level of automotive components development to higher level of R&D by developing integrated automotive platforms and application systems. The target industry beneficiaries of APAS will not be confined to OEM players as APAS will aim at delving into more solid livelihood-related automobile services by enhancing the user experience of both public and private automobile facilities and infrastructure in both Hong Kong and the Greater Bay Area.

In summary, APAS will focus on three main technology areas in view of the prevailing market trends, namely a) Green Transportation; b) Smart Mobility; and c) Intelligent Systems –

(a) **Demand for advanced green public transportation to drive highly efficient operation** – With government policy support in many countries, the promotion of clean energy vehicles has led to new business and technology opportunities in the development of EVs, hybrid vehicles and supporting facilities such as EV chargers. The worldwide trend is to focus on electrification of commercial vehicles to achieve more prominent environmental savings. The market looks for vehicles which have longer ranging distance, shorter refuelling or recharging time, higher passenger capacity and longer non-interrupt operating hours.

To capitalise on this trend, APAS shall pay efforts to develop advanced ultrafast EV charging systems, new solid-state battery for higher power density, and new energy storage media like fuel cell systems. APAS will work closely with industry collaborators to develop EV and hybrid operating fleet vehicles to cope with the market needs in Hong Kong and the Mainland.

(b) **Smarter solutions to combat driver shortage and mis-manipulation** – The fast-growing logistics business, partially due to dominant online shopping habits in new generations, creates a certain degree of demand for labour force in drivers. The driver shortage problem is aggravated by aging problem and lengthy roster patterns of taxi, minibus and bus drivers. This calls for smarter solutions to enhance mobility service qualities and reduce road accidents and fatalities. Besides, it is foreseeable that SAE Level 3-4 autonomous vehicles[6] will be in mass production in coming years. Against this background, APAS needs to develop localised capabilities on autonomous driving, machine learning algorithms, intelligent sensing and controls, etc.

(c) **Connected Vehicle-to-Everything (V2X) platform speeds up a new world of big data** – With the promising prospect of 5G network applications in HK and the Greater Bay Area, connected autonomous vehicles (CAV) will be dominating the future of transportation in the next era and transforming many business models, e.g. car-sharing platform instead of human-driving vehicles. APAS shall pay efforts in connectivity and data analytics with regard to vehicle-to-vehicle (V2V), vehicle-to-infrastructure (V2I), vehicle-to-pedestrians (V2P), etc. to pursue the ultimate goal of enhancing traffic management, mobility and energy saving.

[6] This refers to a classification system based on six different levels (ranging from fully manual to fully automated systems) published in 2014 by SAE International

Technology Area	Thematic Contents
Green Transportation	Vehicle electrification / energy storage management / charging technology / fuel saving & energy recovery / light body weight materials
Smart Mobility	Intelligent control, analytic advisory & accident prevention / smart module & infotainment system / autonomous driving & Internet of Vehicle (IoV) technology
Intelligent Systems	Various intelligent systems including Intelligent Transportation System (ITS) / V2X platform & infrastructure / connectivity & big data analysis / AI & robotics / human-machine interface (HMI)

APAS will continue to dedicate its effort in the development of EV technologies, with focus on vehicle electrification, charging technology, energy management systems and EV control system. In addition, APAS will put more efforts and resources to build the foundation technologies for smart mobility in the next few years, including but not limited to advanced sensing fusion and controls, machine learning & deep learning algorithms, 3D mapping and geo-spatial data building and modelling, autonomous driving technologies, secure and scalable IoV platform, functional safety design etc. Moreover, in respect of intelligent systems, APAS will kick off V2X roadmap and a series of technology applications for smart city including smart infrastructures facilitating enhanced mobility, intelligent transport systems, data analytics and AI adoption in the coming years.

In view of its limited manpower resources, APAS will sustain efforts to collaborate closely with other technology divisions of HKPC and R&D institutions for developing quality projects in line with its technology roadmap.

C. Leveraging the strengths of HKPC and other R&D institutes

Since the merger with HKPC, APAS has benefited from a very strong synergy with other divisions of HKPC by leveraging on the very wide business and industry network of HKPC. Furthermore, HKPC's wide range of expertise in areas of electronics, control, materials and manufacturing processes complements APAS's capabilities and enables APAS to provide more comprehensive technical and R&D support to the industry in Hong Kong.

In addition, APAS has engaged local universities and R&D institutions from the Mainland, Japan, Germany, UK, Australia and the United States in numerous technology projects. Looking ahead, in order to tap into the vast expertise as well as market in the Mainland, APAS is planning to expand its collaborative multi-disciplinary research with Mainland universities such as Tsinghua University (清華大學), Jilin University (吉林大學) as well as other international universities / R&D institutes. APAS also intends to enter into strategic partnership with these prestigious automotive R&D institutions to leverage their domain knowledge and create positive impact on the Hong Kong automotive industry. For example, APAS liaises with Tsinghua University (清華大學) for co-operation on intelligent connected vehicle and autonomous driving technologies.

Looking forward, to get prepared to meet market demands for sustainable green technologies, autonomous driving and intelligent systems in the next few years, APAS will strategically develop the relevant expertise and intellectual properties ("IPs") through seed and platform projects.

2. Commercialisation and Technology Transfer to the Industry

Commercialisation and technology transfer of APAS's R&D results to the industry is the key objective of APAS, which will ensure that the outcomes made are relevant and beneficial to the Hong Kong industry. To this end, APAS will continue to adopt a three-pronged approach of emphasising on collaborative projects; leveraging PSTS; and strengthening contract research to drive results in commercialisation of APAS's R&D portfolio. APAS will also put additional efforts to boost technology licensing opportunities through commercialisation seminars and exhibitions.

3. Application of R&D Outcomes in the Public Sector and Benefits to the Community

(a) Leveraging on public trials

As at March 2019, APAS has conducted 24 projects under the PSTS. Under these projects, APAS collaborated with Government departments, non-profit organisations, and community supporting groups to test trial R&D outcomes. Apart from increasing the potential of commercialisation and building track record for completed projects, maximising the benefits of R&D outcomes to the local community is one of the major aims for APAS. In the coming years, APAS will continue to conduct more public sector trials as well as extend support for the industry and the Government.

(b) Promoting EV technology to the community

A key research highlight of APAS is to promote green transportation that helps address the need to improve the air quality and environmental condition in the region. As EV related projects are coming to a fruitful stage, APAS expects to relay suitable technologies to the community and encourage the adoption of green vehicles, thereby forging a positive impact on public health.

(c) Supporting Hong Kong's smart city and re-industrialisation initiatives

APAS will continue to identify new R&D opportunities in smart city development, promotion of I&T development and re-industrialisation, including adopting more in-vehicle sensors and infrastructure sensors leading to connectivity between vehicles and infrastructure, and expanding the network to V2X by constructing various intelligent systems. More applications and showcases will be explored in collaboration with Government departments and non-governmental organisations to facilitate practical usages and gain feedback for future developments.

4. Promotion Activities and Liaison with Stakeholders, including Local and International Collaboration

APAS aims to broaden its industry connection through campaigns such as commercialisation seminars, open house, public exhibitions, road shows at local universities, as well as industry networking activities. The campaigns will leverage HKPC's established marketing platforms, such as client networks, regular publications and direct marketing channels, to enhance effectiveness and reach out to enterprises, universities and technology institutes, as well as automotive-related associations for collaboration. Strategic partners of APAS include:

- **European Automotive Council (EAC)** – APAS is in discussion with EAC about potential collaboration on promoting its European car brands in Hong Kong. APAS aims to connect these brands with HKSAR government departments with a view to deploying their latest advanced technologies or features for pursuing smart city development in Hong Kong;

- **Scania** [7] – APAS is exploring collaboration with Scania on the potential development of truck fleet management system and truck platoon control system in Hong Kong;

- **Ricardo**[8] – APAS is participating in the EPD's Electric Public Light Bus project with Ricardo as the major technical partner; and

- **StreetDrone (UK) and Autoware Foundation (Japan)**[9] **–** APAS is working with StreetDrone and Autoware Foundation to develop autonomous driving technologies.

In addition to the above, APAS is in discussion on some potential collaborations with other enterprises such as the autonomous vehicle suppliers from the Mainland. Strategic partnerships with them will not only facilitate the early adoption of new automotive

[7] Scania is a global company offering sales and services of trucks and buses in more than 100 countries

[8] Ricardo plc is a global strategic engineering and environmental consultancy that specializes in the transport, energy and scarce resources sectors; their work extends across a range of market sectors, including passenger cars, commercial vehicles, rail, defence, motorsport, energy and environment.

[9] StreetDrone (UK) is a drive-by-wire autonomous vehicle hardware platform technology provider. The Autoware Foundation (Japan) is a non-profit organisation supporting open-source software platform projects enabling self-driving mobility.

technology but also embark on the promotion of innovation and the use of high automotive technologies in the local community. Various collaborations will certainly bring long term economic benefits to Hong Kong.

The major activities for APAS in the coming years include –

(a) **APAS Showcase** – APAS has successfully organised the annual signature event "APAS Showcase" since 2015. In the coming years, we will showcase the new applications of high-speed connectivity in the automotive industry and the capability of AI and big data analytics for the enhancement of smart mobility systems;

(b) **Commercialisation and technology seminars** – APAS will continue the promotion of IPs from R&D projects for licensing opportunities on a regular basis. Technology seminars, of a smaller scale than the APAS Showcase but more frequently organised, will introduce new technology development in the automotive area;

(c) **Open house** – As part of the overall corporate image promotion, APAS will organise open house tour, possibly at the same time as the technology seminars;

(d) **Roadshow at local universities** – APAS will organise roadshows on a quarterly basis to explore and seek collaboration opportunities with local universities;

(e) **Exhibitions and conferences** – APAS aims to increase its international profile through participation in major international and regional exhibitions and conferences;

(f) **Hong Kong Industry Network Clusters Event** – APAS will hold this yearly industry consultation session to study potential topics related to the latest technology trends and the prevailing technology issues faced by the automotive industry;

(g) **E-newsletter** – E-newsletter and Auto News that cover the latest technology development trends and emerging market development of the auto industry will be issued on a monthly basis;

(h) **APAS website** – APAS operates a website, in English and Chinese, with a total of over 750 members in the R&D Club. APAS will continue to provide quality services to club members with the latest updates of R&D projects, commercialisation events, market trends, industry standards and other automotive-related Government policies; and

(i) **Leverage HKPC's network and platform** – APAS will leverage the vast business network and various business platforms of HKPC, such as SME One and TecONE, to promote its R&D outcomes and seek collaboration opportunities.

5. Budget and Cashflow

The approved funding commitment for the operation of APAS up to 31 March 2021 is $299.7 million. To support its continued operation up to 31 March 2025, an additional funding of $84.5 million is required for APAS, bringing the total funding commitment for 19 years of operation to $384.2 million.

Operating Expenditure (in $ million)

	9-year Cumulative 2006-07 to 2014-15	4-year Cumulative 2015-16 to 2018-19	2019-20	2020-21	2021-22	2022-23	2023-24	2024-25	Total
	(Actual)	(Actual)	(Estimate)	(Estimate)	(Estimate)	(Estimate)	(Estimate)	(Estimate)	
Staff [1]	71.2	42.5	14.5	17.0	18.8	20.8	23.0	25.4	233.2
Accommodation [2]	14.0	10.1	3.2	3.5	3.9	4.3	4.7	5.2	48.9
Equipment and other capital cost[3]	21.7	4.0	1.1	1.2	1.3	1.5	1.6	1.8	34.2
Commercialisation [4] (including publicity, marketing, etc.)	4.7	3.9	1.5	1.7	2.0	2.3	2.6	3.0	21.7
Others[5]	20.8	7.7	2.5	2.8	3.0	3.3	3.7	4.0	47.8
Total expenditure:	132.4	68.2	22.8	26.2	29.0	32.2	35.6	39.4	385.8
Less: Admin. overheads[6]	1.6	-	-	-	-	-	-	-	1.6
Total operating cost from ITF :	**130.8**	**68.2**	**22.8**	**26.2**	**29.0**	**32.2**	**35.6**	**39.4**	**384.2**

Explanatory Notes –

(1) Staff cost covers basic salary, Mandatory Provident Fund contributions, medical insurance, salary increment, variable pay and salary. Depending on individual project needs, more staff funded by ITF projects will also be recruited during 2021-2025. Adjustment of ~11% per annum is estimated to cater for growth in activities of APAS in coming years. Staff cost has deducted income generated from centre staff involved in project work.

(2) The accommodation budget has been benchmarked with nearby buildings in Kowloon Tong such as InnoCentre, assuming an increase of around 10% per annum. Such estimates are also based on the plan to request a few more work stations to accommodate additional project-based technical staff including

interns and postdoctoral researchers in anticipation of increasing project number starting from 2021-22.

(3) APAS will continue to procure equipment for lab and internal R&D development purposes.

(4) A provision has been made for an increase by $0.3 million to $0.4 million each year in commercialisation expenditure starting from 2021-22 for promoting R&D deliverables as more R&D projects will be completed by the time and enter into the commercialisation phase. A number of marketing & commercialisation activities are planned to actively promote APAS and its R&D results for successful commercialisation in the four years from 2021 to 2025. The budget mainly covers expenditure for APAS showcases, exhibitions, events, seminars, open house etc. as well as promotion and publicity of APAS.

(5) The "Others" item includes expenses on utilities, recruitment, staff development, service fee, office supplies, printing & stationery, indemnity insurance, repair and maintenance and sundry, and legal & professional fees, etc.

(6) It refers to administrative overhead for in-house projects. There was no administrative overhead reimbursed since the merger with HKPC in November 2012 until January 2019. APAS was eligible to claim administrative overheads starting from 28 January 2019. However, it is estimated that the amount will only be reimbursed after 2024-25 upon completion of the relevant projects and fulfilment of the requisite requirements as specified in the project agreements.

R&D Projects and Expenditure (in $ million)

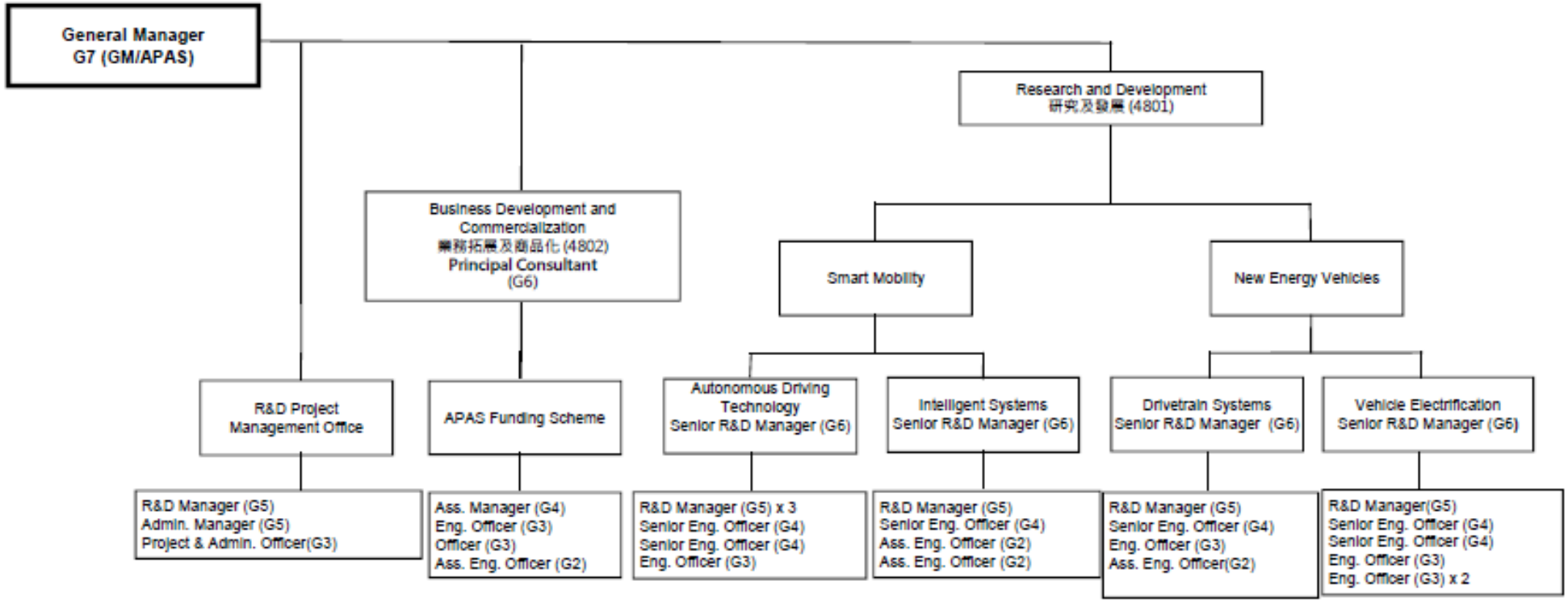
	9-year Cumulative 2006-07 to 2014-15 (Actual)	4-year Cumulative 2015-16 to 2018-19 (Actual)	2019-20 (Estimate)	2020-21 (Estimate)	2021-22 (Estimate)	2022-23 (Estimate)	2023-24 (Estimate)	2024-25 (Estimate)	Total
No. of new projects commenced	81	58	17	20	23	25	27	30	281
No. of projects under commercialisation(1)	28	35	10	12	15	18	20	23	n/a
R&D expenditure ($ million)	182.5	182.2	50.0	62.0	74.0	84.0	94.0	109.0	837.7

Explanatory Notes –

(1) Completed or on-going projects with technologies ready for commercialisation such as licensing and filing of patents.

Appendix

Organisation Chart of APAS



Total 33 posts under the establishment

Annex B

Hong Kong Applied Science and Technology Research Institute ("ASTRI")

PART 1 - General Background

1. Mission and vision

The vision of ASTRI is to be a world-class technology developer and an enabler to enrich lives.

ASTRI's mission is to enhance Hong Kong's competitiveness through applied research.

2. Institutional set-up

ASTRI was founded by the Government of the Hong Kong Special Administrative Region in 2000 with the aim of enhancing Hong Kong's competitiveness in technology-based industries through applied research.

In 2006, ASTRI was designated by the Government as the R&D Centre for Information and Communications Technologies.

In 2012, ASTRI received the approval from the Ministry of Science and Technology to establish, in collaboration with the Southeast University in Nanjing, the first Hong Kong Branch of the Chinese National Engineering Research Centre ("CNERC"), namely the CNERC for Application Specific Integrated Circuit ("ASIC") System (Hong Kong Branch).

ASTRI is governed by a Board of Directors comprising leading personnel from the industrial sector and the academia as well as professionals and Government representatives. Three functional committees, namely Finance and Administration Committee, Technology Committee and Audit Committee, assist the Board in overseeing the business of ASTRI.

3. Organisation

As at 31 March 2019, the staff strength of ASTRI is 660, against an establishment of 729 posts including the Chief Executive Officer. An organisation chart is at Appendix.

PART 2 - Highlight of Operation in 2018-19

I. New R&D Projects and Industry Contribution (in $million)

	2017-18			2018-19		
	No. of New Projects	Project Cost	Industry Contribution	No. of New Projects	Project Cost	Industry Contribution
Platform[1]	23	342.7	83.2	17	272.4	75.5
Collaborative[2]	2	13.0	6.5	0	0	0
Seed[3]	20	54.9	n/a	21	58.0	n/a
Total:	45	410.6	89.7	38	330.4	75.5
Public Sector Trial Scheme	0	0.0	n/a	1	3.0	n/a

II. Operating Expenditure (in $million)

	2017-18	2018-19
Staffing	75.4	83.2
Accommodation	26.6	28.5
Equipment	7.2	5.0
Others	30.4	40.2
Total:	139.6	156.9

[1] Platform projects require industry contribution of at least 10% of the total project cost.
[2] Collaborative projects require industry contribution of 30-50% of the total project cost.
[3] Seed projects are projects which are more forward-looking and exploratory in nature. No industry contribution is required.

III. Industry Income (in $million)

	2017-18	2018-19
	Industry Income	Industry Income
Industry Contribution	89.7	75.5
Licensing/Royalty	7.4	0.6
Contract Services	20.6	20.4
Others	0.2	0.2
Total:	117.9 (117.7)	96.7 (96.6)
Project Cost	410.6 (355.6)	330.4 (266.4)
Level of Industry Income:	33%	36%

Note: *Figures in brackets only include projects requiring sponsorship for the purpose of calculating the level of industry income.*

IV. Other Performance Indicators

	2017-18	2018-19
Number of Organisations Benefitting from the Public Sector Trial Scheme	3	2
Number of Interns Engaged	47	67
Number of Patents Filed	64 (53)	66 (54)

Note: *Figures in brackets denote the numbers of patents granted.*

PART 3 – Evaluation of the Performance of the R&D Centre from 2015-16 to 2018-19

1. R&D Achievements

During the period between 2015-16 and 2018-19, ASTRI actively conducted applied researches to support Hong Kong's R&D in the areas of Smart City, Financial Technologies, Intelligent Manufacturing, Health Technologies and Integrated Circuits ("IC"). It continued to grow in terms of R&D work and commenced 164 projects, as compared with 141 projects commenced in the previous four-year period. The level of industry contribution also increased from 21.7% in 2015-16 to 23.3% in 2018-19.

Number of ITF Projects Commenced

	2015-16	2016-17	2017-18	2018-19
Platform Projects	14	13	23	17
Seed Projects	23	20	20	21
Collaborative Projects	4	4	2	0
Public Sector Trial Scheme Projects	1	1	0	1
Total	**42**	**38**	**45**	**39**

During the period, ASTRI filed 246 patents in countries such as the US and Mainland China, bringing the total of patent filing to 1 088 since 2006. Among the 1 088 patent applications, 818 have been granted so far, including 261 granted between 2015-16 and 2018-19. This strong patent portfolio has supported licensing businesses over the years.

Number of Patents Filed and Granted

	2015-16	2016-17	2017-18	2018-19	Since 2006
No. of Patents Filed	56	60	64	66	1 088
No. of Patents Granted	95	59	53	54	818

For example, ASTRI and a local consumer electronics company reached a long-term strategic partnership. Through the partnership, ASTRI's naked-eye 3D technology had been adopted by some commercially successful products, such as 3D mosaic walls, 3D phones, 3D flat-panel computer screens and naked-eye displays that are able to deliver ultra-high-definition 4K video content. As the key strategic partner, ASTRI contributed to the listing of the consumer electronics company's holding company on Nasdaq in 2017.

ASTRI had also formed partnership with a world leading wireless communications equipment company in the area of cellular vehicle-to-everything ("C-V2X") and in 2018, supported the world's first city-level LTE-V2X application demonstration in Wuxi, Mainland China. 17 use cases of typical application fields such as forward collision warning, intersection collision warning, left turn auxiliary, vehicle blind area or lane change warning were successfully conducted.

In addition, ASTRI was invited by China Advanced Semiconductor Industry Innovation Alliance ("CASA") to assist in the development of China's first "Third-generation Semiconductor Power Electronics Technology Roadmap" ("the Roadmap"). As the only institution from Hong Kong being involved in the process, ASTRI provided professional advice, communicated with relevant overseas institutions, and helped with the essential drafting and compilation work. The Roadmap was released in July 2018, setting set out a recommended R&D direction for China's power electronics.

Over the years, ASTRI has received a number of prestigious local, regional and international awards for its R&D projects. The most recent and prominent ones include –

(a) A total of 21 Awards (including 4 Gold Medals with Congratulations of the Jury, 7 Gold Medals, 9 Silver Medals and 1 Bronze Medal) at the 47tg International Exhibition of Inventions of Geneva in 2019, with an increase from 14 awards (including 3 Gold Medals with the Congratulations of the Jury, 8 Gold Medals and 3 Silver Medals) in 2018;

(b) Smart Living Silver Award for Cervical Cancer Screening Management System ("CCSMS") at Hong Kong ICT Awards 2019. CCSMS is a convenient, effective, accurate and scalable computer-aided diagnostic platform and it has been commercialised through one of the largest diagnostic service providers in the Mainland and Hong Kong;

(c) Three awards at the Hong Kong Awards for Industries 2018, namely Technological Achievement Award for Narrowband Internet of Things ("IoT") solutions, Equipment and Machinery Design Certificate of Merit for the All-in-one Virtual Reality Head Mount Display, and Equipment and Machinery Design Award for the Collaborative Mobile Manipulator ("CMM") for Industrial Head Clean Room;

(d) Smart Business Gold Award for Palm Fusion Biometric Access Control System at Hong Kong ICT Awards 2018. The System captures both palm print and palm vein features of users' hands in offering solution for higher security and effective management of personal data;

(e) Top Award for Communication-based Train Control ("CBTC") System at the Asia Pacific ICT Alliance Awards 2017. The CBTC System was developed based on ASTRI's commercial-grade advanced wireless system (TD-LTE technologies) for the train control signaling network system of the Wuhan Metro Line 6, which commenced operation in December 2016.

The system reduces signal interference and shortens signal communication, thereby enhancing the safety, reliability and efficiency of subway operation;

(f) Merit Award at the Asia Pacific ICT Alliance Awards 2017 and Merit Award in Public Sector Excellence at World Information Technology and Services Alliances ("WITSA") Awards 2018 for Smart Water IoT System. The Smart Water IoT System has been implemented into the Supervisory Control and Data Acquisition ("SCADA") system of the Water Supplies Department. It significantly reduces the data transmission time and data query time of SCADA system. The successful experimental result was published in IWA-ASPIRE 2019 Conference (Asia Pacific Regional Group, International Water Association).

(g) Three awards (Outstanding Internet of Vehicles ("IoV") Management System, Outstanding IoT for Smart Water Management, and Outstanding Text Correction System on Mobile Devices) at the Hong Kong Smart City Awards 2018 by ET Net.

2. Commercialisation and Technology Transfer to the Industry

ASTRI made steady efforts on commercialising R&D outcomes and initiated a total of 236 technology transfers between 2015-16 and 2018-19 as follows -

	2015-16	2016-17	2017-18	2018-19
Total Number of Technology Transfers	53	60	72	51
- *Industry Collaborative Project agreements signed*	5	4	3	0
- *Contract research project agreements signed*	31	31	43	32
- *Licensing agreements signed*	17 ^	25 ^	26 ^	19 ^

^ *Some licensing agreements include contract research services provided by ASTRI.*

3. Application of R&D Outcomes in the Public Sector and Benefits to the Community

During the period between 2015-16 and 2018-19, ASTRI was actively conducting applied researches to support Hong Kong's developments in Health Technology, Smart City and Financial Technologies. ASTRI launched a total of three Public Sector Trial Scheme ("PSTS") projects and three platform projects initiated by Government departments to promote the applications of R&D outcomes in the public sector, bringing benefits to the local community. Examples of these projects include -

(a) In collaboration with Jockey Club Center for Positive Ageing ("JCCPA") and Jockey Club Cadenza Hub ("Cadenza Hub"), ASTRI trialed its Cardio-Vascular Monitoring Device ("CVMD") prototypes for continual blood pressure measure and arterial stiffness index measurement for the elderly in 2015. Suggestions for improvement were shared with industry partners to enhance the success of commercialisation of the developed technology;

(b) ASTRI partnered with the Energizing Kowloon East Office ("EKEO") in 2016 to develop a scalable, seamless integrated indoor and outdoor Geographical Information System ("GIS"). Large-scale public trials of Smart City applications based on the developed technology were conducted in Kowloon East, Tsuen Wan and Hong Kong Science Park. The Urban Renewal Authority ("URA") released a mobile app "TW Smart Parking" (荃易泊), which uses ASTRI's Smart Indoor and Outdoor GIS technologies in providing users real time car park vacancy data in the Tsuen Wan area together with car park information.

(c) In collaboration with the Hong Kong Education City, ASTRI leveraged on its Cyber Security Research and Practice Platform to conduct trials with local schools in 2019 to raise the schools' awareness of cyber security and enhance their security measures.

(d) In 2018-19, ASTRI commenced a platform project with the Water Supplies Department to establish an industrial IoT platform with Distributed Network Protocol ("DNP3") and Long Range ("LoRa") for real-time communications in a hostile environment without electricity and mobile communications signals where devices need to be deployed. The purpose is to enable robust, low-energy, low-cost and scalable real-time communication in utilities applications.

4. Promotion Activities and Liaison with Stakeholders, including Local and International Collaboration

Throughout the years, ASTRI had hosted and participated in events, conferences and expos, showcasing its work and exchanging experience and insights with ecosystem partners. ASTRI's marketing and communication initiatives seek to inspire a new generation of talented technology professionals and advocates. Some are illustrated as follows -

(a) The ASTRI Technovation Summit 2018 was one of the richest and most impactful platforms in the year that inspired compelling conversations on a smart future for Hong Kong powered by artificial intelligence ("AI").

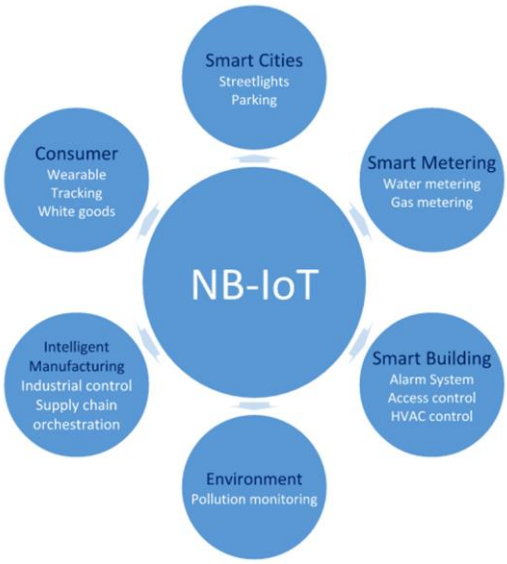
(b) ASTRI and the Hong Kong Science and Technology Parks Corporation ("HKSTPC") co-organised the 5G and IoT forum in March 2019. Senior Government officials and key industry players, local operators and network solution providers, standards bodies including Groupe Speciale Mobile ("GSM") Association and Institute of Electrical and Electronics Engineers ("IEEE") were present.

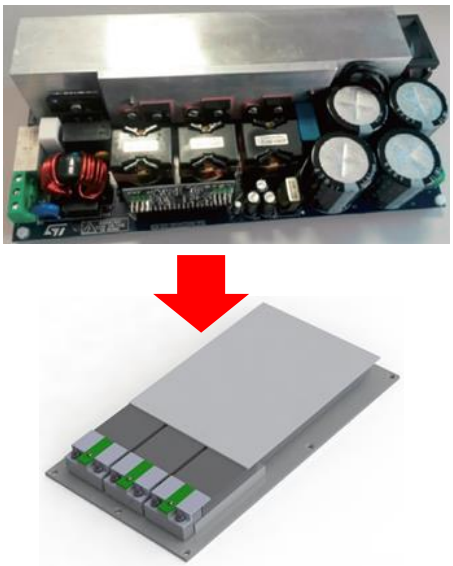
(c) Succeeding the FinTech Career Accelerator Scheme ("FCAS") launched in December 2016, ASTRI organised the FCAS 2.0 in 2018 in partnership with the Hong Kong Monetary Authority ("HKMA"), HKSTPC and Cyberport to expand the talent pool for the development of the Fintech sector in Hong Kong by giving students an early exposure to the sector.

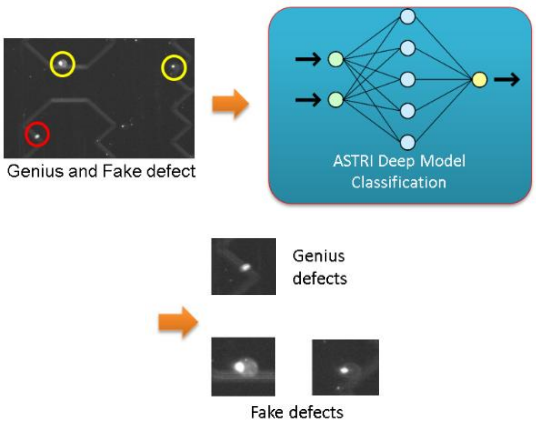
(d) Established in 2017 in collaboration with HKSTPC and funded by ITC, the Smart City Innovation Centre ("SCIC") has continued to be a shared platform for researchers, start-ups and industries to try new ideas and contribute to breakthrough innovation. With its modern infrastructure and facilities, the Centre attracted more than 400 visiting groups in 2018-19. Focusing on 5G, smart manufacturing and various smart city innovations, the SCIC showcases ASTRI's capabilities and achievements in these areas. It echoes the I&T strategy spelled out in the Chief Executive's Policy Addresses. Since its inception, nearly 4 500 individuals, including students, academics, journalists, Government officials, foreign delegations and industry partners, have visited the SCIC.

Part 4 - Progress of Selected Projects on R&D, Commercialisation and Use of R&D Outcomes in the Public Sector from 2015-16 to 2018-19

Project / Technology	Status / Progress
1. Cellular Vehicle-to-Everything ("C-V2X") Technology  *C-V2X Demo*	C-V2X technology ASTRI has developed a C-V2X technology, through which vehicles may communicate with one another, pedestrians, and roadside infrastructure to enhance road safety, deliver a better driving experience and support the development of the internet of vehicles ("IoV"). Awards The technology won: 1. "Outstanding Internet of Vehicles Management System (Smart Mobility)" award at the Hong Kong Smart City Awards 2018 by ET Net. 2. Silver Medal at the 47th International Exhibition of Inventions of Geneva in 2019.
2. Blockchain Technology  *Announcement of the creation of Hong Kong's first property-purchase blockchain platform in February 2019*	Property-Purchase Blockchain Platform ASTRI collaborated with New World Development Company Limited in February 2019 to jointly create Hong Kong's first property-purchase blockchain platform. Bank of China (Hong Kong) ("BOCHK") is the first bank to participate and apply the new platform to its services. Advanced Blockchain technology allows the platform to provide an all-in-one support service to buyers, banks and related bodies. With the collaboration, Property technology ("PropTech") is the breakthrough that will fundamentally reshape Hong Kong's real estate industry, saving time and resources in the property buying process.

Project / Technology	Status / Progress
3. Narrowband-Internet of Things ("NB-IoT") Technology  *NB-IoT applications.*	<u>NB-IoT transceiver solution</u> ASTRI has developed NB-IoT solutions including an IP platform that supports the 3rd Generation Partnership Project ("3GPP") standard for User Equipment applications consisting of a radio frequency ("RF") transceiver, a digital baseband, a power management unit and a power amplifier. The design and implementation of the solution enable miniaturised chips, low design and production cost, and a wide range of applications and devices in the modern era. The NB-IoT transceiver is a low power and low cost design for IoT applications. It is suitable for use in battery-powered handheld devices and sensor nodes applications. The NB-IoT transceiver technology was licensed to a Mainland semiconductor company in 2018-19. The technology won: 1. Technological Achievement Award at the Hong Kong Awards for Industries ("HKAI") 2018. 2. Gold Medal at the 46th International Exhibition of Inventions of Geneva in 2018.
4. Head Mount Display ("HMD") Technology  *All-in-one virtual reality HMD.*	<u>All-in-one Virtual Reality Head Mount Display ("HMD")</u> ASTRI has developed the unique all-in-one HMD device that leverages both Virtual Reality and Augmented Reality technologies. Its innovative sensor fusion and optimised operating system offer advanced multi-functional features for numerous Smart City applications such as healthcare, infotainment and education. The technology won: 1. Equipment and Machinery Design Certificate of Merit Award at HKAI 2018. 2. Silver Medal at the 46th International Exhibition of Inventions of Geneva in 2018.

Project / Technology	Status / Progress
5. High Density Power Module  *High density power module.*	ASTRI has developed high density power module designs for applications such as consumer electronics, telecommunication and data centre applications. The technology not only offers compact power module design but also enhances device performance and manufacturing capability for future power modules development in the semiconductor industry. The technology won a Gold Medal at the 47th International Exhibition of Inventions of Geneva in 2019. The high density power module technology was licensed to a Hong Kong semiconductor company in 2018-19.
6. Automated Form Processing System ("AFPS")  *Automated form processing system.*	ASTRI has developed an automated form processing system which enables form digitalisation effectively and better accuracy. The technology is a key step in AI technology engagement for automated form processing in financial industry. The technology won a Gold Medal at the 46th International Exhibition of Inventions of Geneva in 2018. The automated form processing technology was licensed to a Hong Kong financial company in 2018-19.

Project / Technology	Status / Progress
7. Smart Behaviour Analytics Platform  *Smart behaviour analytics platform for utilities applications.*	ASTRI has developed a smart behaviour analytics platform for utilities applications such as smart water management application. The platform predicts and detects pipe leakages so as to reduce the water being wasted. The technology enables smart water analysis and management without large human effort. The technology won an "Outstanding Internet of Things for Smart Water Management (Smart Environment)" award at the Hong Kong Smart City Awards 2018 by ET Net. The smart behaviour analytics platform technology was licensed to a Hong Kong company in 2018-19.
8. Establishment of HKT-ASTRI Smart City Joint Laboratory  *Announcement of establishing HKT-ASTRI Smart City Joint Laboratory in November 2018.*	HKT and ASTRI established the HKT-ASTRI Smart City Joint Laboratory in November 2018 to pursue advanced technologies and solutions for smart city. The HKT-ASTRI Smart City Joint Laboratory focuses on smart city infrastructure, smart mobility (including electronic road pricing and connected vehicles) and fore-running technologies such as blockchain, big data analytics, AI for smart economy.
9. Deep Learning Machine Vision Platform  *Deep learning machine vision platform for defect classification.*	ASTRI has developed a deep learning machine vision platform which provides defect detection algorithms and a smart machine vision software. The platform enhances the precision and reliability of the inspection machine to relieve manpower, and boosts up the production without compromising quality. The deep learning machine vision platform technology was licensed to a Hong Kong company in 2018-19.

Project / Technology	Status / Progress
10. Cyber Security Service for the Education Sector  *ASTRI has worked with the local education sector to strengthen their security awareness and practices.*	ASTRI has worked with a Hong Kong education company and a Hong Kong academic institute to try out various security-related experiments and solutions in local schools in January 2019 in order to strengthen their security awareness and practices. ASTRI has deployed the cyber security solutions to the identified schools and evaluate the improvement of their information security level. ASTRI will also provide cyber security training to the IT staff of the schools in order to raise their skill level and know-how in cyber security.

PART 5 – Future Plan of the R&D Centre from 2021-22 to 2024-25

1. Technology Roadmap and R&D Programme

The organisation allows ASTRI to take on broad initiatives, each of which requiring the wide spectrum of the core competences that ASTRI has been building. These initiatives are –

(a) Smart City:

ASTRI has made a significant achievement in 4G and pre 5G technology development, intelligent systems and computer vision applications. Moving forward, ASTRI will continue to leverage the existing know-how to help the industry in the following technology segments -

i. Intelligent systems for smart city applications

- Industrial IoT: An industrial IoT platform with DNP3 and LoRa for real-time communications in a hostile environment without electricity and mobile signals. This platform will be used in utilities applications (e.g. smart water);
- Chatbot: Enhance the core technologies on natural language processing ("NPL") and develop applications for clients in different segments such as banking, insurance, and retail industry to serve their application demands;
- Handwritten Chinese recognition and automatic form processing technologies and applications, e.g. smart government and elderly care, to improve operational efficiency;
- Human centric sensing fusion for biometric identification applications;
- Smart Optics for Augmented Reality ("AR") head mount display with integrated sensing features; and
- Mobile spectroscopy and hyperspectral imaging on smartphone or other mobile devices for environmental sensing and personal daily applications.

ii. Communications technologies with focuses on next generation networks

- Connectivity (5G): 5G small cell and networking technologies; vertical market or private network/applications;
- Smart mobility: C-V2X networking and traffic management,

- Smart mobility trial (electronic road pricing ("ERP"), V2X), connected vehicle, smart road infrastructure, smart parking, and connected autonomous vehicle; and
- IoT: Long-haul IoT applications such as long-haul IoT, and IoT blockchain (distributed ledger) for data exchange.

iii. Computer vision technology applications

- Smart camera applications: ASTRI plans to develop AI system for applications such as intelligent home, driving assistant, health monitoring and rehabilitation and smart retail.

(b) Financial Technologies ("FinTech"):

In cybersecurity area, ASTRI will continue to support the Cybersecurity Intelligence Sharing Platform ("CISP"), which was fully deployed in March 2018 and made available to all the users of the Hong Kong Association of Banks ("HKAB"), the Hong Kong Police Force and the HKMA.

In addition, blockchain and smart wealth management are also important technology R&D directions of the FinTech initiative in the coming five to six years. Their respective R&D directions are illustrated as follows:

i. Blockchain: Improvement of the blockchain technologies and platforms to enhance the performance of blockchain applications on the cloud, protect the privacy of transaction, promote the widespread adoption of secure transaction applications on cloud computing platform with better efficiency and hence lower operating cost; and

ii. Smart wealth management: Development of a smart wealth management platform through combining different blocks of calculation, optimisation and estimation requiring rich knowledge and techniques in finance, mathematics, statistics, and AI together. The strength of this platform is that it can provide dynamic monitoring with time rolling window, robust portfolio, game-driven and behaviour finance-based questionnaire, and event-driven analysis based on big data and AI, such that an accurate know-your-customer ("KYC") and optimised asset allocation and portfolio optimisation become possible.

(c) Intelligent manufacturing, focusing on AI and robotics:

With the focuses on AI and robotics, the intelligent manufacturing initiative will upgrade the manufacturing technologies and application solutions along the directions illustrated as follows:

i. Intelligent sensing enabled by intelligent machine vision and sensing devices & integration technologies:

- AI/deep learning-based software platform for industrial inspection involving defect inspection and classification for flexible display, and 3D measurement for curved cover glass;
- Intelligent industry robot with focus on 2D/3D Eye-in-Hand visual sensing module with AI-based recognition & cognition algorithm for smart factory applications; and
- Sensing devices for industry IoT as for manufacturing process & quality control.

ii. Virtual prototyping, which deploys Model-Based Systems Engineering principle for supporting the system-level design and emulation of the complex system dynamics and the evaluation of the overall system performance prior to constructing any physical prototypes. The purpose is to reduce design iterations and optimise for higher levels of performance and reliability. New applications will have an impact on reducing design costs and improving design performance and reliability throughout the value chain from system technologies to developers and operators.

iii. Advanced semiconductors for power and energy applications: Leveraging the wide bandgap characteristics of Gallium Nitride ("GaN") and Silicon Carbide ("SiC") materials, high efficient power conversion systems can be realised, which can be deployed in applications such as Smart Power Hub, Direct Current ("DC") Building, Intelligent Energy Storage Systems, making our city smarter and more efficient.

(d) Health Technology ("HealthTech")

In the coming years, ASTRI will address the areas in medical image diagnosis/ data analytics and healthcare solutions. They are highlighted as follows:

i. Medical image analytics and capsule endoscope: Using technologies on detection, recognition and screening of digital images to provide and display the related medical information. Deep learning and other advanced technologies will be leveraged to improve sensitivity performance; and

ii. Smart healthcare centre: A multi-functional and digitalised platform to provide elderly with a smarter living area. The related preventive healthcare will leverage on emerging technologies, for example, wristband, bed sensor, physical training system, healthcare app and devices, and interactive games.

(e) Application Specific Integrated Circuit ("ASIC") (through its role as the Hong Kong Branch of the CNERC for ASIC System)

The CNERC for ASIC System focuses on R&D, technology transfer and talent training on microelectronics and IC and systems in the fields of systems & applications and packaging. Moving forward, the CNERC for ASIC System will be addressing the technology R&D in the following areas:

i. Systems & applications

- Next generation wireless IoT technologies and / or system on chips ("SoCs") such as the massive Machine Type Communications ("mMTC") to support a wealth of new and diverse connected devices and services that comprise the IoT in the 5G era;
- Library / module co-design technologies for advanced semiconductor manufacturing technologies;
- Dedicated high-efficiency, scalable, and customised AI processors for various applications including 3D/4K/8K video acceleration / enhancement / analytics applications, and object recognition;
- Fuse hardware accelerated video technologies deeply to support low-latency and high-reliable AI applications; and leverage deep learning algorithm, front-end, and back-end optimisation technologies to expand AI chips' capabilities; and
- Next generation cellular small cell SoC.

ii. Packaging for smart power and energy systems

- Silicon Carbide ("SiC")-based power devices and matrix converter (AC-AC);
- Smart power conversion systems (AC-DC, DC-DC and DC-AC); and
- Intelligent energy storage for Automated Guided Vehicles ("AGV") applications.

2. Commercialisation and Technology Transfer to the Industry

Moving forward, ASTRI will strengthen its efforts in commercialising R&D achievements. A multi-functional effort will be established to form go-to-market strategy by understanding customers' needs and matching ASTRI's achievements with these needs. For example, we will explore opportunities with outside organisations in the application of augmented reality ("AR") and virtual reality ("VR") in various industries. Possible applications include video conferencing. In another example, chatbot and Chinese handwritten optical character recognition technologies can be applied in the service industry for improvement of user experience and automation purpose.

ASTRI will continue to cooperate with CASA, assisting the Alliance in formulating the Third-generation Semiconductor Power Electronics Technology Roadmap. ASTRI will also continue to partner with world leading telecommunication companies in the region to develop V2X technologies.

Further, ASTRI will continue to support activities leading to IP commercialisation such as IP Hatch in which companies enter the event seeking investment or IP licensing opportunities. ASTRI will also continue to take part in international events such as the annual International Exhibition of Inventions of Geneva. This event provides a platform for ASTRI to showcase its inventions to an international audience and to receive recognition.

3. Application of R&D Outcomes in the Public Sector and Benefits to the Community

ASTRI's strategies are as follows –

(a) ASTRI will drive for technology deployment in the end. Technology deployed in the community should be robust, reliable, user friendly, and with performances meeting all the requirements and standards. It should be stressed that industrial designs and user friendliness will be highly considered and should be integrated as part of the deployment plan. As appropriate, ASTRI will conduct further trials with the Government, non-governmental organisations or other relevant parties before commercialisation.

(b) ASTRI will focus on contributing in areas where it has the core technical competences and deployable R&D results. ASTRI plans to conduct collaboration with domain experts in a complementary manner.

Clear deliverables and goals have to be defined for trials in the public sector and the community. These valuable public field trials will provide the much-needed information on the product reliability and quality, user feedback on improvements, and its confidence level on the technology. Various "design experiments" will be integrated in the programme to obtain such information. For example, with the support from the Hong Kong Jockey Club, ASTRI has developed a smart IoT platform and participates as one of the co-organisers of "Fun to Move @JC", which is a five-year pilot programme launched in 2017 to develop a sustainable model to enhance primary students' physical activity level with the help of technology.

4. Promotion Activities and Liaison with Stakeholders, including Local and International Collaboration

ASTRI will promote itself as an intelligent and trusted brand with deep knowledge in applied science and technology. Its brand marketing and communications activities will position ASTRI as –

(a) A thought leader with sound expertise and knowledge in innovative technology applications –

- To continue to organise and participate in thought leadership forums and seminars. For example, ASTRI will organise its annual flagship event "ASTRI Technovation Summit", partner with Government agencies and other quangos to co-organise events on communication technologies, data analytics, FinTech, smart mobility and intelligent manufacturing, and actively participate in events and innovation expos organised by industry leaders;

- To continue to promote Hong Kong's I&T prowess and ASTRI's work in international events such as the International Exhibition of Inventions of Geneva, Mobile World Congress, Hong Kong International ICT Expo, PT Expo and Consumer Electronics Show. ASTRI will also participate in leading local and international award programmes to attain prestige and recognition for its innovation endeavours; and

- The ASTRI University Advisory Council ("AUAC") as well as the SCIC will continue to enhance collaborations with the academia, industry and talents, aiming to share insights, facilitate technological innovations, support tech ventures, and promote STEM talents in Hong Kong and beyond.

(b) An enabler of innovation-led growth for Hong Kong –

- Leveraging traditional and digital channels, effective media publicity and direct engagements to convey ASTRI's messages to the audiences, ASTRI will raise awareness of what it does and how its work benefits Hong Kong, and will instill confidence and pride among ordinary residents in Hong Kong's overall I&T development.

5. Budget and Cashflow

Total expenditure incurred by ASTRI since 1 April 2006 up to 31 March 2019 was $4,937.1 million, which included operating expenditure amounting to $1,618.8 million and R&D expenditure amounting to $3,318.3 million. It should be noted that the operating expenditure is largely met from Government's annual recurrent subvention. ASTRI's latest estimates for its operating expenditure and R&D expenditure for 2019-20 to 2024-25 are as follows -

Operating Expenditure (in $ million)

	9-year Cumulative 2006-07 to 2014-15 (Actual)	4-year Cumulative 2015-16 to 2018-19 (Actual)	2019-20 [6] (Estimate)	2020-21 (Estimate)	2021-22 (Estimate)	2022-23 (Estimate)	2023-24 (Estimate)	2024-25 (Estimate)	Total
Staff [1]	605.5	309.8	98.5	94.7	102.3	108.4	114.9	120.6	1, 554.7
Accommodation[2]	170.5	109.3	30.9	31.0	32.3	35.1	35.7	37.2	482.0
Equipment and other capital cost[3]	41.9	28.1	11.1	8.8	11.3	11.5	7.3	3.0	123.0
Commercialisation[4] (including publicity, marketing, etc.)	23.0	12.8	7.1	5.7	8.1	8.5	9.0	7.5	81.7
Others[5]	190.8	127.1	30.3	31.3	34.1	34.9	33.7	34.5	516.7
Total expenditure:	**1,031.7**	**587.1**	**177.9**	**171.5**	**188.1**	**198.4**	**200.6**	**202.8**	**2,758.1**

Explanatory Notes –

(1) Staff cost includes basic salaries, Operational Reserve (for R&D staff), Mandatory Provident Fund contributions, variable payment, medical and life insurance. Backend support for project management / branding / commercialisation activities will be enhanced in the next few years.

(2) Accommodation includes rent, rates and management fees.

(3) Equipment includes IT equipment, furniture and fixtures. Efforts will be made to enhance ASTRI's digital infrastructure and IT security in the next few years.

(4) Commercialisation includes advertising, PR activities, commercialisation and marketing activities, tech forum expenses.

(5) Other costs include IP management, consultancy, legal & professional fees, utilities expenses, general office expenses, etc.

(6) Operating expenditure for 2019-20 is according to the budget as approved by the Board of Directors in December 2018.

R&D Projects and Expenditure (in $ million)

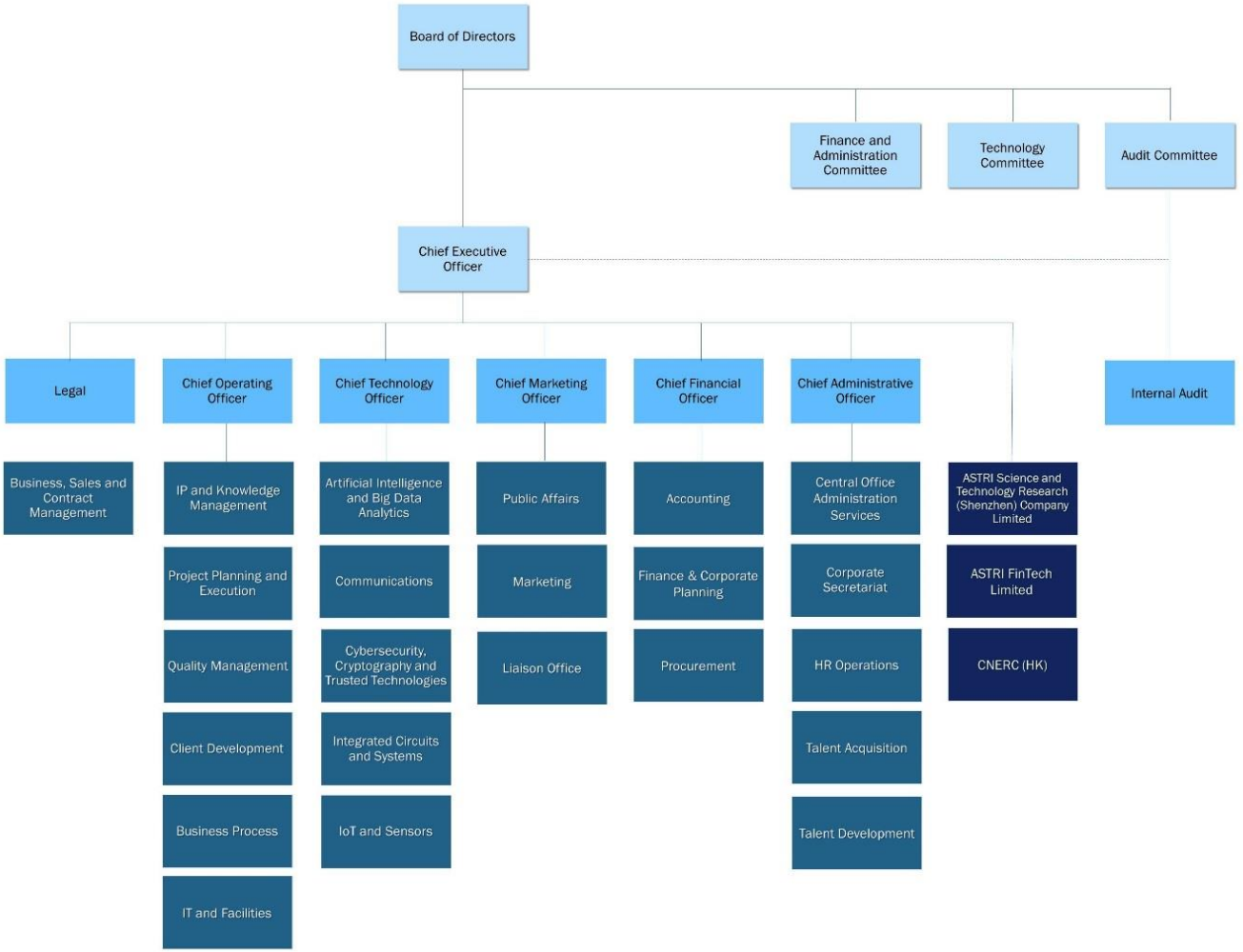
	9-year Cumulative 2006-07 to 2014-15 (Actual)	4-year Cumulative 2015-16 to 2018-19 (Actual)	2019-20 (Estimate)	2020-21 (Estimate)	2021-22 (Estimate)	2022-23 (Estimate)	2023-24 (Estimate)	2024-25 (Estimate)	Total
No. of new projects commenced	337	164	46	45	46	46	47	47	778
No. of projects under commercialisation (1)	234	77	21	21	21	21	22	22	n/a
R&D expenditure ($ million)	2,144.4	1,173.9	358.0	348.0	382.0	402.0	408.0	411.0	5,627.3

Explanatory Notes –

(1) Completed or on-going projects with technologies ready for commercialisation such as licensing and filing of patents.

Appendix

Hong Kong Applied Science and Technology Research Institute (ASTRI)
Organisation Structure (as at 1 September 2019)



R&D Organisation Structure (as at 1 September 2019)

Annex C

Hong Kong Research Institute of Textiles and Apparel ("HKRITA")

PART 1 - General Background

1. Mission and vision

The mission of HKRITA is to be the leading centre of excellence in research, development and technology transfer in textile, apparel, footwear and fashion technologies. The major technology focus areas of HKRITA include –

(a) new materials and textiles and apparel products;
(b) advanced textiles and clothing production technologies;
(c) innovative design and evaluation technologies; and
(d) enhanced industrial systems and infrastructure.

2. Institutional set up

HKRITA is a non-profit company wholly-owned by the hosting organisation, the Hong Kong Polytechnic University.

The Board of Directors of HKRITA oversees the operation and development of the R&D Centre. It is underpinned by a Technology Committee and an Executive Committee which are responsible for reviewing and endorsing project proposals and overseeing administrative matters respectively.

HKRITA is required to prepare annual plans and quarterly/annual reports on its operation and submit them to the Commissioner for Innovation and Technology for approval.

3. Organisation

As at 31 March 2019, the staff strength of HKRITA is 75. An organisation chart is at Appendix.

PART 2 - Highlight of Operation in 2018-19

I. New R&D Projects and Industry Contribution (in $million)

	2017-18			2018-19		
	No. of New Projects	Project Cost	Industry Contribution	No. of New Projects	Project Cost	Industry Contribution
Platform[1]	9	77.8	19.0	12	66.7	13.0
Collaborative[2]	5	14.7	7.5	4	8.9	4.6
Seed[3]	1	1.9	0.03	4	11.2	n/a
Total:	15	94.4	26.5	20	86.8	17.6
Public Sector Trial Scheme	6	6.1	n/a	3	6.7	n/a

II. Operating Expenditure (in $million)

	2017-18	2018-19
Staffing	21.0	23.9
Accommodation	4.4	3.0
Equipment	2.6	2.5
Others	6.3	7.7
Total:	34.3	37.1

[1] Platform projects require industry contribution of at least 10% of the total project cost.

[2] Collaborative projects require industry contribution of 30-50% of the total project cost.

[3] Seed projects are projects which are more forward-looking and exploratory in nature. No industry contribution is required.

III. Industry Income (in $million)

	2017-18	2018-19
	Industry Income	Industry Income
Industry Contribution	26.5	17.6
Licensing/Royalty	0.5	0.2
Contract Services	0.1	6.3
Others	0.7	4.4
Total:	27.8 (27.4)	28.5 (26.0)
Project Cost	94.4 (92.5)	86.8 (75.6)
Level of Industry Income:	30%	34%

Note: *Figures in brackets only include projects requiring sponsorship for the purpose of calculating the level of industry income.*

IV. Other Performance Indicators

	2017-18	2018-19
Number of Organisations Benefitting from the Public Sector Trial Scheme	26	13
Number of Interns Engaged	53	77
Number of Patents Filed	38(9)	37(6)

Note: *Figures in brackets denote the numbers of patents granted.*

PART 3 – Evaluation of the Performance of the R&D Centre from 2015-16 to 2018-19

1. R&D Achievements

HKRITA, one of the most prestigious research institutions internationally for the textiles and clothing industry, has continued to build strong and effective relationship with various stakeholders in the past four years.

The challenges of the textile and clothing industry have grown throughout the years from maximising profits to understanding the needs of various stakeholders and their role in corporate social responsibility. HKRITA continued to build its own research competence in textile recycling and high-performance textile technologies, with a focus on sustainable development and environmental protection that can not only enhance the competitiveness of Hong Kong's textile industry but also benefit the society as a whole. A four-year collaboration with one of the world's largest fashion and design companies led to a series of textile recycling projects with successful industrial applications. These include technologies that effectively separate materials in polyester-cotton blend fabrics for reprocessing and reuse, as well as hydrothermal and biological treatment methods that not only remove a long-standing barrier to recycling post-consumer textiles but also generate quality recycled materials for producing textile and non-textile products.

These award-winning projects have been put into practice at both industrial and retail levels. A local spinning mill was opened in September 2018, being the first spinning mill opened in Hong Kong in around 50 years, which applies technologies of a sustainable and effective means of fibre-to-fibre recycling. A "Garment to Garment" ("G2G") shop was established in The Mills, Tsuen Wan in 2018 to demonstrate the garment recycling technology to the public.

HKRITA has also been contributing to various sectors of the community. This includes joint efforts with the Hong Kong Sports Institute ("HKSI") to develop sportswear and devices that positively increase the comfort and confidence of athletes, as well as ongoing cooperation with the Tung Wah Group of Hospitals ("TWGHs") to develop wearable electronics and smart garments that improve the quality of life of the elderly and facilitate better management of elderly centres.

For the four-year period from 2015-16 to 2018-19, HKRITA's industrial contribution level stood at a healthy average of 26.7%, with 83 new projects commenced. The level of industry income increased from 30% to 34% from 2017-18 to 2018-19, demonstrating its growing support from the industry and progress in commercialisation and technology transfer.

2. Commercialisation and Technology Transfer to the Industry

Since September 2010, the HKRITA Business Development team has been promoting and commercialising its R&D project deliverables to the industry through various channels. During the four-year period from 2015-16 to 2018-19, HKRITA signed 27 licensing agreements with total commercialisation income received amounting to $14.2 million.

Some successful examples of commercialisation /technology transfer include -

(a) Spinning System for Chitosan Yarn - Chitosan, known for its antibacterial property, is derived from the exoskeletons of crustaceans such as crabs and shrimps. The spinning process of the yarns made of chitosan fibre exhibits a tendency to lock or wind together due to the material's high electrostatic discharge, resulting in a high level of wastage in the production process. The spinning system for chitosan yarn solves the problems of roller-winding and greatly reduces wastage and production cost, while maintaining mechanical properties. The technology has already been licensed to interested licensees immediately after its launch.

(b) Sleeping Thermal Comfort Assessment System – The system is a one-stop solution, including an indoor and microclimate simulation instrument, and a systematic evaluation system to assess the physical, physiological and psychological parameters under a sleeping condition, which helps to evaluate sleeping thermal comfort. It can facilitate the assessment of sleepwear and bedding textiles. The technology has been licensed to companies including a well-known Hong Kong mattress manufacturer with international recognition.

(c) Low Temperature Rapid Evaporation System – The system adopts a low pressure relaxation process other than conventional washing and tumble drying cycle and works to achieve water evaporation by lowering air pressure. Two non-exclusive licenses have been issued to a system builder and a leading sweater manufacturer in Hong Kong. More discussions with other interested companies are expected.

(d) Smart Warehouse Solution – The project in progress is for development of an automatic warehouse solution for a yarn spinning mill which aims to improve the goods inbound and outbound accuracy and order picking efficiency.

3. Application of R&D Outcomes in the Public Sector and Benefits to the Community

HKRITA has been working with multiple public organisations to get the most out of its research outcomes to benefit our society and community.

The work of HKRITA benefits people from many walks of life. It started from preparing the Hong Kong Rowing Team to participate in the 2014 Asian Games, then extended the support and collaboration to the Fencing Team in 2015-16. The research outcomes optimised the physical property and performance of the competition wears and training wears. HKRITA developed, prototyped and tested warming suits for the Rowing Team and asymmetric footwear for the Fencing Team. The teams achieved remarkable results in the 2014 Asian Games in Korea and the 2016 Olympic Games in Brazil.

HKRITA also collaborated with the disciplinary forces to work on their duty uniforms and extreme condition gear. These include heat management uniforms and next-to-skin thermal protective garments which provide thermal comfort, quick dry and flame-retardant properties. The satisfactory trial result from the relevant Public Sector Trial Scheme ("PSTS") project eventually awarded HKRITA with orders of thousand sets of this garment.

HKRITA also engaged with non-profit service groups like the TWGH to develop suitable textile-based solutions for the elderly. These included the Anti-Strip jumpsuits to avoid patients suffering from behavioural disorder such as Alzheimer's and dementia from removing their diapers at inappropriate times, thus improving their quality of life through better hygiene. The jumpsuits attracted enquiries through different channels and repeated orders were received from different centres of the TWGHs. This technology had been successfully licensed to a garment manufacturer which enabled the continuity of the jumpsuits' supply.

4. Promotion Activities and Liaison with Stakeholders, including Local and International Collaboration

HKRITA organised regular conferences and technology seminars to share results of its work, get inputs and to forge closer ties with its stakeholders and research partners. Since 2016, the biennial Innovation and Technology Symposium has been turned into an annual event, which has been well-received by industry leaders and other research institutes in the textiles-related disciplines. In 2017 and 2018, the Symposium was one of the highlights in the Fashion Summit, which provided a platform to inspire ideas on sustainable development for the fashion industry. It was successfully held with overwhelming responses.

The event attracted around six hundred participants in 2018, including management executives, technologists, R&D experts and professionals from different textile and garment-related stakeholders.

HKRITA has participated in the Hong Kong Fashion Week since 2006. It has supported Business of Design Week since 2016. In September 2016, HKRITA collaborated with PMQ (known as Policy Married Quarters before revitalisation) to present its first ever technology-integrated Smart Fashion Runway

& Exhibition, with the theme “Material Translation”. The fashion show successfully attracted over 350 participants with around 9,000 visitors attending the exhibition. In 2017, HKRITA debuted in Design Inspire (Swedish Pavilion) to showcase its sustainable projects with a prestigious international fashion foundation.

HKRITA has reached out to the sustainable and innovative sector through participation in international events like Climate Change Forum (Summer 2016), Asian Textile Conference (Summer 2017), Copenhagen Fashion Summit (Summer 2018), Textile Exchange Forum (Fall 2018), Techstyle Conference (Spring 2019) and PI Apparel (Spring 2017-19).

HKRITA has received over 70 local and international delegations from 2016 to 2018. It has also gathered ideas and comments on technology and projects through channels such as the online enquiry platform on HKRITA’s website and the Asia IP Exchange. Since 2012, HKRITA has also established its presence on Facebook, YouTube and LinkedIn.

The communication efforts of HKRITA are directed at various types of stakeholders. InnoCarnival and the Gerontech and Innovation Expo are the platforms HKRITA targets to engage the youth and the public in Hong Kong.

Over the last few years, HKRITA has garnered admirable accolades in international innovation and technology competitions. So far, it has won 67 international and local awards, of which 42 were received in the last 4 years.

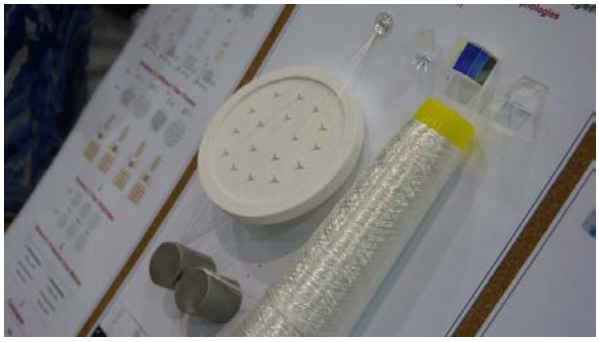
A significant international recognition is the International Exhibition of Inventions of Geneva. At the 47th International Exhibition of Inventions of Geneva in 2019, HKRITA won three gold medals, one silver medal and two bronze medals. Over the years, HKRITA has won 45 medals, including 21 gold medals from this event. In 2019, HKRITA also won the world renowned Red Dot Award: Product Design with its G2G recycling system.

Local awards that HKRITA has won over the years include the Hong Kong Awards for Industries and the Hong Kong Green Innovations Awards.

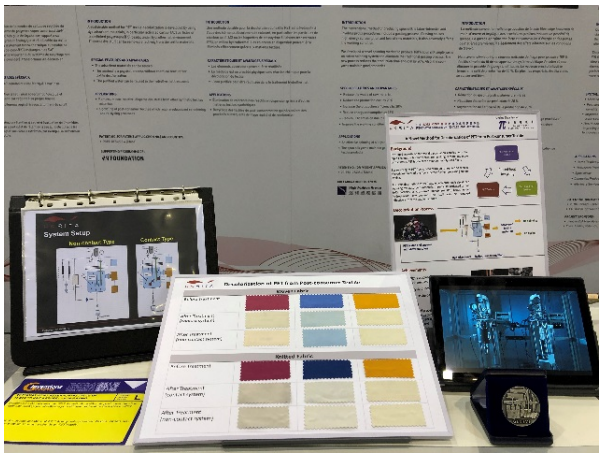
HKRITA’s recent accomplishments and awards have received growing media coverage. During the last 4 years, it has been featured in over 450 publications.

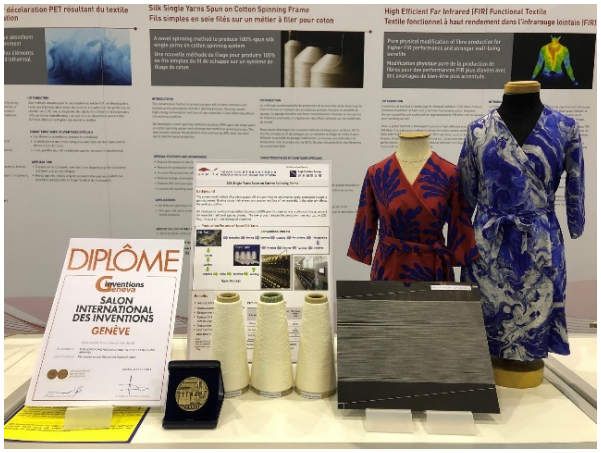
PART 4 - Progress of Selected Projects on R&D, Commercialisation and Use of R&D Outcomes in the Public Sector from 2015-16 to 2018-19

Project / Technology	Status / Progress
1. Garment to Garment ("G2G") System – A Mini Mill in Retail Space  	This is a mini production line in a retail shop that recycles post-consumer garments into clean, wearable clothes. The complete process takes place in a 40-foot glass-walled container. Its anti-vibration, noise- and dust-controlled design minimises disturbance to nearby businesses and can be operated within community areas like shopping malls. Visitors can look inside to view the components running the system, and enhance their experience by recycling their own used clothes. This first G2G system is located at The Mills, a revitalised art and cultural complex in Hong Kong. The G2G system won the Red Dot Award: Product Design and a gold medal in the 47th International Exhibition of Inventions of Geneva in 2019.

Project / Technology	Status / Progress
2. Highly Efficient Far Infrared ("FIR") Functional Textile  	Conventional production of FIR fibre involves expensive chemical treatment to achieve heat preservation, which degrades the yarn properties and quality. Further, the FIR effect is weakened after washing. HKRITA's innovative physical method defines the cross-sectional profile of fibre and modifies its parameters ideally for fibre spinning, improving the brightness, finesse, linear shape and drawing method to achieve optimal performance from a highly efficient and top-quality FIR fibre. Compared to the conventional method, this is more cost-competitive and eco-friendly. The solution provides permanent FIR function for heat preservation and well-being benefits, such as keeping the wearer's body warm, improving metabolism and sleep quality, facilitating fatigue recovery, and increasing blood oxygen and circulation. The project won a gold medal and Thailand Award for the Best International Invention from the National Research Council of Thailand in the 47th International Exhibition of Inventions of Geneva in 2019.

Project / Technology	Status / Progress
3. Eco-friendly Cellulosic Superabsorbent Polymer  	This project transforms cellulose powder recycled from used cotton polyester blends into superabsorbent polymer ("SAP") which can absorb more than 30 times the volume of liquid and retain more than 20 times the volume of liquid relative to its own mass. With great water retaining and moisture releasing properties, the cellulosic SAP is an ideal agricultural water retention agent, helping agricultural products adapt to extreme climate conditions, e.g. drought and over-rain. The cellulosic SAP is made from textile wastes and its water release and retention function can be reused on both sunny and rainy days. The project won a gold medal in the 47th International Exhibition of Inventions of Geneva in 2019.

Project / Technology	Status / Progress
4. A Novel Method for Decolourisation of PET from Post-Consumer Textiles  	Sustainable PET textile decolourisation uses dye adsorbent materials, activated carbon (“AC”) particles or crosslinked polystyrene (“PS”) beads in a hydrothermal environment to remove dispersed dyes effectively from PET textiles. It is a physical process that involves no chemical reaction. Another benefit is the low cost of the dye adsorbents relative to current decolouring chemical agents. With an average 94% reduction of colour intensity, the approach is effective in decolouring fibre, yarn, fabric or garment (PET textiles) which can be re-dyed and reused to make new garments. The purified water can be reused in the hydrothermal treatment. The project won a silver medal in the 47th International Exhibition of Inventions of Geneva in 2019.

Project / Technology	Status / Progress
5. Silk Single Yarns Spun on Cotton Spinning Frame  	Conventional spun silk production is labour-intensive, involving tedious procedures including a gassing step. Gassing results in high energy consumption and loss of raw materials, and adversely affects working conditions. This new spinning method produces 100% spun silk single yarns on a cotton spinning system without the gassing process, and thus reduces CO2 emissions. It also reduces energy consumption by 15% and production time by 20%, while increasing production efficiency by 20%. The factory work environment is greatly improved, and the spun silk yarns maintain good quality. The project won a bronze medal in the 47th International Exhibition of Inventions of Geneva.

Project / Technology	Status / Progress
6. Wearable Electronic for Better Quality Community Care of the Elderly  	This project features collaboration among HKRITA, LSCM, and ASTRI. The project developed a smart wear system for elderly care homes by integrating different tracker technologies. The outer apparel includes a wind-proof and water-proof jacket, with built-in RFID, GPS and iBeacon tracking systems. It helps caretakers effectively manage the elderly during daily care services and outdoor activities. This anti-wandering system won the Best Smart Care Technology Solution Award in the 6th Asia Pacific Eldercare Innovation Awards for the Elderly Services Section of TWGHs Community Services Division. The smart wear system has been implemented in 11 elderly centres under TWGHs. Training was provided to the centre staff before the application of the wear system.

PART 5 – Future Plan of the R&D Centre from 2021-22 to 2024-25

1. Technology Roadmap and R&D Programme

"On the Road to Sustainability, Industry Advantage and Better Society; weaving infinite possibilities……"

Historically, the textile and apparel industry has an image of being a major polluter and consumer of resources, particularly water. The current trend of fast fashion and convenience of e-commerce are also generating heaps of briefly-loved but quickly discarded textiles. Consumers are beginning to demand greater corporate sustainability efforts, putting market pressure on fashion brands to shift from productivity and profit, to finding long-term, systematic solutions that can mitigate the environmental impact of clothing.

HKRITA has been working hard to address this challenge, and present a number of ground-breaking developments poised to shift the industry towards a cleaner future whilst bringing benefits to the society as a whole.

Making a linear industry circular with textile recycling innovations

One of the major areas of breakthrough is in textile recycling, i.e. developing a closed-looped recycling system for post-consumer textile wastes which enables material separation of cotton polyester blends. The separated polyester fibres are ideal for spinning and manufacturing of new fabric, while cellulose powders, decomposed from cotton, can be applied to functional products or generated fibre.

Building on strong support from industry, deep commitment from industry parties and successful commercialisation of the projects, HKRITA will lead its future research on this framework towards sustainability.

Dyeing process protects precious natural resource

The protection of precious water resources and mitigation of wastewater production will also be a key focus in the framework of development. One of the pivotal development projects is a waterless dyeing process that addresses water scarcity and wastewater production problems, two environmental issues long associated with fabric dyeing, and drives down cost and energy.

Mobilising the community

To translate the lab achievements into dynamic industrial solutions for Hong Kong and other cities, HKRITA targets to enhance sustainability awareness on a wider societal level and align devoted efforts with public and business interests. Innovations like the unique G2G recycling system in a retail shop make sustainability concepts accessible and relevant. Designed to be easily installed in shopping malls and other

retail locations, the mini-scale system offers the public full visibility into the entire process of turning old clothing into clean, recycled garments. This not only builds on the existing initiatives to promote sustainability technologies, but also opens new channels enabling the fashion industry to interface with consumers and mobilise the community for sustainable garments.

Leading the way for a cleaner fashion industry in Hong Kong and beyond

HKRITA's latest achievements in creating cutting-edge solutions for the industry echo the market forces that led to its establishment in 2006. Amidst Hong Kong's textiles manufacturing industry's efforts to move up the value chain, HKRITA was founded to transform the industry through pioneering research outcomes and new enterprise solutions. HKRITA has always been focused on transforming the way textiles are designed, made and handled after consumption.

Looking ahead, HKRITA will foster more partnerships along the textile, apparel, and fashion value chain and curate further opportunities to turn discoveries into viable business models. With experience and access to some of the city's finest research talent, HKRITA is uniquely positioned to promote Hong Kong as a vibrant global hub of ideas, solutions and networks for sustainability innovation in textiles and apparel.

HKRITA will continue to focus on areas including new materials, production and evaluation technologies, and enterprise systems targeting research themes of sustainability, industry advantage, and improvements for society.

2. Commercialisation and Technology Transfer to the Industry

With its R&D focus on the themes of sustainability, industry advantage and better society, HKRITA is promoting to the industry its technologies relating to zero discharge, waterless technologies, technologies on energy efficiencies, and manufacturing technologies so as to enhance the efficiency throughout the supply chain to drive competitiveness. Highlights of major HKRITA projects with commercialisation potential are as follows –

(a) Development of a G2G Recycling System – This is a mini production line in a retail shop at the Mills, Tsuen Wan that recycles post-consumer garments into clean, wearable clothes. The complete process takes place in a 40-foot glass-walled container. Visitors can view the components running the system and enhance their experience by recycling their own used clothes.

(b) Innovation of Highly Efficient FIR Functional Textiles – Conventional production of FIR fibre involves expensive chemical treatment to achieve heat preservation, which degrades the yarn properties and quality. HKRITA's innovative physical method defines the cross-sectional profile of fibre and modifies its parameters ideally for fibre spinning. This cost-competitive and eco-friendly technology provides permanent FIR function for heat preservation and well-being benefits, such as improving

metabolism and sleep quality, facilitating fatigue recovery, and increasing blood oxygen and circulation.

(c) Cellulosic Superabsorbent Polymer (SAP) from Post-consumer Textile Waste – This project transforms cellulose powder recycled from used cotton polyester blends into SAP which can absorb more than 30 times the volume of liquid and retain more than 20 times the volume of liquid relative to its own mass. With great water retaining and moisture releasing properties, the cellulosic SAP is an ideal agricultural water retention agent, helping agricultural products adapt to extreme climate conditions. The cellulosic SAP is made from textile wastes and its water release and retention function can be reused on both sunny and rainy days.

(d) Materials and Systems for Decolorisation of PET from Post-consumer Textile – Sustainable PET textile decolourisation uses dye adsorbent materials to remove dispersed dyes effectively from PET textiles. It is a physical process that involves no chemical reaction. Another benefit is the low cost of the dye adsorbents relative to current decolouring chemical agents. With an average 94% reduction of colour intensity, the approach is effective in decolouring fibre, yarn, fabric or garment (PET textiles) which can be re-dyed and reused to make new garments. The purified water can be reused in the hydrothermal treatment.

3. Application of R&D Outcomes in the Public Sector and Benefits to the Community

PSTS projects are derived from completed and successful platform and collaborative projects, which are ready to be commercialised to the local industry. HKRITA continues to conduct trials of its projects in various non-profit organisations, government departments, and community group. It aims not only to benefit our community, but also to quickly demonstrate its R&D impact and look for opportunities for improvements.

The total number of completed platform and collaborative projects up to 31 March 2019 was 116, of which some required further enhancement of the prototype produced in order to meet the industry's needs and respective requirements before commercialisation.

Public sector organisations and Government departments such as TWGHs, Marine Division of the Hong Kong Police Force and HKSI have collaborated with HKRITA on trial tests of project deliverables on health care textiles, effective tracking system for elderly, functional garment, high performance sportswear, etc.

On-going PSTS projects being conducted by HKRITA include:

(a) Intelligent Wearable System for Enhancing Mobility of People with Parkinson's Disease – The project produces wearable monitoring device for

patients of Parkinson's disease that guide them to walk by a control unit with laser and earphone devices.

(b) Green Functional Underwear for the Elderly with Limited Mobility – The project produces underwear and socks by fabrication of poly-hydroxybutyrate-co-hydroxyvalerate ("PHBV") / polylactide acid ("PLA") / cotton blend yarns with antimicrobial properties for better hygiene, which helps to improve the quality of life of the elderly suffering from limited mobility.

(c) High Performance Hong Kong Bespoke Men's Suiting for an Updated Urban Professional Application and Image-based Precise 3D Human Model Customisation on Smart Phones for Fashion Applications - This is a mobile application that can project a person's body shape and size accurately in seconds for bespoke suiting.

4. Promotion Activities and Liaison with Stakeholders, including Local and International Collaboration

Looking ahead, HKRITA's marketing priority will be to complement its R&D efforts to generate industry interest in the deliverables of completed projects and to explore opportunities of collaboration on new research initiatives. HKRITA will continue to organise and support various conferences and seminars with different organisations such as the Hong Kong Trade Development Council, The Mills Fabrica, other research institutes, local and international universities, and other international institutions to promote its R&D programme to the industry and explore collaboration opportunities with both industry and research partners. HKRITA will also organise and participate in international trade shows or technology fairs to promote its commercialised technologies. It plans to continue its participation in events like Gerontech and Innovation Expo, Inno Desgin Tech Expo, Startme Up Festival and various other important international events.

HKRITA also facilitates dialogues and international collaborations among industry, non-government organisations ("NGOs"), the academic and R&D sectors on turning the textiles and fashion industry sustainable. HKRITA held a fruitful first meeting with the United Nations Environment Programme ("UN Environment") in April 2019, which aimed to encourage international discussion towards achieving the UN's Sustainable Development Goals ("SDGs") by bringing together the industry with the NGO and academic sectors. The discussion came to a conclusion that it is crucial for the industry to develop a series of sustainable practices in building long-term values with their stakeholders. Looking forward, HKRITA will take a proactive role in connecting various parties to further exchange cases and best practices, and to promote engagement through high-level international dialogues to facilitate concrete initiatives in accomplishing the SDGs in the near future.

The Centre Report has been published biennially since 2014. Apart from publishing the Centre Report for disseminating Centre's technology news and updates, as well as the foresight of the senior management, HKRITA will continue to produce specialised materials for specific projects or for special events.

Other major communication channels to be adopted by HKRITA include –

(a) the website will be revamped with mobile friendly app interface with higher user-friendliness. Project information and the latest news and events of HKRITA can be easily accessed via mobile devices;

(b) HKRITA e-newsletter will continue to be published on a quarterly basis. This will have articles on projects as well as news on current industry matters;

(c) technology tips and latest research and innovation news will continue to be spread through media like Facebook, You Tube, and WeChat; and

(d) its electronic direct mailing will enable fast and efficient communication with industry partners.

5. Budget and Cashflow

The approved funding commitment for the operation of HKRITA up to 31 March 2021 is $344.5 million. To support its continued operation up to 31 March 2025, an additional funding of $214.3 million is required for HKRITA, bringing the total funding commitment for 19 years of operation to $558.8 million.

Operating Expenditure (in $ million)

	9-year Cumulative 2006-07 to 2014-15 (Actual)	4-year Cumulative 2015-16 to 2018-19 (Actual)	2019-20 (Estimate)	2020-21 (Estimate)	2021-22 (Estimate)	2022-23 (Estimate)	2023-24 (Estimate)	2024-25 (Estimate)	Total
Staff [1]	90.1	80.4	27.3	29.8	32.4	35.1	37.8	40.9	373.8
Accommodation	9.3	20.3	9.0	9.3	10	10.8	11.7	12.7	93.1
Equipment and other capital cost	4.0	15.2	1.8	0.8	5	1.8	1.8	1.8	32.2
Commercialisation[2] (including publicity, marketing, etc.)	11.8	12.2	3.2	3.3	3.7	3.9	4.1	4.3	46.5
Others[3]	12.1	15.0	5.8	5.3	4.4	4.6	4.8	5.0	57
Total expenditure:	127.3	143.1	47.1	48.5	55.5	56.2	60.2	64.7	602.6
Less: Admin. overheads[4]	-	10.7	6.1	4.7	4.9	5.4	5.6	6.4	43.8
Total operating cost from ITF :	**127.3**	**132.4**	**41.0**	**43.8**	**50.6**	**50.8**	**54.6**	**58.3**	**558.8**

Explanatory Notes –

(1) Staff cost covers basic salary, Mandatory Provident Fund contributions, contract-end gratuity, medical insurance, etc. The staff establishment of HKRITA is forecast to reach 50 posts by 2024-25.

(2) The budget for commercialisation mainly covers expenditure for exhibitions, production of prototypes as well as publicity and advertisements.

(3) Other miscellaneous cost items include human resource management-related expenses, IT programming and maintenance fees, professional fees, utility expenses, etc.

(4) The administrative overheads received from in-house R&D projects conducted by HKRITA will offset the operating cost involved in supporting these projects.

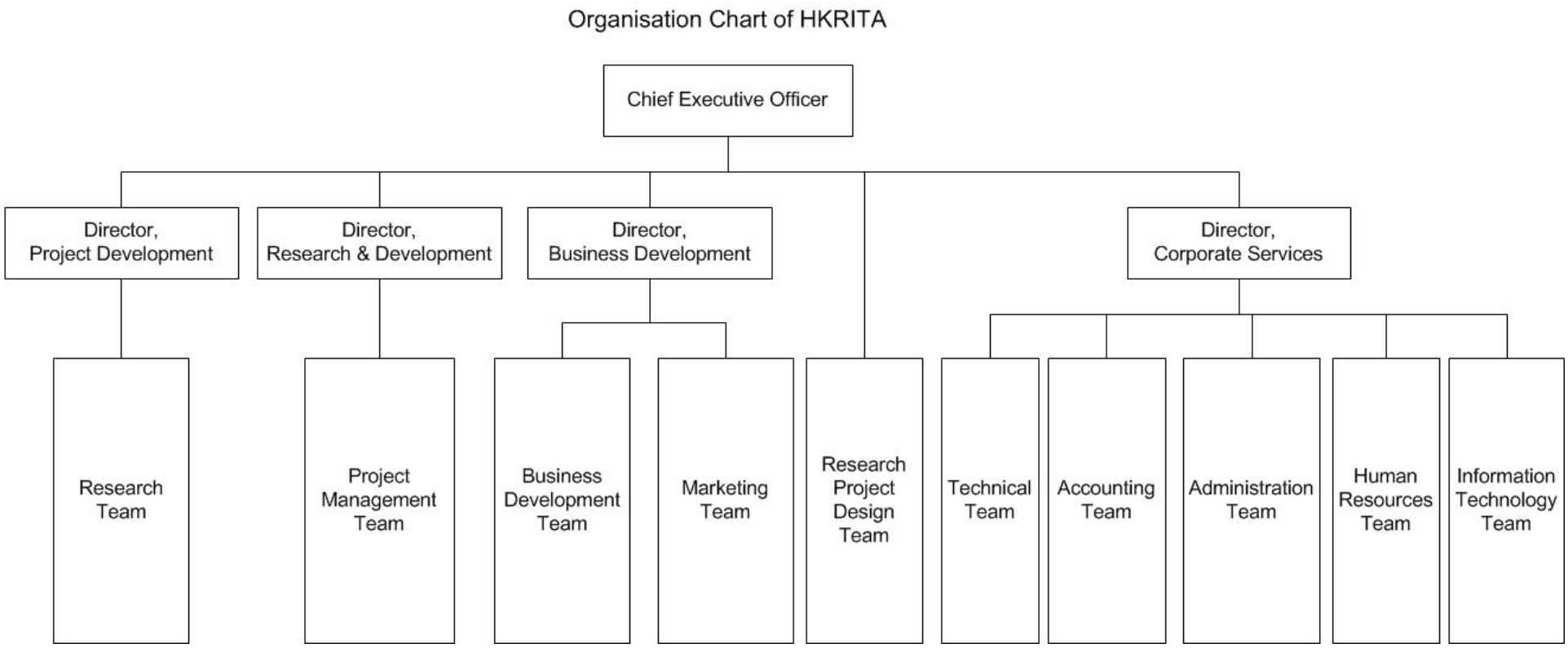
R&D Projects and Expenditure (in $ million)

	9-year Cumulative 2006-07 to 2014-15 (Actual)	4-year Cumulative 2015-16 to 2018-19 (Actual)	2019-20 (Estimate)	2020-21 (Estimate)	2021-22 (Estimate)	2022-23 (Estimate)	2023-24 (Estimate)	2024-25 (Estimate)	Total
No. of new projects commenced	134	83	24	25	26	27	28	29	376
No. of projects under commercialisation[(1)]	49	68	76	84	92	101	110	119	n/a
R&D expenditure ($ million)	255.6	254.5	99.6	109.4	114.6	123.6	129.0	134.6	1,220.9

Explanatory Notes –

(1) Completed or on-going projects with technologies ready for commercialisation such as licensing and filing of patents.

Appendix


Organisation Chart of HKRITA
Chief Executive Officer
Director, Project Development
Director, Research & Development
Director, Business Development
Director, Corporate Services
Research Team
Project Management Team
Business Development Team
Marketing Team
Research Project Design Team
Technical Team
Accounting Team
Administration Team
Human Resources Team
Information Technology Team

Annex D

Logistics and Supply Chain MultiTech R&D Centre ("LSCM")

PART 1 - General Background

1. Mission and vision

The Logistics and Supply Chain MultiTech R&D Centre (formerly known as Hong Kong R&D Centre for Logistics and Supply Chain Management Enabling Technologies) ("LSCM") was founded in 2006 with a mission to foster the development of core competencies in logistics and supply chain related technologies and to facilitate the adoption of these technologies by industries of Hong Kong and Mainland China to enhance competitiveness.

The major technology focus areas of LSCM include –

(a) Infrastructure Information Technology System;
(b) Internet-of-Things ("IoT") and Radio Frequency Identification ("RFID") Technology;
(c) Location-based Service ("LBS") Technology;
(d) Logistics and Supply Chain Analytics and Applications;
(e) Supply Chain Security; and
(f) Financial Services & e-Commerce Technology.

2. Institutional set-up

LSCM is set up as a non-profit-making company, jointly owned by its hosting organisations, namely the University of Hong Kong, the Chinese University of Hong Kong and the Hong Kong University of Science and Technology.

The Board of Directors of LSCM oversees the operation and development of the R&D Centre. It is underpinned by a Technology Committee and a Finance and Administration Committee.

LSCM is required to prepare annual plans and quarterly/annual reports on its operation and submit them to the Commissioner for Innovation and Technology for approval.

3. Organisation

As of 31 March 2019, the staff headcount of LSCM is 124, including the Chief Executive Officer. The organisation chart is at Appendix.

PART 2 - Highlight of Operation in 2018-19

I. New R&D Projects and Industry Contribution (in $million)

	2017-18			2018-19		
	No. of New Projects	Project Cost	Industry Contribution	No. of New Projects	Project Cost	Industry Contribution
Platform[1]	6	68.1	7.1	6	73.5	18.7
Collaborative[2]	3	7.3	3.5	2	2.6	1.3
Seed[3]	5	13.7	n/a	6	16.7	n/a
Total:	14	89.1	10.6	14	92.8	20.0
Public Sector Trial Scheme	7	28.0	n/a	11	31.1	n/a

II. Operating Expenditure (in $million)

	2017-18	2018-19
Staffing	18.8	23.9
Accommodation	7.2	9.7
Equipment	0.4	0.8
Others	3.1	2.8
Total:	29.5	37.2

[1] Platform projects require industry contribution of at least 10% of the total project cost.
[2] Collaborative projects require industry contribution of 30-50% of the total project cost.
[3] Seed projects are projects which are more forward-looking and exploratory in nature. No industry contribution is required.

III. Industry Income (in $million)

	2017-18	2018-19
	Industry Income	Industry Income
Industry Contribution	10.6	20.0
Licensing/Royalty	0.3	0.4
Contract Services	4.0	9.6
Others	-	0.1
Total:	14.9 (14.8)	30.1 (30.0)
Project Cost	89.1 (37.0)	92.8 (64.6)
Level of Industry Income:	40%	46%

Note: *Figures in brackets only include projects requiring sponsorship for the purpose of calculating the level of industry income.*

Other Performance Indicators

	2017-18	2018-19
Number of Organisations Benefitting from the Public Sector Trial Scheme	27	31
Number of Interns Engaged	20	13
Number of Patents Filed	17(2)	46 (5)

Note: *Figures in brackets denote the numbers of patents granted.*

PART 3 – Evaluation of the Performance of the R&D Centre from 2015-16 to 2018-19

1. R&D Achievements

The performance of LSCM during the period from 2015-16 to 2018-19 has been marked by considerable improvement, when compared with the previous four years of operation. During the period, 80 projects have commenced, which compares favourably with the 48 projects in the previous four-year period of Centre's operation. The level of income received from the industry increased significantly from 24% on average during the period from 2011-12 to 2014-15 to 35% on average during the period from 2015-16 to 2018-19. It is also encouraging to see the increase of industry contribution pledged from $31.7 million during the period from 2011-12 to 2014-15 to $54.6 million during the 2015-19 period.

LSCM has sustained a healthy growth by commencing 25 new projects in 2018-19 (up from 21 projects in 2017-18). It also achieves 46% for the level of income received from the industry, representing the highest level since the establishment of the Centre in 2006.

LSCM is also keen on extending its technological capability in focused areas. LSCM has further extended its technology roadmap to better fit the change of technology environment and the demands of the society and industry. For instance, the Centre focuses on robotics and automation that are related to logistics. The Centre has done numerous projects on Autonomous Guided Vehicle ("AGV"), Follow-Me Robots, and other automatic systems. The Centre also developed technology focus in other areas including artificial intelligence ("AI"), big data analytics, blockchain and supply chain security.

As a result, LSCM has been engaged with different sectors including ports and customs, logistic management, elderly care, and non-governmental organisations ("NGOs") to pioneer the big data analytics work. Blockchain applications were developed such as "e-cheque wallet" for the Hong Kong Monetary Authority and an authentication blockchain for supply chain management contracted by a US listed company. LSCM also developed technology applications in the areas of contraband detection for airport safety, anti-smuggling and unauthorised intrusion for boundary security.

2. Commercialisation and Technology Transfer to the Industry

LSCM has made remarkable achievement in terms of commercialisation of R&D results. During the four-year period from 2015-16 to 2018-19, LSCM signed a total of 79 licensing agreements, representing 88% increase from 42 licensing agreements made during the period of 2011-12 to 2014-15.

With the expansion of the Centre's technology portfolio in the past few years, the Centre has diversified its contributions to different sectors of the local community serving government departments, private companies, and NGOs alike.

For example, two local companies licensed the RFID-Enabled Sensing Technologies developed by LSCM in collaboration with the Chinese University of Hong Kong for facilitating real-time environmental monitoring and risk management. Two system

integrators licensed the AGV developed by LSCM in 2016 to help their clients minimise processing time and enhance efficiency in their warehouse management. A construction company and a local technology consultant have adopted the smart construction platform developed by LSCM in collaboration with the Hong Kong Polytechnic University to reduce project delay and improve productivity. In addition, three shopping malls in Hong Kong have adopted the indoor localisation, tracking and navigation systems developed by LSCM. Three system integrators have licensed the Centre's elderly tracking, RFID Gatedoor and Service Logging Kiosk solution to better serve the needs of the elderly.

Apart from technology licensing, the Centre has also enhanced its technology transfer to the industry through significant growth in contract research projects with deliverables developed from Innovation and Technology Fund ("ITF")-funded projects during the past several years. Examples of significant contract research projects include:

(a) An Asian branch office of an international anti-counterfeiting solutions company has engaged the Centre to develop a product authentication technology with its Blockchain solutions;

(b) A cargo terminal in Hong Kong engaged the Centre to customise RFID Sensing technologies to enhance operational efficiency and workplace productivity within their warehouses;

(c) The Transport Department commissioned LSCM to develop the Smart Traffic Control System at Tai Tam Road (Dam Section) to collect real-time traffic information for adjustments of road signals to reduce traffic delays; and

(d) An elderly care home engaged the Centre for providing Thermal Sensing System solution for detecting abnormal movements and behavioural patterns of the elderly.

3. Application of R&D Outcomes in the Public Sector and Benefits to the Community

Since the launch of the Public Sector Trial Scheme, LSCM has been actively engaged with different Government bureaux/departments, public bodies, NGOs and industry/trade associations to adopt solutions for improving their operations and benefitting the community. There are 29 PSTS projects commenced during the period from 2015-16 to 2018-19 and 38 organisations benefitting from these PSTS projects, as compared with 24 PSTS projects commenced during the period from 2011-12 to 2014-15 benefiting 32 organisations.

Some selected examples of LSCM's effort in application of R&D outcomes in the public sector include:

(a) The RFID Blind Cane Navigation System developed by LSCM to provide guidance to the visually impaired was adopted by the Hong Kong Society for the Blind, Yuen Long Home for the Aged Blind and West Kowloon Cultural

District. A social enterprise has licensed the technology to offer related service solutions in the market;

(b) Technologies developed by LSCM to serve elderly care centres and attention homes, which include service logging and information kiosk system, infrared thermal safety system, RFID-tagged vest & gate door system and GPS tracking technologies, were adopted by various public organisations including the Hong Kong Housing Society, Pok Oi Hospital, Social Welfare Department and Tung Wah Group of Hospitals, among which Clague Garden Estate was awarded as "Age-Friendly Cities and Communities" by the World Health Organization in 2015; and

(c) LSCM collaborated with the University of Hong Kong to promote the Virtual Reality Cave technology, which is a fully immersive and automatic cave-like virtual environment for training and evaluating the decision-making and high-order skills of professionals. The technology has been widely accepted and is now adopted by the Construction Industry Council, University of Hong Kong School of Professional and Continuing Education, and Occupational Safety and Health Council, etc.

LSCM will continue its effort to promote the application of R&D outcomes in the public sector, fostering more collaboration opportunities between the public sector and the Centre to promote commercialisation.

4. Promotion Activities and Liaison with Stakeholders, including Local and International Collaboration

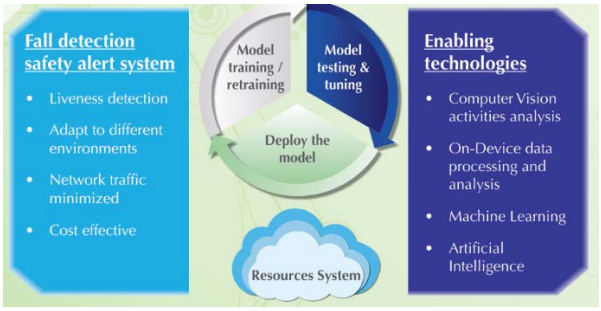
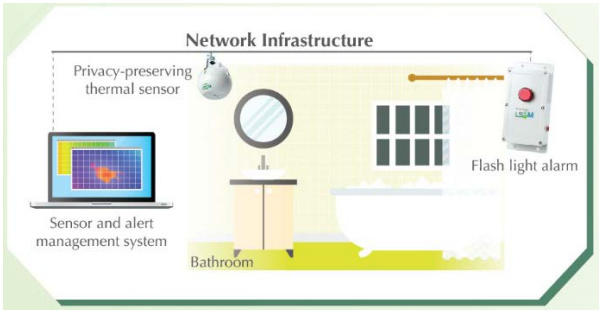
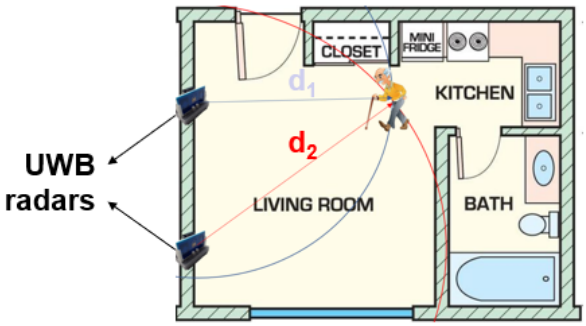
LSCM has been actively approaching the industry and the public through two signature events – the LSCM Logistics Summit and LSCM Roadshow. The Summit in 2018 marked a historical high record of over 1 000 guests to gather related industry players, technology experts, academia and government officials to facilitate collaboration and partnership. The LSCM Roadshow is also a breakthrough in promoting LSCM's technologies and solutions, attracting much interests from the trade and the public.

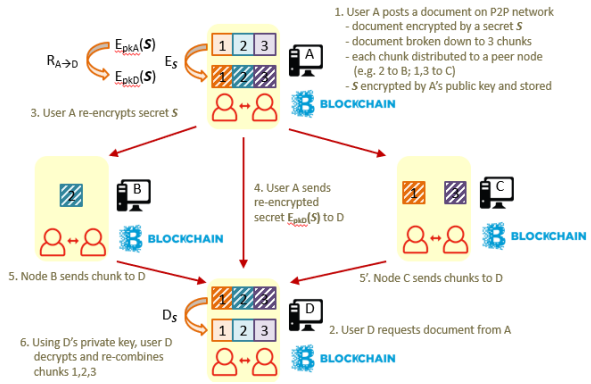
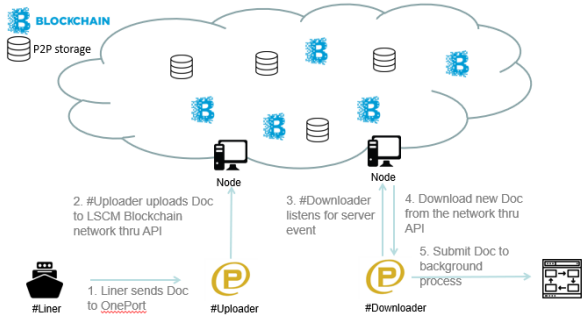
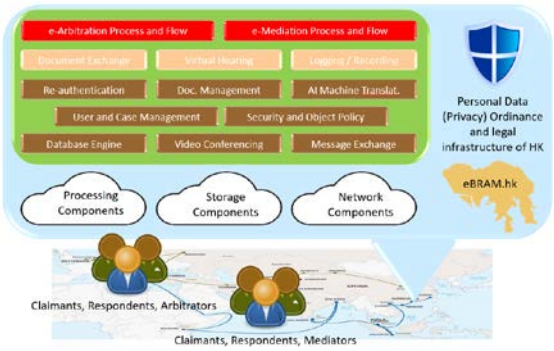
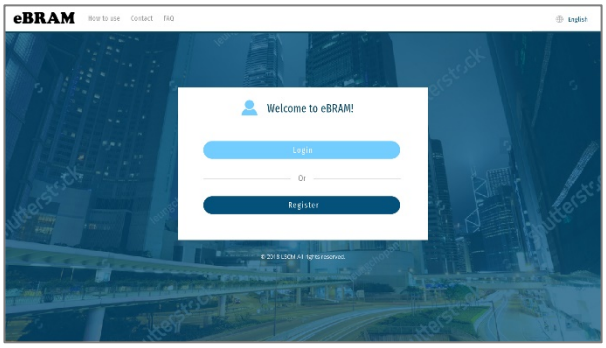
Apart from the two signature LSCM events, LSCM also actively conducts technology forums and participates in industry trade events to engage with different industry communities. In 2018-19, LSCM co-organised and participated in more than 47 trade events. In particular, the Centre has been the official technology partner of the Asian Logistics and Maritime Conference for two consecutive years (2017 and 2018) by presenting "Event Attendance Monitoring System" to facilitate the event organiser in monitoring the visitors' attendance and mobility.

LSCM also offers membership to interested parties with regular communication in the format of electronic Direct Mail ("eDM"), eNewsletter and industry news. The number of LSCM members is now accumulated to 1 333 members. It is estimated that the "equivalent publicity value" of LSCM would amount to $19 million in 2018-19.

PART 4 - Progress of Selected Projects on R&D, Commercialisation and Use of R&D Outcomes in the Public Sector from 2015-16 to 2018-19

Project / Technology	Status / Progress
1. Immersive Virtual Reality ("VR") Empowered Training System  *Opening ceremony of OSHC's new training centre held in March 2019* 	LSCM and the University of Hong Kong have developed a VR-empowered work safety and scenario training platform for the Occupational Safety and Health Council ("OSHC") and Construction Industry Council. The VR training platform not only provides a cost-effective training method as compared with the traditional training method, but also tracks and monitors a trainee's learning process which could subsequently be assessed for the effectiveness. The training system was installed in the OSHC's new training centre opened in March 2019. This training platform has been commercialised through four licensing agreements and eight contract research projects. In addition, the team has also developed an immersive VR empowered training system for authentic aircraft maintenance operation training and performance qualification, which won a silver medal at the 47th International Exhibition of Inventions of Geneva in 2019.
2. Smart Traffic Control System  	The Transport Department has deployed the Smart Traffic Control System developed by LSCM at Tai Tam Road (Dam Section) to collect real-time traffic information for adjustments of road signals to reduce traffic delays. This application was awarded a silver medal at the 47th International Exhibition of Inventions of Geneva in 2019.

Project / Technology	Status / Progress
3. Infrared Thermal Sensing Safety Alert System for the Elderly  	LSCM has collaborated with an elderly rehabilitation centre to develop an infrared thermal sensing safety alert system for the elderly. The system is a privacy preserving system designed for monitoring an individual's safety in a bathroom or toilet. This low-cost thermal sensing system can detect and analyse human movement in a private space. When the body movement is not detected for a pre-defined period of time, an alarm will alert the caretakers. The sensing and alert management system provides a centralized platform for thermal sensor array and alert monitoring for nursing care within an elderly premise. This application was awarded a gold medal at the 47th International Exhibition of Inventions of Geneva in 2019.
4. Ultra-wideband Technology for Solitary Activity Monitoring  	LSCM has developed a low-cost solitary activity monitoring system that measures the activity levels of the elderly in the living room and detects any abnormal conditions by using the latest ultra-wideband ("UWB") and signal processing technologies. This system preserves the privacy of the elderly while providing real-time feedback to help caretakers provide efficient remote monitoring. UWB technology provides an alternative solution to application developers because UWB radar is less sensitive to ambient conditions and imposes less privacy issue as compared with conventional vision monitoring solution. LSCM is in collaboration with an elderly care centre to trial this system.

Project / Technology	Status / Progress
5. Entrusted Decentralised Exchange  **Pilot Application (Oneport) - Workflow**  	LSCM has developed an Entrusted Decentralised Exchange which provides a platform facilitating business document exchange. Leveraging blockchain technology and peer-to-peer storage, business documents can be shared on a decentralized exchange. Proxy re-encryption allows only designated reader to decrypt and read the document. The exchange enables trading partners to carry out due diligence on information such as supplier financials, location and capacity of manufacturing plants, patents and trademark. A publicly listed company has licensed LCSM's blockchain applications and carried out a contract research project.
6. e-Arbitration / Mediation Cloud Services Platform ("eBRAM")   	As an initiative for the legal sector, LSCM has developed an Online Dispute Resolution Cloud Services Platform for e-Arbitration / Mediation. The platform also utilises AI technology to develop a domain-specific language translation system. With the development of the Belt and Road Initiative, the platform will be able to showcase Hong Kong's innovation and technological ability and enhance Hong Kong's role as an international city in Asia for arbitration and mediation. The platform is currently under trial with users including members of the arbitration profession and the legal sector.

PART 5 – Future Plan of the R&D Centre from 2021-22 to 2024-25

1. Technology Roadmap and R&D Programme

According to a report from the Hong Kong Trade Development Council, as one of the four pillar economy sectors in Hong Kong, the trading and logistics industry employed over 727 500 employees and accounted for 22% of GDP in 2017. With the "Greater Bay Area initiative" being taken forward, Hong Kong, as a transportation and logistics hub in the heart of Asia, will need to relentlessly reinvest in innovation and technology ("I&T") to maintain and elevate its position. The adaptation of I&T has been the top policy agenda of the HKSAR Government and LSCM has been in the forefront to capture such potential and integrate I&T into the logistic sector.

LSCM's long-term vision and mission is to become a leading centre of excellence, and initiate and conduct R&D activities to develop core technological competencies in areas including, but not limited to, logistics and supply chain management, robotics, e-Commerce, elderly care services, and other related industries in Hong Kong.

LSCM targets to broaden and strengthen its core technological competency in the following technology areas –

(a) Infrastructure System & LBS;
(b) IoT;
(c) AI and Big Data;
(d) Robotics Process Automation/ Intelligent Process Automation;
(e) Smart City; and
(f) Supply Chain Security/ Regulatory Technology.

LSCM will, based on this enhanced roadmap, develop demand-driven R&D projects, with an emphasis on providing innovative solutions to enable its clients, in particular small and medium sized enterprises ("SMEs"), to move up the value chain.

Infrastructure System & Location-Based Services	Internet-of-Things	Artificial Intelligence and Big Data	Robotics Process Automation / Intelligent Process Automation	Smart City	Supply Chain Security / Regulatory Technology
- Cross-boundary e-lock Customs Clearance Technology - e-Trade Facilitation Platform - Ecommerce/Deal-making/Dispute Resolution Platform Technologies - Wireless Communications Technologies - BIM-based Construction and Asset Management - Satellite Positioning, Navigation and Communications - LBS Technologies - Secured IP Storage/Trade Enabling Technologies	- Supply Chain IoT Platform - Video Analytics / Decision-Making - Wearable Electronics - RFID-based Foundation Technologies - Smart Logistics - Smart Supply Chain - Smart Warehouse Management System	- E-logistics - Trade-related activities Big Data Analytics - Chatbot for Logistics, Trade, and Retail Activities - Transportation AI and Big Data Support - Virtual/Augmented /Mixed Reality Technologies	- Robotics (AGVs, robotic arms, human robot interactions, soft sensors and actuators, platooning) - Software Robotics - End-to-End Supply Chain Fulfilment RPA/IPA - E-service Platform Interconnectivity - E-Education / Training Robotics	- Genrotechnology and Smart Community - Smart Asset Management - Public Safety Enhancement - Transport Smart System	- e-Cheque / Financial Transaction / Monetary Technology - Blockchain Applications - Authentication Technologies - Smart Contract Technologies - Cloud/Network/ Information System Security - Homeland Security Screening And Data Analytics

Applications of LSCM's Core Technological Competency

2. Commercialisation and Technology Transfer to the Industry

LSCM has experienced continuous growth in the past few years. It believes a sustainable growth will be best delivered through capitalising on the Government and industrial support and continuous innovation.

On the way forward, LSCM will adopt the following tech-transfer strategies:

(a) To continue developing PSTS projects to showcase the availability and performance of the Centre's technologies, which may lead to commercialisation/tech-transfer opportunities in the form of contract research projects and licensing;

(b) To contribute to the Government's smart city initiatives through LSCM's technologies, such as HK-Zhuhai Trade Facilitation Platform ("eTFP") and e-Arbitration and Mediation Platform ("eBRAM"); and

(c) To promote our identity as the "designated local research institution" ("DLRI") under the Scheme of "Enhanced Tax Deduction for Qualifying R&D Expenditure in Hong Kong" to system integrators ("SI") and industry partners, and to facilitate sell-through of our Centre's technologies to SMEs and end users.

3. Application of R&D Outcomes in the Public Sector and Benefits to the Community

LCSM will continuously drive its R&D deliverables to realisation and commercialisation through PSTS projects. As of end of March 2019, LSCM has conducted 53 PSTS projects. By collaborating with different Government Departments, non-profit organisations, and community groups, LCSM has been proactively pushing its research outcomes to benefit our society and community.

LSCM has positioned itself to take on an active role in facilitating the Government's policy drive. For instance –

Smart City Initiative – LSCM will pursue an expanded portfolio of opportunities under the Government's initiatives to further drive the development of Hong Kong into a smart city through innovation and technology, focusing on multiple fields such as IoT, AI, video analytic and LBS location technologies. LSCM will focus its effort in driving further cooperation with different industry sectors and research institutes for the benefit of local industries and the community.

E-logistics and E-commerce Initiative – Leveraging on the close partnership with the Government and regulatory body, LSCM will initiate the "e-Trade Finance Information Facilitation" for due diligence processes between international e-commerce trading. Moreover, LCSM's will press on with its effort to promote automation in Hong Kong's logistic and supply chain sector through robotic process automation.

Social and Elderly Care Services (Gerontechnology) – Facing an inexorable growth in the ageing population in Hong Kong, our society is in need of technologies to support the elderly service industry so as to ease the pressure on the caretakers and reduce the manpower required. LSCM will continue to be proactive in developing a variety of gerontechnologies to enhance the quality of life of the elderly as well as other people in need.

Greater Bay Area Initiative – LSCM will engage and collaborate with different organisations to promote its eTFP to facilitate SMEs in the "Greater Bay Area". With Hong Kong's strong legal foundation, global connections and its role as a leading international arbitration centre, LSCM will develop an online platform for deal-making and dispute resolution.

4. Promotion Activities and Liaison with Stakeholders, Including local and International Collaboration

LSCM has been building its corporate identity and gaining recognition among the industry practitioners since its establishment through effective marketing promotion, corporate event organisation, trade engagement and impactful media publicity. In the coming years, LSCM will continue to strengthen its corporate image and promote the R&D deliverables by organising more industry-oriented events and generate more powerful media coverage.

With LSCM's unique position as connecting the Government, industry, academia and research sector, the Centre will continue to strive for initiating local R&D of technology, as well as drive collaboration between LSCM and the industry and public sector through effective communications with the target segments.

As the Government is determined to develop Hong Kong into an international innovation and technology hub, numerous funding schemes and initiatives were introduced. Many overseas leading R&D institutes are planning to set up branches in Hong Kong, which leads to lots of cooperation opportunities. LSCM will seek and work with global leading R&D institutes to promote international co-operation in R&D and collaborate with industries and communities to embrace innovation and technology.

5. Budget and Cashflow

The approved funding commitment for the operation of LSCM up to 31 March 2021 is $362.4 million. To support its continued operation up to 31 March 2025, an additional funding of $276.8 million is required for LSCM, bringing the total funding commitment for 19 years of operation to $639.2 million.

Operating Expenditure (in $ million)

	9-year Cumulative 2006-07 to 2014-15	4-year Cumulative 2015-16 to 2018-19	2019-20	2020-21	2021-22	2022-23	2023-24	2024-25	Total
	(Actual)	(Actual)	(Estimate)	(Estimate)	(Estimate)	(Estimate)	(Estimate)	(Estimate)	
Staff [(1)]	92.1	73.2	29.9	32.3	35.2	38.0	40.9	44.1	385.7
Accommodation [(2)]	24.2	26.7	12.8	13.3	20.4	21.5	19.6	22.5	161.0
Equipment and other[(3)] capital cost	6.1	2.7	1.2	0.5	3.5	2.6	0.7	0.8	18.1
Commercialisation[(4)] (including publicity, marketing, etc.)	15.9	15.8	4.4	4.2	4.4	4.6	4.8	5.0	59.1
Others[(5)]	22.9	14.6	7.2	7.0	32.3	18.2	7.4	7.5	117.1
Total expenditure:	161.2	133.0	55.5	57.3	95.8	84.9	73.4	79.9	741.0
Less: Admin. overheads	11.7	14.1	8.3	10.5	11.8	13.5	15.0	16.9	101.8
Total operating cost from ITF :	**149.5**	**118.9**	**47.2**	**46.8**	**84.0**	**71.4**	**58.4**	**63.0**	**639.2**

Explanatory Notes –

(1) Staff cost covers basic salary, Mandatory Provident Fund contributions, contract-end gratuity, variable pay and medical insurance. Extra administrative/supporting staff is budgeted for the Centre expansion to better manage projects and centre operations. Staff cost for individual R&D projects as part of project expenditure will be separately funded by the ITF.

(2) It is expected that the rental fee will experience an upward adjustment. Extra rental cost estimated at $6.1 million will also be required during office renovation.

(3) Equipment spending is budgeted for the procurement of furniture, office equipment and IT/laboratory equipment, taking into account an increase in staff number and the expected replacement of obsolete equipment. The Centre will also continue to improve and upgrade its existing systems, software, IT equipment and office data management system to meet operational needs.

(4) To promote LSCM's research deliverables and technology development, the Centre will take a more proactive role in disseminating the R&D results and promoting commercialisation and will put strong efforts in sustaining the corporate identity and organising various industry-oriented events.

(5) LSCM's office premises are currently distributed in four locations at the Cyberport and the Hong Kong Science Park. To cope with the Centre's growth, cultivate cross-team R&D, and enhance operational efficiency, LSCM will take the opportunity of expiry of current tenancy agreements to consolidate its premises in phases. Estimated expenditure covers one-off capital expenditure including $21.4 million for the renovation works for the new office, $8.1 million for setting up of an enhanced laboratory for R&D work and $3 million for setting up a technology showcase area.

Other operating cost items also include utilities, office expenses, repair & maintenance fees, legal & professional service fees, various insurance for the Centre, staff training, etc.

R&D Projects and Expenditure (in $ million)

	9-year Cumulative 2006-07 to 2014-15	4-year Cumulative 2015-16 to 2018-19	2019-20	2020-21	2021-22	2022-23	2023-24	2024-25	Total
	(Actual)	(Actual)	(Estimate)	(Estimate)	(Estimate)	(Estimate)	(Estimate)	(Estimate)	
No. of new projects commenced	77	80	25	25	26	26	27	27	313
No. of projects under commercialisation(1)	37	55	62	69	77	85	94	103	n/a
R&D expenditure(2) ($ million)	303.5	323.3	86.1	90.4	104.0	119.6	137.5	158.1	1,322.5

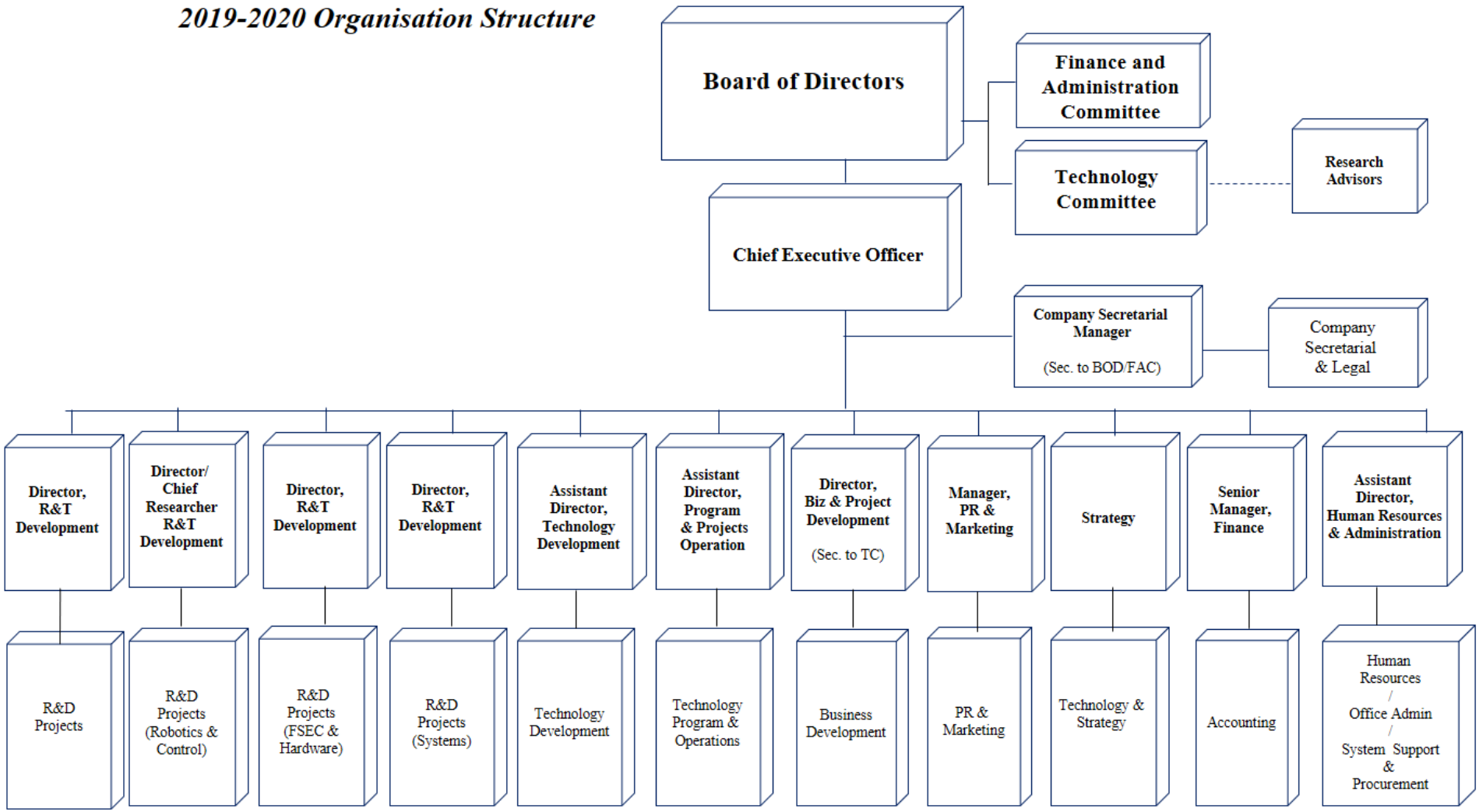
Explanatory Notes –

(1) Completed or on-going projects with technologies ready for commercialisation.

(2) Apart from ITF-funded R&D projects, R&D expenditure for 2021-22 to 2024-25 will include projects in collaboration with other R&D institutes and technology consultancy services.

Appendix

LSCM Organisation Chart



Annex E

Nano and Advanced Materials Institute ("NAMI")

PART 1 - General Background

1. Mission and vision

The mission of NAMI is to serve as Hong Kong's platform for technology development in the areas of nanotechnology and advanced materials. In particular, NAMI will –

(a) cultivate technology research talents to create innovative materials;
(b) identify and conduct innovative, market-driven R&D projects in collaboration with the local industry and research community; and
(c) drive the commercialisation of R&D outcomes.

2. Institutional set up

NAMI was established in 2006 as a non-profit-making company, wholly-owned by the hosting organisation, the Hong Kong University of Science and Technology ("HKUST").

The Board of Directors of NAMI oversees the operation and development of the R&D Centre. It is underpinned by –

(a) a Technology Committee which is responsible for reviewing and endorsing project proposals;
(b) a Finance and Administration Committee which is responsible for advising on and overseeing administrative matters; and
(c) an Audit Committee which is responsible for overseeing the governance of NAMI, including internal audit.

NAMI is required to prepare annual plans and quarterly/annual reports on its operation and submit them to the Commissioner for Innovation and Technology for approval.

3. Organisation

As at 31 March 2019, NAMI has a Centre staff strength of 56. In addition, it has 180 research positions under its R&D project teams. An organisation chart is at Appendix.

PART 2 - Highlight of Operation in 2018-19

I. New R&D Projects and Industry Contribution (in $million)

	2017-18			2018-19		
	No. of New Projects	Project Cost	Industry Contribution	No. of New Projects	Project Cost	Industry Contribution
Platform[1]	6	42.6	10.1	4	27.6	4.5
Collaborative[2]	20	62.9	31.7	26	90.6	43.6
Seed[3]	12	33.5	n/a	11	30.7	n/a
Total:	38	139.0	41.8	41	148.9	48.1
Public Sector Trial Scheme	3	2.9	n/a	2	2.4	n/a

II. Operating Expenditure (in $million)

	2017-18	2018-19
Staffing	34.0	39.6
Accommodation	11.0	9.4
Equipment	6.3	6.8
Others	14.3	17.8
Total:	65.6	73.6

[1] Platform projects require industry contribution of at least 10% of the total project cost.
[2] Collaborative projects require industry contribution of 30-50% of the total project cost.
[3] Seed projects are projects which are more forward-looking and exploratory in nature. No industry contribution is required.

III. Industry Income (in $million)

	2017-18	2018-19
	Industry Income	Industry Income
Industry Contribution	41.8	48.1
Licensing/Royalty	1.3	2.9
Contract Services	12.4	12.8
Others	1.4	2.2
Total:	56.9 (56.1)	66 (65.4)
Project Cost	139.0 (105.5)	148.9 (118.1)
Level of Industry Income:	53%	55%

Note: *Figures in brackets only include projects requiring sponsorship for the purpose of calculating the level of industry income.*

IV. Other Performance Indicators

	2017-18	2018-19
Number of Organisations Benefitting from the Public Sector Trial Scheme	20	19
Number of Interns Engaged	11	6
Number of Patents Filed	51(46)	27(65)

Note: *Figures in brackets denote the numbers of patents granted.*

PART 3 – Evaluation of the Performance of the R&D Centre from 2015-16 to 2018-19

1. R&D Achievements

Between 2015/16 and 2018/19, NAMI had significant progress on R&D with stronger emphasis on conducting demand-driven collaborative projects in partnership with local enterprises and commercialisation of the project results. The new business model emphasised on proactively and effectively aligning research objectives with market needs, which had successfully enabled the continuous growth of research revenues and commercialisation income, as well as increase in the number of licenses, awards and products launched by the industry sponsors.

The number of of collaborative projects increased from 16 amounting to $36.8 million in 2014-15 to 26 amounting to $90.6 million in 2018-19, representing an increase of project cost by 146%.

For the period between 2015-16 and 2018-19, NAMI commenced 174 ITF projects, involving a project cost of $529.3 million. Among these projects, 22 (or 12%) are platform projects, 106 (or 61%) are collaborative projects, 36 (or 21%) are seed projects and 10 (or 6%) are projects under the Public Sector Trial Scheme (“PSTS”).

NAMI’s technologies received international recognitions for technical achievements. In the past four years, NAMI won over 40 international awards in 3 major global events hosted by leading industry organisations, namely, RD100 and Consumer Electronics Show (“CES”) Innovation Awards in USA, and the International Exhibition of Inventions of Geneva. These winning technologies were the results of our industry-sponsored projects and validated the technical advantages of NAMI’s core technologies which included but were not limited to the Nanofibre, Germ Repellent Plastics, Nano Bubble, Waste Recycling, Thermal Management Materials, Flexible and Printed Electronics and Batteries, Super and Eco Concrete, etc.

2. Commercialisation and Technology Transfer to the Industry

In the four-year period from 2015-16 to 2018-19, NAMI signed 66 licensing agreements which compared favorably to the performance in the previous four-year period from 2011-12 to 2014-15, during which there were 19 signed licensing agreements. The total commercialisation income from 2015-16 to 2018-19, including income from contract research, was around $52.9 million as compared with $17.4 million between 2011-12 and 2014-15. NAMI also filed 217 patents for the period from 2015-16 to 2018-19, and was granted 132 patents.

In 2018-19, NAMI granted a total of 24 technology licences, including 17 background IP licences. Total licence income received was $3.5 million. These background IP licences also generated 17 collaborative projects.

NAMI’s emphasis on commercialisation of project results led to the launch of a total of 19 new products that were enabled by its technologies (as at end March 2019). For example, a major construction materials supplier in Hong Kong (K. Wah Construction Materials)

launched a non-load-bearing concrete block with improved fire resistance. Moreover, our germ-repellent plastics technology has enabled development of new products such as germ-repellent medical breathing tubes. NAMI's microalgae technology has also been incorporated into a green wall product for air purification with high CO_2 removal performance of up to 90%. Other notable technologies that are under the manufacturing scale-up phase include Multifunctional High Efficiency Particulate Air ("HEPA") media for air purification, nanofiber anti-pollution window screen, germ-repellent food packaging materials, and ultra-lightweight thermal insulation panels.

3. Application of R&D Outcomes in the Public Sector and Benefits to the Community

NAMI has been taking an active role in promoting the use of R&D results in the public sector which will benefit the community. From 2015-16 to 2018-19, NAMI has been implementing 10 PSTS projects. For example -

(a) NAMI completed a trial collaborating with the Vegetable Marketing Organization and School of Life Sciences of the Chinese University of Hong Kong. The results showed that NAMI's quantum-dot-based grow light with changeable spectrum for different vegetable growth stages could increase vegetable growth rate by 30-50%. Some licensing deals are in discussion.

(b) NAMI completed a trial collaborating with the Energizing Kowloon East Office to evaluate the performance of self-cleaning coating for glass panels in a glass lift tower at a food market. The results showed that the coating was hydrophobic that can reduce maintenance cost and improve hygiene of glass panels. Self-cleaning coating product was launched in 2017-18.

(c) NAMI completed a trial collaborating with the Architectural Services Department on using NAMI's recycled-materials-based environmental mortar to repair about $20m^2$ defective area in five government buildings. The trial results showed satisfactory mechanical performance and cost effectiveness.

(d) NAMI is currently working with the Architectural Services Department on evaluating the performance of NAMI's Rubberized Paving Block made of waste tyre in Kwun Tong Industrial Culture Park that could potentially reduce the landfill burden of waste tyre rubber. One of the industry sponsors has set up a production line in Hong Kong and started commercialising the product.

(e) NAMI is currently working with the Drainage Services Department on evaluating the performance of conduits with internal riblet-structure patterns in Shatin Waste Water Treatment Plant that could enhance water flow efficiency for energy saving.

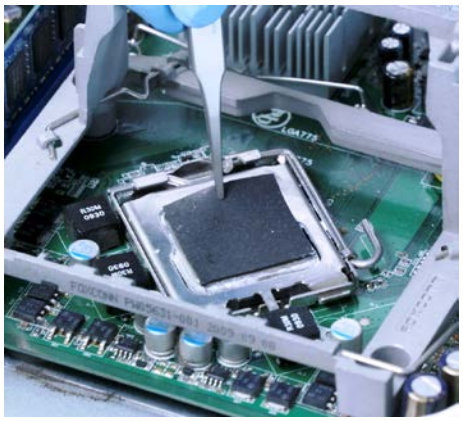
(f) NAMI is currently working with the Hong Kong Council of the Boys' Brigade on evaluating the performance of green wall system with ultra-lightweight thermal insulation panels strengthened by palm-fiber.

4. Promotion Activities and Liaison with Stakeholders, including Local and International Collaboration

Over the past years, NAMI has significantly increased the scope and intensity in promoting its technology competencies, research outcomes and commercialisation achievements. These included organising and participating in technology seminars, conferences, workshops, local and international trade shows as well as other publicity activities, etc. The annual NAMI Showcase and concurring activities received very good response from its collaborating partners, trade associations, local enterprises as well as the public, and had brought about many new collaborating opportunities. The Sixth International Symposium on Nanotechnology in Construction ("NICOM6") held by NAMI (jointly with the Hong Kong Polytechnic University) in early December 2018 was well received by more than 200 local and overseas participants, where NAMI's technology competencies and commercialisation success also gained much recognition. NAMI has also disseminated its technological development, core competence and ready-to-market technologies through a new corporate video, product videos, regular press advertorials and other social media channels, etc.

NAMI collaborates with local universities like the Hong Kong Polytechnic University, the HKUST etc. to jointly conduct research projects in advanced materials for technology transfer to the industries, and organise technology seminars/conferences. NAMI also proactively partners with the trade associations to support local industries through research collaboration and commercialisation.

PART 4 - Progress of Selected Projects on R&D, Commercialisation and Use of R&D Outcomes in the Public Sector from 2015-16 to 2018-19

Project / Technology	Status / Progress
1. Thermal Management Materials Technology 	This advanced thermal management technology platform offers 2-4 folds increase in thermal conductivity and at least 50% reduction in the contact resistance as compared with the conventional materials in the market. The new materials can offer revolutionary and superior thermal management for 5G system. This technology received international awards in RD100, CES Innovation Awards and the International Exhibition of Inventions of Geneva. One of the completed collaborative projects – Anisotropic Silicone Thermal Pad - was successfully commercialised, with products launched in market in 2018.
2. Quantum Dot ("QD") Technologies 	QDs have become widely used for displays and lighting component markets due to its superior color performance and reduced power consumption. NAMI has developed QD technologies with various applications, one of which is a new display solution for cellphones markets. NAMI is also exploring the application of this technology to TV display. In addition, the QD technologies were also applied to develop new lighting solution and grow light applications. A trial on grow light has recently been completed by the Vegetable Marketing Organization and the School of Life Sciences of The Chinese University of Hong Kong.

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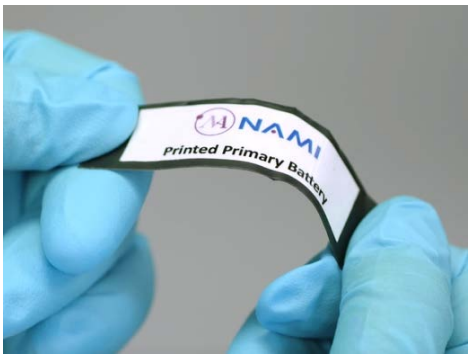
Project / Technology	Status / Progress
3. Flexible and Printable Batteries  	NAMI has developed flexible and printable batteries as highly flexible, super-safe and even printable power source for flexible electronics, providing new application opportunities in the emerging wearable electronics and IoT markets. NAMI's flexible batteries were first developed for wearable or portable electronic devices. Two of the industry sponsors have set up production lines in Hong Kong and Mainland China. Besides, printed battery technology has been applied in developing wireless asset tracking tags that made long distance asset tracking possible; and on flexible Printed Circuit Board ("PCB") as a self-powered all-in-one component for electronics.
4. Waste Recycling Technologies 	NAMI has developed recycling technologies for different wastes, such as, food wastes, rubber tires, egg shells, glass and plastics. One of the industry sponsors has set up a production line in Hong Kong to recycle rubber tires into rubberised paving blocks. The Architectural Services Department is also applying the paving blocks at one of its sites for evaluation. Besides, food wastes can be turned into animal feeds and other usable materials. Recently, it is being explored on how NAMI's waste recycling technologies can be used to treat the spent coffee grounds and soy residue.

Project / Technology	Status / Progress
5. Nanofibre Technologies 	NAMI's Nanofibre technologies have been applied on various projects, including the development of Multifunctional HEPA media for air purification. The industry sponsor has set up a new production facility in Hong Kong. The technologies have also been applied on developing anti-pollution nanofibre window screens, water filtration and facial mask products, battery separators, waste water treatment, etc.
6. Germ Repellent Materials Technology 	NAMI's Germ Repellent Materials Technologies, in the form of additives or coatings, can be used for making plastic and paper materials repellent to germs without using leachable biocides. This is compatible with traditional manufacturing processes like injection molding and coatings, with wide applications ranging from food containers to medical products. The technologies have been applied to develop germ repellent resins, consumer products, bathroom fixtures and medical devices. NAMI is transferring the technology to an industry sponsor to produce germ-repellent varnish for children books and food paper boxes. It targets to launch the products in the market in end 2019/early 2020.
7. Development of an Antibacterial and Anti-dust Coating for Air Ducting 	NAMI has developed a waterborne coating, which prevents the accumulation of dust and inhibits the growth of bacteria, mould and mildew, in air ducts to ensure good indoor air quality. The industry sponsor has set up a production facility in Hong Kong to scale up the production of the coating. The coating will be launched to the market in 2020.

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PART 5 – Future Plan of the R&D Centre from 2021-22 to 2024-25

1. Technology Roadmap and R&D Programme

NAMI's technology roadmap will continue to evolve in the upcoming years to address the ever changing market dynamics in the market place. However, NAMI's overall goal will remain to develop nano and advanced materials based innovative products in its five focused market sectors –

- Energy;
- Electronics;
- Construction;
- Environmental; and
- Healthcare.

With critical mass building up in each of NAMI's focused market sector, NAMI is developing core competencies in each sector that are capable of sustaining long term multi-product development partnership with its industry sponsors. This can be achieved through the continuous development, refinement and improvement of various platform technologies in NAMI. These platform technologies can include the fabrication and formulation knowhow of advanced materials such as nano fiber, lithium ion battery, functional plastics, super concrete, advanced coating as well as waste recycling and bio-degradable technologies for various applications. The key objective is to achieve maximum leverage from its key technologies and knowhow to drive product commercialisation and re-industrialisation in multiple areas. The key development efforts in the five focused market sectors are –

Energy

NAMI will continue to develop innovative technologies in three energy related areas, viz. "Energy Efficiency", "Energy Absorption", and "Energy Generation", and will focus on expanding the application of current core technologies and developing next generation products.

(a) Energy Efficiency

NAMI's R&D approach is to develop novel energy-efficient materials and advanced manufacturing. NAMI has been developing high performance thermal-insulation and thermal-regulated materials including NanoSponge, polymer aerogel and nano phase change materials ("PCM"), which substantially reduce energy consumption in building, utility plants, boiling and chill systems, cold-chain storage and workplace. NAMI also focuses on lightweight materials with robust mechanical strength. NAMI's fiber reinforcement technology allows replacement of metal with composite materials without sacrificing the mechanical strength. Advanced manufacturing process offers breakthroughs in production that could significantly reduce energy input and materials required for production and transportation of goods as well as provision of services, while driving innovation. For instance, self-propagating high-temperature synthesis ("SHS"), nano ceramic, and nano catalyst reduce energy usage in the manufacturing process and improve the productivity.

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(b) Energy Absorption

NAMI's smart protection material ("SPM") technology is built on its knowledge and experience in polymer chemistry and sol-gel process for energy absorption and impact protection. This technology has been further developed with anti-cutting, anti-puncture and anti-explosive functions to provide occupational and personal safety protection. NAMI will continue to develop more advanced SPM technologies, such as Auxetic materials and high performance foam gel, to offer more robust protections to devices, equipment, and human beings.

(c) Energy Generation

NAMI focuses on the development of innovative technologies to power up wearable and low power communicative devices without battery. Its Nanogenerator technologies are based on piezo-, tribo-, and thermal-electricity, which could generate sufficient electricity to power up LED, smartwatch, sensors, Bluetooth communication and GPS. Besides, piezoelectricity nanogenerator ("PEG") can be used as dynamic force sensor with ultra-high sensitivity and wide sensing range, which is essential to human-machine interface. NAMI will continue to develop the next generation nanogenerator with more power output and higher sensitivity. This will likely involve many novel technologies, including electromagnetic nanogenerator, hybrid nanogenerator, 3D technology for metal and inorganic materials, ferroelectric polymers, and novel nanomaterials for nanogenerator.

Electronics

NAMI will continue to explore the emerging technologies in the following areas: battery technologies, optical materials, printed sensors, thermal management materials and auto-fitting eMuscle materials.

(a) Battery technologies

NAMI will focus on the battery technologies for applications to achieve high energy, high power, high safety as well other breakthrough. These include the following –

- Nanofiber-on-electrode technology for a separator free high energy battery
- Materials development for lithium metal batteries, including the 3D nanofiber ceramic/polymer hybrid solid electrolyte and lithium metal anode materials development (target >350Wh/Kg)
- High energy Si-C anode materials with advanced conductive agent which can be applied to 300Wh/Kg lithium ion batteries
- Printed electrolyte with ionic conductive ceramic fillers
- Water based rechargeable battery technology
- Battery being printed on the PCB basing on solid electrolyte.

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(b) Thermal Management Materials

NAMI will keep on building its technology competence in the following areas –

- Develop highly thermal conductive silicone rubber polymer matrix and aligned carbon/metal compound materials for new generation heatsinks.
- Develop next generation aligned graphite for a higher thermal conductivity and lower cost as anisotropic thermal conductive materials. Anisotropic ceramic thermal pad will also be developed to meet the requirements for high breakdown voltage and fire retardant performance.
- Utilise the silver nanoparticles as a low temperature sintering die attach materials in today's high power and 5G communication electronics.

(c) Printed Sensor Technologies

NAMI will continue its focus on sensing materials, elastic conductive materials, printing process, and hardware/software development, including –

- Elastic pressure sensor array for low pressure detection
- Electronic medical patch for human or pet healthcare
- Develope electronic skin basing on the sensor array technology.

(d) Optical Materials

NAMI will drive the next generation materials in the area of optical materials, such as Luminescent materials, Light absorption color changing materials, Nanoimprinted optical structured materials, etc. These include –

- Tunable sun spectrum for grow light application, developing high end grow light for flowers, fruits, and Chinese herbs indoor planting
- Non heavy metal containing QDs for next generation display development
- Light manipulation (diffusion, reflection, and absorption) materials for a better thermal/optical control
- Optical controlling of different electronic devices such as lightings and displays
- Anti-counterfeit labels for high end products.

(e) Auto-fitting Polymer eMuscle Materials

NAMI will start the development of auto-fitting materials basing on the shape memory polymer materials. The research efforts will mostly focus in the following -

- Temperature sensitive eMucle materials for toy applications
- Development of 1D, 2D, and 3D shape auto fitting eMuscle materials for wearable electronics and medical devices which need a perfect sealing
- Shape memory materials with the auto-fitting function being driven by electricity for portable auto-fitting devices for a continuous medical fixation.

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Construction

NAMI will continue the thrusts in endeavouring the development of advanced construction and building materials technologies in order to address the demands from the local industries towards innovative and sustainable city. The planned development includes -

(a) Modular Integrated Construction ("MiC") represents the new era of innovative construction method which transfers labour-intensive processes and wet works at construction sites to off-site pre-cast yards through standardisation. Through the close collaboration among the Government, industry, academia and research sectors, NAMI will form cluster technologies for the future of MiC with efficiency and competitiveness. The technologies include high performance lightweight concrete materials, high strength steel and welding technology, ultra-flexible & durable waterproof materials and systems, effective joints and innovative structural engineering design, concrete-steel composites for joint-less design, etc. Full scale experimental validation platform will be established by NAMI which can form a solid reference for the whole industry.

(b) Based on the continuous success of NAMI in turning wastes into resources for construction such as utilising fly ash and slag as geopolymer-based foamed panels and repair mortar, construction and demolition ("C&D") waste and recycled glass as fire resisting blocks, recycled glass and aggregates as water permeable concrete, recycled asphalt as pavement ("RAP"), etc., NAMI will continue the efforts in developing eco-friendly building materials such as low-heat cement technology, natural nanostructured minerals such as halloysite as nano-reinforcements as well as admixture carriers for concrete and polymer, plant-based cellular materials as lightweight construction materials with superior thermal, acoustic but fire resistant.

(c) Advanced coating technologies for construction have been well established in the sector, from waterproof coating for buildings, self-cleaning coating for glass facade, anti-bacteria anti-dust coating for metal air dusts, to sol-gel based nanoscale coating with anti-corrosion, anti-fog features. NAMI will continue to develop the functional coating material technologies for buildings such as humidity control technology, anti-bacteria and anti-fungi nanomaterials, meta-materials for thermal insulation and indoor light filtering, etc.

Environmental

NAMI continues to focus on driving the recycling of municipal solid wastes ("MSW") and also improving public hygiene and sanitisation. The major development and application areas include -

(a) Recycling Technologies and Bio-degradable Materials – NAMI has developed novel recycling technologies in the last few years for all major kinds of MSW, producing high value recycled products in order to create financial incentives for recycling. NAMI will continue to use this approach to further develop recycling technologies for specific MSWs. Bio-degradable material development is another key technology which can ease our landfill burden. There are great application

opportunities for many industries including the food industry and merchanise delivery industry, where large amount of packaging materials are being used. NAMI will further develop not only new, low-cost and safe bio-degradable materials but also additives that can accelerate bio-degradability of conventional plastics.

(b) Sanitisation Technologies – NAMI-patented Plasma Driven Catalytic ("PDC") technology is already established and licensed for air purification products. It is now being evaluated for anti-mould and surface disinfection applications in food, building maintenance and other industries. Nano bubble of ozone has been proven to be effective in dissociating most organic pollutants and killing bacteria in domestic and industrial water treatment. It can also be used for pesticide removal for agricultural produce. Different products are scheduled to be in the market in 2019.

(c) Water Purification – Besides nano bubble of ozone, which can provide both domestic sanitization as well as industrial waste water purification, NAMI has also developed nano fiber-based ultra and nano filtration membranes to achieve not only filtration performance similar to reverse osmosis ("RO") membrance but also much higher throughput and durability. Domestic drinking water purifier products based on its nano fiber membranes will be available in the market in 2020. Different large scale waste water treatment processes using its membranes are also being optimized for industrial applications in 2020.

Healthcare

NAMI continues to focus on advanced bio-materials, drug delivery systems, healthcare nanofibers, and functional plastics for applications under the initiative of "Healthy Living with CARE", with marketable products in four main areas: PersonalCARE, HomeCARE, MedicalCARE and FoodCARE -

(a) Advanced Bio-materials – NAMI will broaden its formulation expertise to naturally-derived herbal ingredients and biologics, such as peptides, proteins and probiotics the native molecular conformation or viability of which is essential to their functions. By taking advantage of these bio-active molecules, innovative products in PersonalCARE and FoodCARE can be developed. Examples of new applications include the use of aqueous botanical extracts to replace the most abundant ingredient found in most skincare products – purified water for enhanced dermal rejuvenation function (PersonalCARE) and the infusion of prebiotics and viable probiotics (i.e. synbiotic formulation) in food and beverage for enhanced nutritional value (FoodCARE).

(b) Drug Delivery Systems – Various delivery systems, such as microdepots, oral dissolving films and core-shell microspheres, as well as processing techniques, such as nanomisation, nanocrystallisation and microwave-assisted extraction are established and their combinations with different active pharmaceutical ingredients, either small molecules, herbal materials or biologics, allow the development of high value pharmaceutical products in MedicalCARE – both

Western and Traditional Chinese Medicines. NAMI will continue to endeavor in this area in joint effort with its collaborators and focus mainly on over-the-counter products for less stringent regulatory requirement and quick time to market.

(c) Healthcare Nanofibers – A number of commercialised or soon-to-be-launched products have been successfully developed with healthcare nanofibers in HomeCARE (e.g. multifunctional HEPA media and anti-pollution window screen), PersonalCARE (e.g. invisible hydrating facial mask) and MedicalCARE (e.g. super breathable N95 facemask). Most, if not all, of these products are designed for one-time use. In the next frontier of healthcare nanofiber development, we are expanding applications into durable nanofiber-based materials with lamination technique. In addition, efforts have also been made to revolutionise the materials suitable for electrospinning (from organic polymers to inorganic particles) and the nanostructures of nanofibers (from nonwoven mesh to sub-nanofibers). With the new development, applications beyond filtration and delivery are expected, such as functional textiles in HomeCARE and nanofiber-based bio-sensor in MedicalCARE.

(d) Functional Plastics – In addition to biocide-free, germ-repellent plastics, several other built-in features such as porous plastics and foamed plastics have been developed to enrich the functional plastics technology platform. With the specialised formulation, traditional plastics are made to be porous in structure and become breathable; and this feature is useful in food packaging to extend the shelf-life of fresh produces (FoodCARE) and respiratory filter for medical application (MedicalCARE). On the other hand, an eco-friendly solution for plastics reduction is developed by means of high performance foaming agents, which are compatible with conventional as well as bio-degradable plastics. The foamed plastics are formed with minimal tradeoff in mechanical strength and find applications in a variety of areas including food packaging (FoodCARE) and housewares (HomeCARE). It is targeted to create a series of useful features so that each or combination of them can be put together to generate new unique plastics materials.

2. Commercialisation and Technology Transfer to the Industry

Our support of technology transfer to sponsors does not only facilitate commercialisation but can also help drive the re-industrialisation of Hong Kong. Six industry sponsors set up manufacturing facilities in Hong Kong in 2018-19 to commercialise NAMI's project results and a number of industry sponsors intend to produce their products in Hong Kong as well. For example, two of NAMI's industry sponsors recently set up manufacturing plants to produce nanofiber HEPA media and facial mask respectively. Moreover, an industry sponsor has built its production line for nano silicon dioxide slurry for chemical mechanical polishing applicable on sapphire glass for cellphone screen, silicon wafer for semiconductors, optical lens and watch, etc. NAMI will continue to collaborate with and support the industries in technology transfer and encourage them to manufacture the technology results in Hong Kong.

MiC will be included as a key technology in NAMI's development plan to complement government's initiatives in this area. A major ITF-funded project proposal which is supported by relevant Government departments, the Construction Industry Council, the Hong Kong Polytechnic University, the Chinese National Engineering Research Centre for Steel Construction (Hong Kong Branch) and the Hong Kong University of Science and Technology, etc. is in the pipeline.

The development of NAMI's platform technologies in the past few years has brought a signiciant number of local and international awards to NAMI and its industry sponsors. These award-winning platform technologies can support industries to develop new applications through further R&D and licensing. Leveraging on the market scale of the Greater Bay Area, NAMI will continue to strengthen its support to Hong Kong industries ,as well as increase the scope and intensity in promoting its technologies to maximise commercialisation opportunities and collaborating with research bodies and industry organisations.

3. Application of R&D Outcomes in the Public Sector and Benefits to the Community

NAMI will continue to leverage the PSTS to increase the success of commercialisation of project results. While NAMI will leverage on PSTS to support our industry sponsors to accelerate commercialisation of its technologies, NAMI will also complement government initiatives in supporting the development of growing industrial segments, such as waste recycling, green technologies, etc. In addition, for major government policies, such as MiC, NAMI will actively explore new technical solutions in advance materials. More proactive engagement with relevant public sector bodies will be initiated to drive and support the development of new industrial segments and technology advantages for Hong Kong's economic growth.

4. Promotion Activities and Liaison with Stakeholders, including Local and International Collaboration

More extensive and focussed promotion activities and new initiatives will be undertaken apart from the existing annual programmes to promote NAMI's unique position as a materials expert in Hong Kong and its applied research and commercialisation achievement as well as re-industrialisation success stories. These will help open up more collaboration opportunities with the local enterprises, local and overseas research institutes, trade assiciations and etc. The activities will include seminars, conferences, workshops, local and international trade shows, product videos and other promotional videos, press advertorials/releases and etc.

NAMI will continue to participate in major local and international technology award events to validate its core competencies and impact on technological development as well as successful commercialisation by the industry sponsors.

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5. Budget and Cashflow

The approved funding commitment for the operation of NAMI up to 31 March 2021 is $690 million. To support its continued operation up to 31 March 2025, an additional funding of $439.5 million is required for NAMI, bringing the total funding commitment for 19 years of operation to $1,129.5 million.

Operating Expenditure (in $ million)

	9-year Cumulative 2006-07 to 2014-15	4-year Cumulative 2015-16 to 2018-19	2019-20	2020-21	2021-22	2022-23	2023-24	2024-25	Total
	(Actual)	(Actual)	(Estimate)	(Estimate)	(Estimate)	(Estimate)	(Estimate)	(Estimate)	
Staff [(1)]	172.7	133.3	48.8	49.9	55.0	61.1	66.1	70.4	657.3
Accommodation [(2)]	26.1	46.5	16.8	17.9	22.5	26.6	28.0	33.2	217.6
Equipment and other capital cost[(3)]	34.4	32.2	6.3	6.5	8.5	15.0	9.0	10.6	122.5
Commercialisation[(4)] (including publicity, marketing, etc.)	5.7	7.9	2.5	2.7	3.6	3.8	4.0	4.2	34.4
Others[(5)]	42.5	67.3	21.9	23.5	25.3	28.7	30.4	32.6	272.2
Total expenditure:	281.4	287.2	96.3	100.5	114.9	135.2	137.5	151.0	1,304.0
Less: Admin. overheads	13.7	41.0	15.9	16.7	18.8	26.2	19.8	22.4	174.5
Total operating cost from ITF :	**267.7**	**246.2**	**80.4**	**83.8**	**96.1**	**109.0**	**117.7**	**128.6**	**1,129.5**

Explanatory Notes –

(1) Staff cost covers basic salary, Mandatory Provident Fund contributions, medical insurance and is budgeted to include inflation and salary adjustment. The Centre staff establishment of NAMI is forecast to reach 68 posts by 2024-25.

(2) The increase in expenditure for accommodation from 2021-22 is mainly due to the acquisition of additional office and laboratory space to cater for the continuous expansion of NAMI.

(3) Increase in the equipment and other capital cost from 2021-22 to 2024-25 is due to the renovation of new laboratory and office space.

(4) Commercialisation budget increases over the years to meet the growth in the number of projects.

(5) Other miscellaneous cost items include IP management, property management fee, utility expenses and various administrative expenses.

R&D Projects and Expenditure (in $ million)

	9-year Cumulative 2006-07 to 2014-15 (Actual)	4-year Cumulative 2015-16 to 2018-19 (Actual)	2019-20 (Estimate)	2020-21 (Estimate)	2021-22 (Estimate)	2022-23 (Estimate)	2023-24 (Estimate)	2024-25 (Estimate)	Total
No. of new projects commenced	139	174	47	49	51	53	55	57	625
No. of projects under commercialisation(1)	31	59*	34	38	42	46	50	55	n/a
R&D expenditure ($ million) (2)	275.3	373.4	160	170	180	190	200	210	1,758.7

Explanatory Notes –

(1) The estimates are based on projects with projected payment from royalties and potential licensing deals.

(2) The estimates are based on past expenditure trends and the increase in the number of new projects.

* Project with royalties/licensing income received in multiple financial years is counted as one project.

Appendix

Organisation Chart of NAMI