出國報告(出國類別：考察)

香港應科院(ASTRI) 5G 通訊國際合作參訪

服務機關：經濟部技術處
姓名職稱：張嘉祥科技專家
派赴國家：香港
出國期間：**105** 年 **4** 月 **6** 日至 **4** 月 **7** 日
報告日期：**105** 年 **5** 月 **23** 日

摘要

- **出國目的**
  - ASTRI 香港應用科技研究院副總裁莊哲義博士邀請資策會赴港討論第五代行動通訊 5G 合作事宜
  - 資策會於 4 月 1 日來函本處，邀請科技專家張嘉祥隨團指導
- **參訪預期效益**
  - 了解香港應用科技研究院 5G 技術發展重點，作為國內 5G 技術發展規劃參考。
  - 尋求與香港應科院在 5G 的研發合作，以加速研發時程

關鍵詞： 4G, B4G, 5G, 行動通訊

目錄

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壹、前言

此次因資策會的邀請，參加香港應科院(ASTRI) 5G 通訊國際合作參訪，發現 ASTRI 目前 LTE L1 和 EPC/vEPC 已嶄露頭角，已建立國際的 Visibility。其研發特色是

- 與國際大廠介接綿密，包括 Intel, NXP 等都有深厚的合作關係
- 與業界合作密切，其預算必須有 40%來自業界
- 與 operator 關係密切，包括致力於 Nano Cell 的發展，參加國際的 Trial 等等

而 ASTRI 的研發策略是

- 以 signal processing 和 DPI/EPC 為主
- L2/L3, SoC 或 NFVI 平台由 partner 提供
- 未來將致力於 Cloud Base MEC(含 BB pool) 以及 Service chaining 和 MEC 發展

這種與國際 Eco-system 串聯的研發策略是值得我們參考的

貳、工作會議及考察行程

- 交通行程

	4/6 (三)	4/7 (四)
上午	搭國泰 CX407 08:00-09:50 桃園-香港	CX402 19:00-20:35 香港-桃園
下午	14:00-16:00 **ASTRI**	

- 會議行程及與談重點

日期		行程	內　　容
4/6 (三)	上午	出發	搭國泰　CX407 08:00-09:50　桃園-香港
	下午	14:00 – 18:30 ASTRI.	公司/單位：香港應用科技研究院　ASTRI 地點：香港沙田香港科學園科技大道東 2 號光電子中心 5 樓 議題：討論第五代行動通訊 5G 合作事宜 人員： - 莊哲義、副總裁　（研發群組總監） - 歐嘉棟、研發總監　(通訊技術群組) - 劉辛怡、總監　(通訊技術群組) - 招溢利、經理　(通訊技術群組) - 陳少平、高級經理　(通訊技術群組) - 郭慧民、主任工程師　(通訊技術群組) - 苗家豪、總監　(通訊技術群組) - 曾江洲、總監　(通訊技術群組) - 范世君、總監　(通訊技術群組) - 楊美基、首席科技總監　(CTO 辦公室) - 岑冠文、高級經理　(CTO 辦公室) 議題一：ASTRI 通訊技術及展示 議題二：ASTRI RAN 技術 議題三：ASTRI EPC & NFV 技術
4/7 (四)	下午	回程	CX402 19:00-20:35 香港-桃園

一、 香港應科院(ASTRI) 5G 通訊國際合作參訪

- **會議議程**

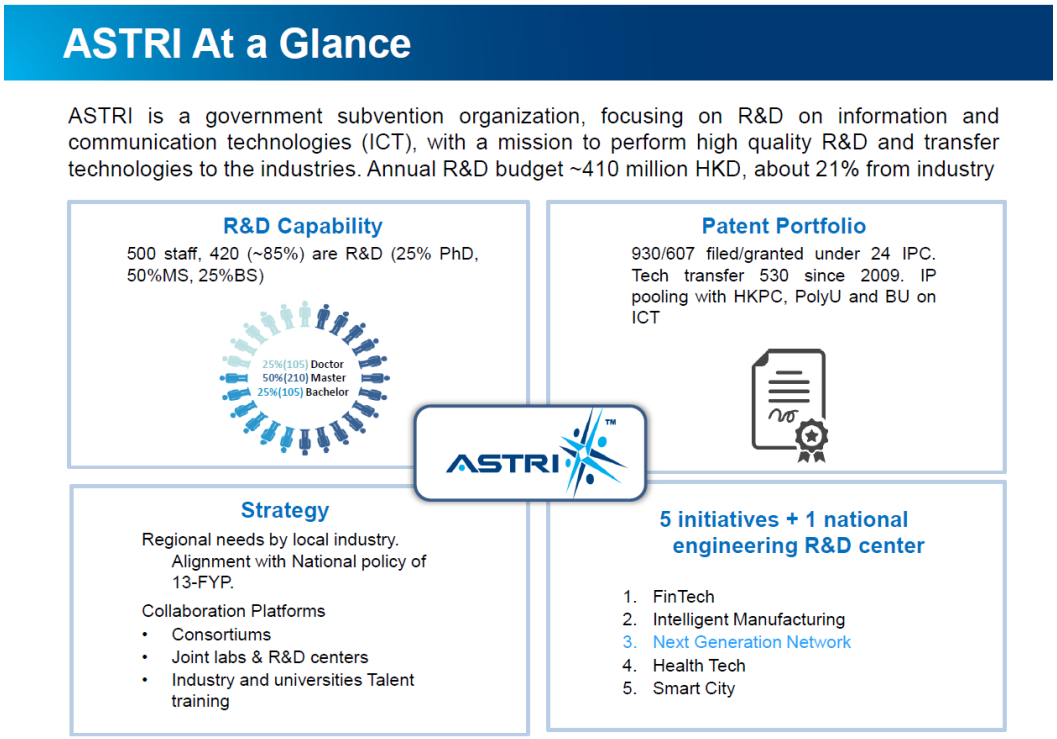
Time	Agenda
14：00 ~ 14：10	Arrival of Taiwan Delegation and Business Card Exchange
14：10 ~ 15：00	ASTRI 通訊技術及展示
15：10 ~ 16：30	ASTRI RAN 技術
16：30 ~ 18：00	ASTRI EPC & NFV 技術
18：00 ~ 18：30	Discussion

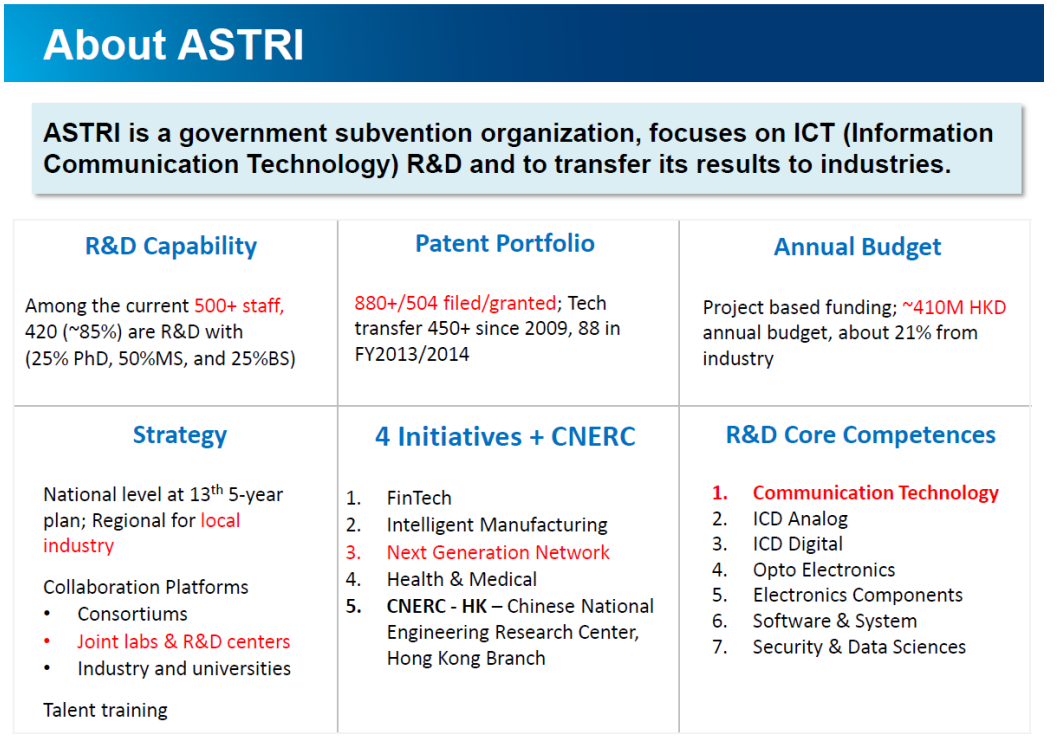
- **ASTRI 人員**

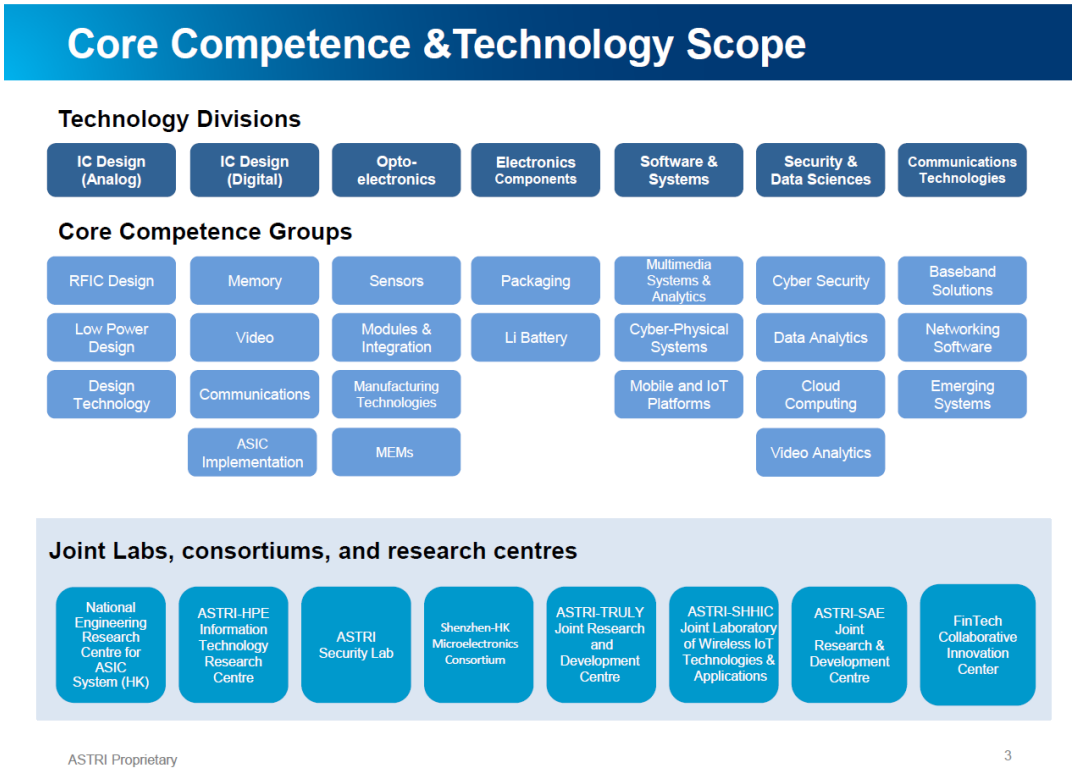
	姓　　名	職　　稱
1.	莊哲義	副總裁 （研發群組總監）
2.	歐嘉棟	研發總監 (通訊技術群組)
3.	劉辛怡	總監 (通訊技術群組).
4.	招溢利	經理 (通訊技術群組)
5.	陳少平	高級經理 (通訊技術群組)
6.	郭慧民	主任工程師 (通訊技術群組)
7.	苗家豪	總監 (通訊技術群組)
8.	曾江洲	總監 (通訊技術群組)
9.	范世君	總監 (通訊技術群組)
10.	楊美基	首席科技總監 (CTO 辦公室)
11.	岑冠文	高級經理 (CTO 辦公室)

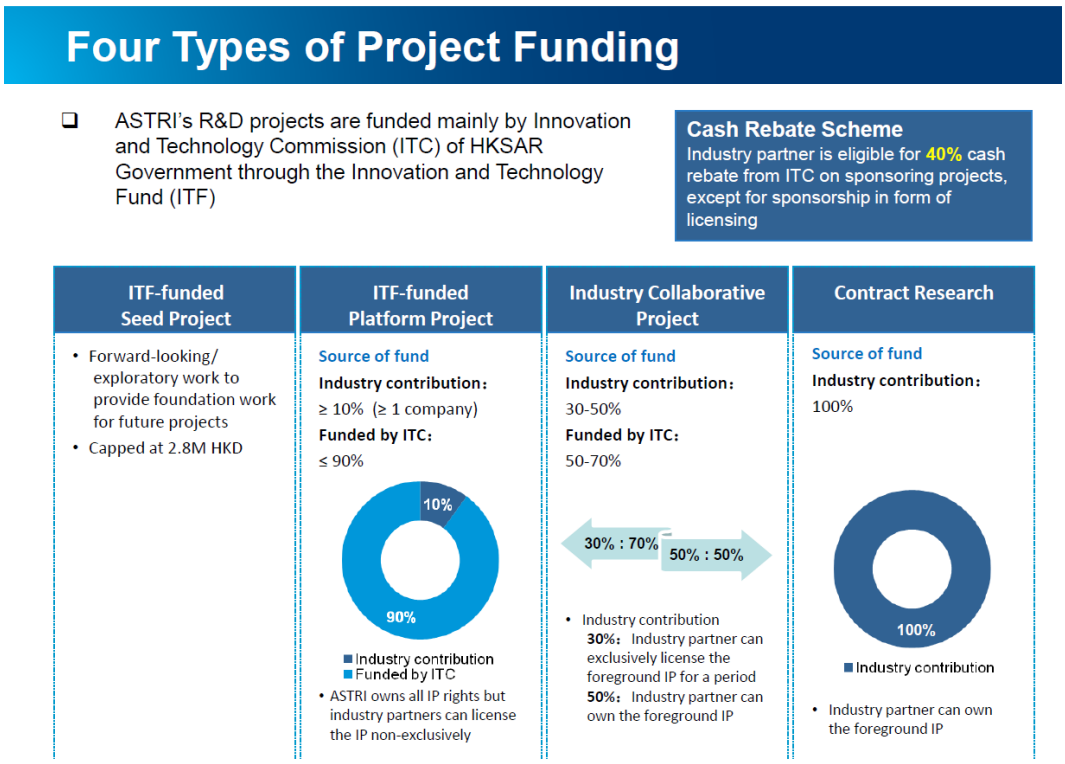
- **ASTRI 通訊技術及展示**

初到 ASTRI, 首先由莊哲義副總裁介紹 ASTRI 整體概況，及其再通訊或是 5G 目前發展概況。







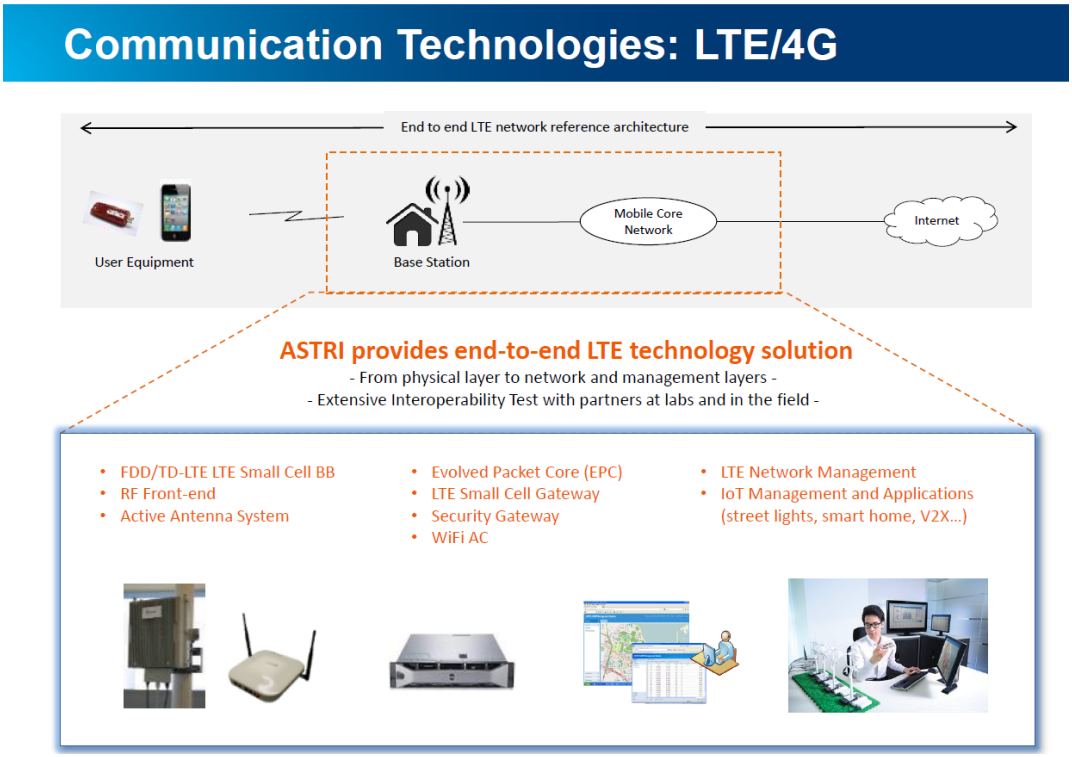


應科院以行政總裁為首，並由來自工商界、學術界及香港特區政府之代表組成的董事局所管治。董事局設有三個功能委員會，分別為財務及行政委員會、科技委員會及審計委員會，以協助董事局管理應科院各項事務。財務與行政委員會監督應科院財務及行政事宜，

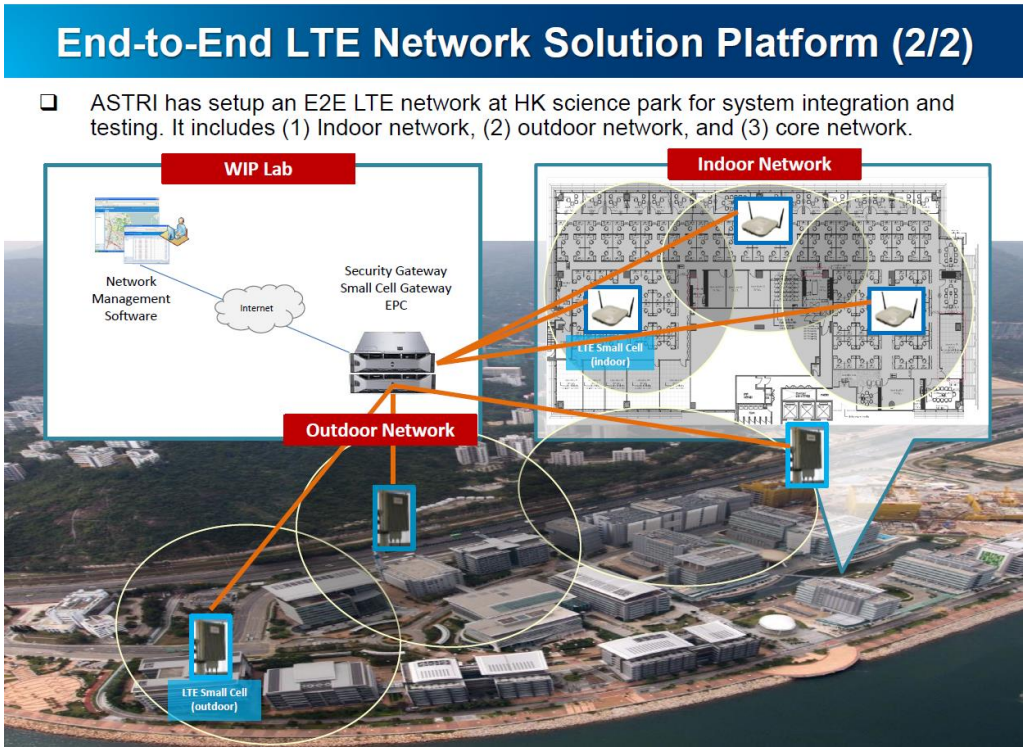
科技委員會監督應科院的研究項目，而審計委員會則確保內部及外部審計程序被適當地執行。

行政總裁對董事局承擔應科院整體管治的責任，並由總部行政人員協助處理行政、市場、財務、業務發展、技術管理和其他支援服務。應科院的研發核心能力分成七個技術部統籌發展。

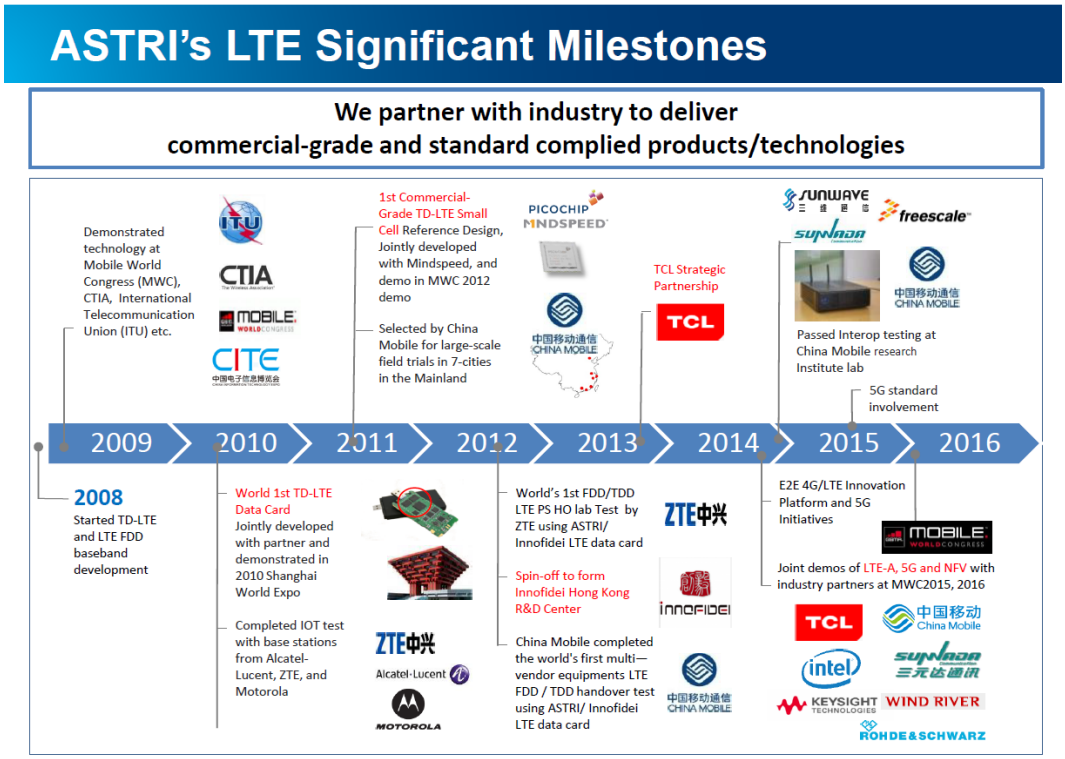
目前應科院約有 500 名員工，其中研發人員約 400 名。應科院開發資訊和通訊技術，提高各行業的技術能力和競爭力，從而支持香港發展成為可持續的和多元化的經濟體系和社會。研發項目是針對四方面的應用，即金融技術、智能製造、新一代通訊網絡，以及醫療健康。與我國比較不同的是要求業界配合款高達 40%，但不限制業界是否是香港的廠商。



目前 ASTRI 在通訊的研發是由 LTE 和物聯網 IoT 慢慢朝著 5G 邁進。研發重點包含 (1) LTE RF & Baseband (2) EPC & LTE Gateway 和 (3) LTE 網管及物聯網等。



ASTRI 在沙田維持一個相當 sizeable 實驗網，試煉自己所開發的技術。



ASTRI 的國際能見度算相當不錯的。其基頻技術供應給 NXP 當 reference design，EPC 移轉給 INTEL 提供內部使用，與 INTEL 合寫 small cell 的白皮書，與三元達共同發展發展 Nanocell & NFV 技術，並於 MWC 2016 公開展示。

ASTRI @ MWC2016 (1/2)

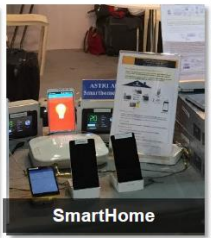
ASTRI Technologies showcased at MWC16

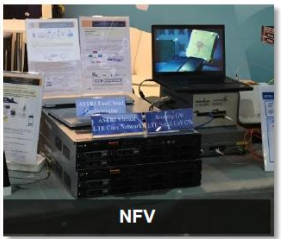
D2D


LTE/LTE-A Marco Cell


MTC

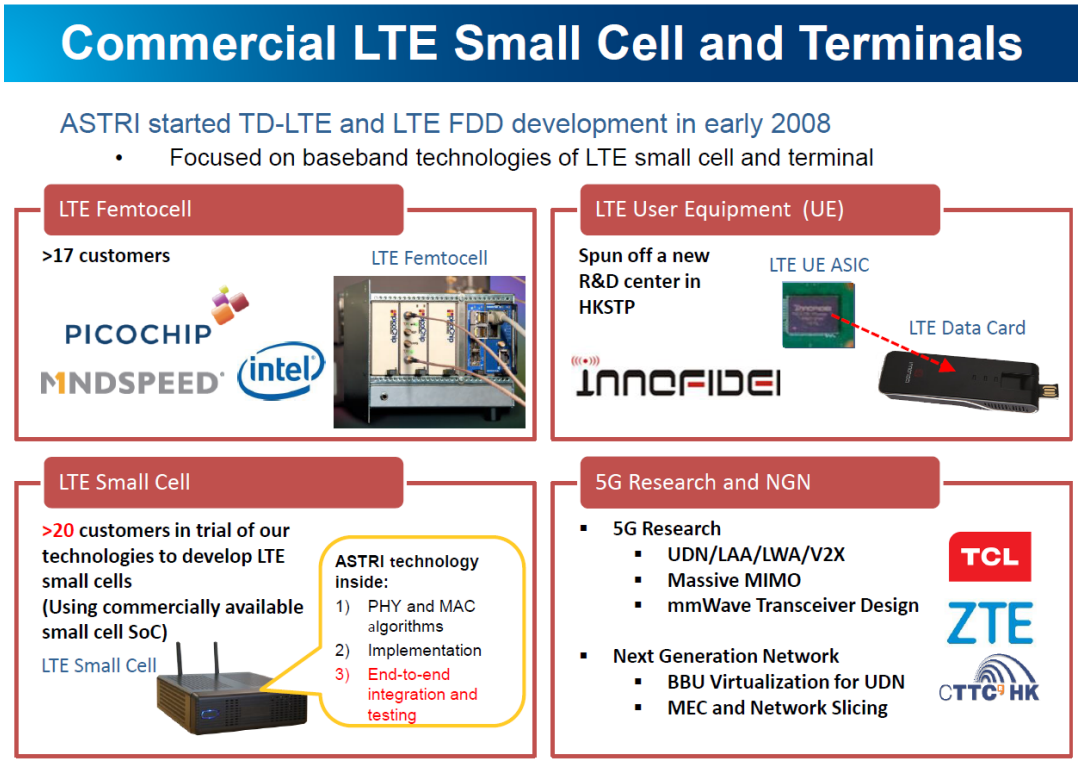

MIMO


SmartHome


NFV

- **ASTRI RAN 技術**

ASTRI 在通訊約有 80 餘人，但如果加上通訊 IC 設計就有超過 100 人以上的規模。ASTRI 的 RAN 的技術由開發基頻 Baseband 技術起始。ASTRI 並不開發 MAC 以上的 L2/L3 技術，但與國際知名的廠商合作。從早期 (2008)與 PICO CHIP 合作，在 PICO CHIP 的 SOC 發展 Baseband 技術，到先期 pioneer L1 API "Standard" FAPI。目前已有 20 家廠商移轉，並有一家的 spinoff 公司。

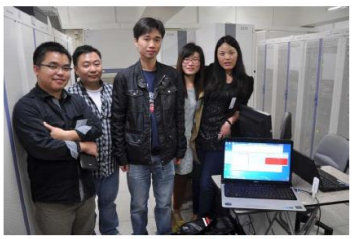


ASTRI 相當重視與 operator 的合作。

- In 2011, China Mobile organized the TD-LTE field trials in 7 cities
- ASTRI/ InnofideiUE was 1 of 3 UE SoCvendors that completedthe trial
- March 2014, ASTRI/Sunnada small cells pass ~90% China Mobile Research Institute conformance tests (2012 –2014)
- June 2014, passed China MobileResearch Institute small cell IOT testing.
- Dec 2015: Rank #1 candidate in CMCC small cell tender. Their OEM partner is also selected in the list of tender.

Operators and IOTs

- ASTRI closely work with operators and partners to perform IOT and trials



China Mobile Hong Kong
TDD/FDD handover testing 2012

China Mobile Research Institute
Small Cell IOT 2014

ASTRI Proprietary

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- ASTRI/ Innofidei UE was 1 of 3 UE SoC vendors that completed the trial

First 3 UE vendors

ASTRI INNOFIDEI QUALCOMM HISILICON

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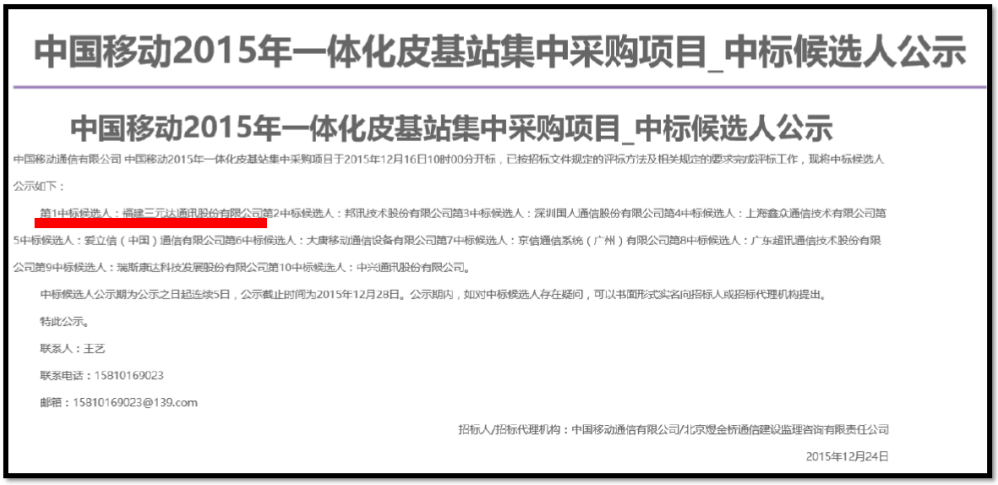


中国移动2015年一体化皮基站集中采购项目_中标候选人公示

中国移动2015年一体化皮基站集中采购项目_中标候选人公示

中国移动通信有限公司 中国移动2015年一体化皮基站集中采购项目于2015年12月16日10时00分开标，已按招标文件规定的评标方法及相关规定的要求完成评标工作，现将中标候选人公示如下：

第1中标候选人：福建三元达通讯股份有限公司第2中标候选人：邦讯技术股份有限公司第3中标候选人：深圳国人通信股份有限公司第4中标候选人：上海鑫众通信技术有限公司第5中标候选人：爱立信（中国）通信有限公司第6中标候选人：大唐移动通信设备有限公司第7中标候选人：京信通信系统（广州）有限公司第8中标候选人：广东超讯通信技术股份有限公司第9中标候选人：瑞斯康达科技发展股份有限公司第10中标候选人：中兴通讯股份有限公司。

中标候选人公示期为公示之日起连续5日，公示截止时间为2015年12月28日。公示期内，如对中标候选人存在疑问，可以书面形式实名向招标人或招标代理机构提出。

特此公示。

联系人：王艺

联系电话：15810169023

邮箱：15810169023@139.com

招标人/招标代理机构：中国移动通信有限公司/北京慢金标通信建设监理咨询有限责任公司

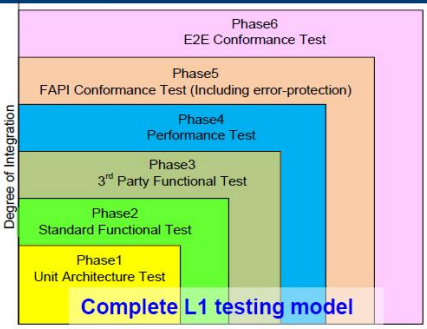
2015年12月24日

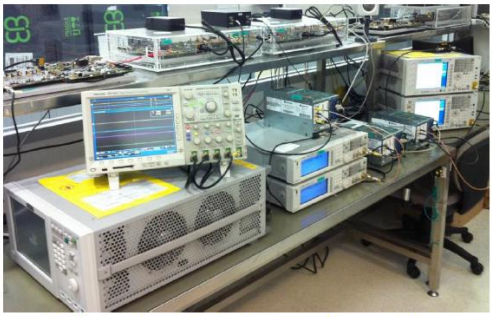
ASTRI 相當重視測試，除了在沙田有一個 end to end 的測試場地和測試頻譜 (2.6GHz)，ASTRI 也開發的 L1 完整的測試案例擁有 5 萬個 test casese.

ASTRI Test Infrastructure

- ASTRI enabled a complete test infrastructure for commercial grade L1 verification.
- We have implemented and verified >50K tests to cover all 3GPP L1 standard requirements.
- The maturity in L1 is important for our partners to commercialize the reference design.

- **Our developed test infrastructure can mature L1 software to commercial quality**

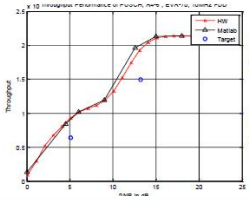




Fully automatic test regression system

Test Strategy Phase 1					
	Total	PC8608		PC8609	
		10MHz	5MHz	10MHz	5MHz
# Total Requirements	15400	3850	3850	3850	3850
# Supported Requirements	6160	1636	1396	1705	1423
# Tests	5617	1532	1238	1591	1256
# Design/Implicit	240	60	60	60	60
# Test results = PASS	5617	1532	1238	1591	1256
# Test Results = PWC	0	0	0	0	0
Tests Passing (PASS and PWC)	100.00%	100.00%	100.00%	100.00%	100.00%

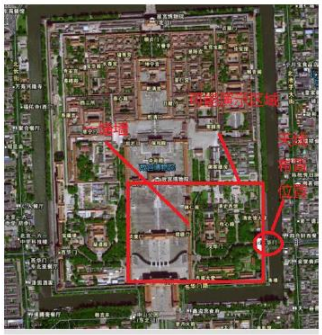
Fully verified results with all 3GPP standards



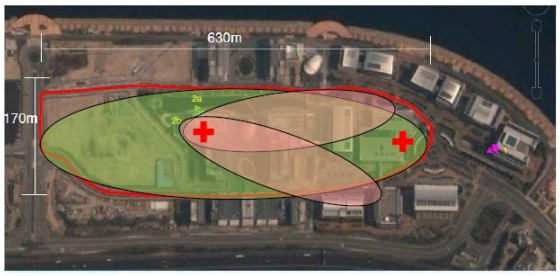
High performance with large margin

Perfect match with algorithm model

Field Trials and Deployment



400MHz public safety & video surveillance (Beijing)



2300MHz Hong Kong Science Park

ASTRI 的 5G 研發方向：在 Radio Access Network 方面包括

- **C-RAN**
- **UDN**
- **Massive MIMO**
- **Spectrum Sharing**
- **MTC**
- **D2D/V2X**

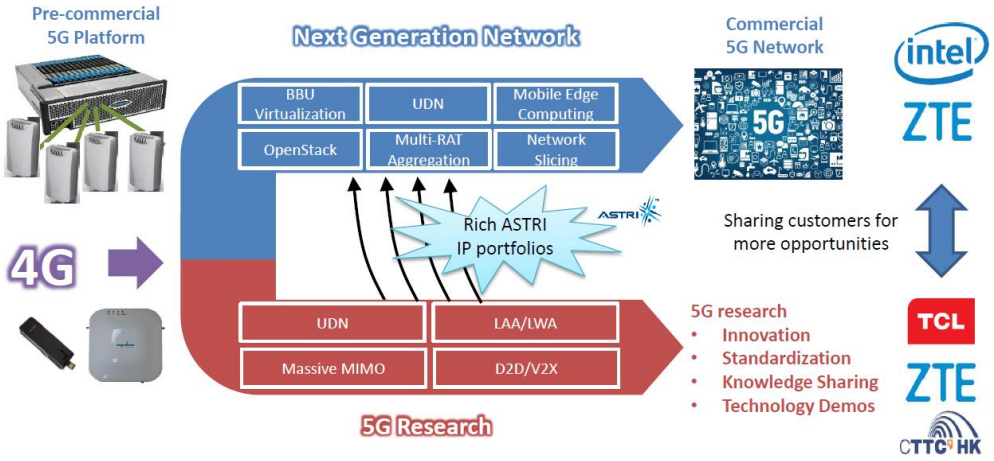
在 Network Architecture 方面包括

- **NFV**
- **Orchestrator**
- **SFC**
- **MEC**

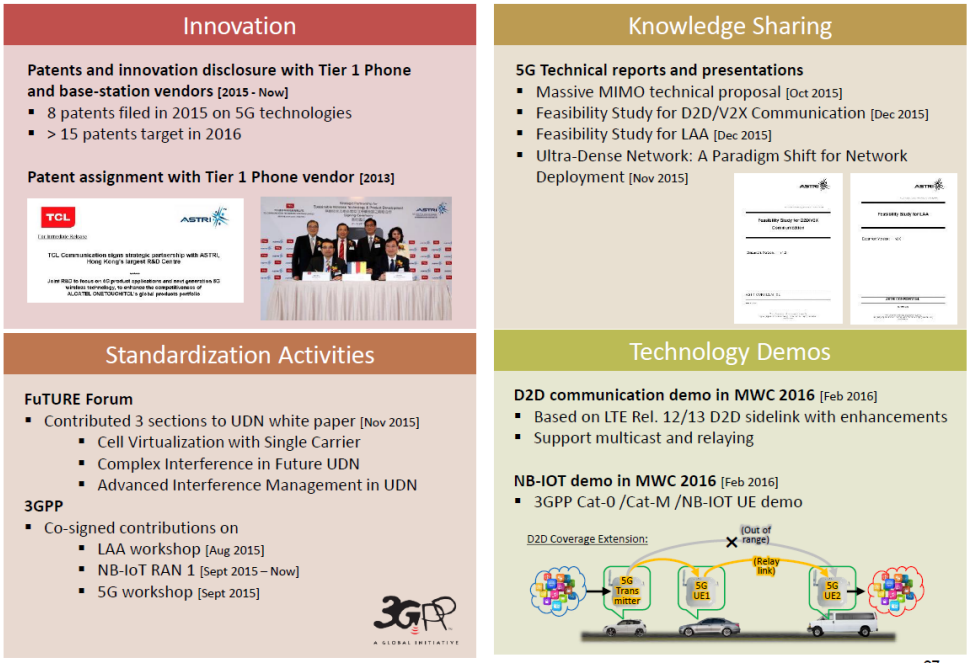
其中在 RAN 方面，ASTRI 期盼

- **ASTRI 5G R&D focuses on 5G research and Next Generation Network (NGN) development**
- **5G research impacts the standardization and NGNevolves over standardization**
- **ASTRI’ s pre-commercial platform enables the 5G evolution and attracts more customers**

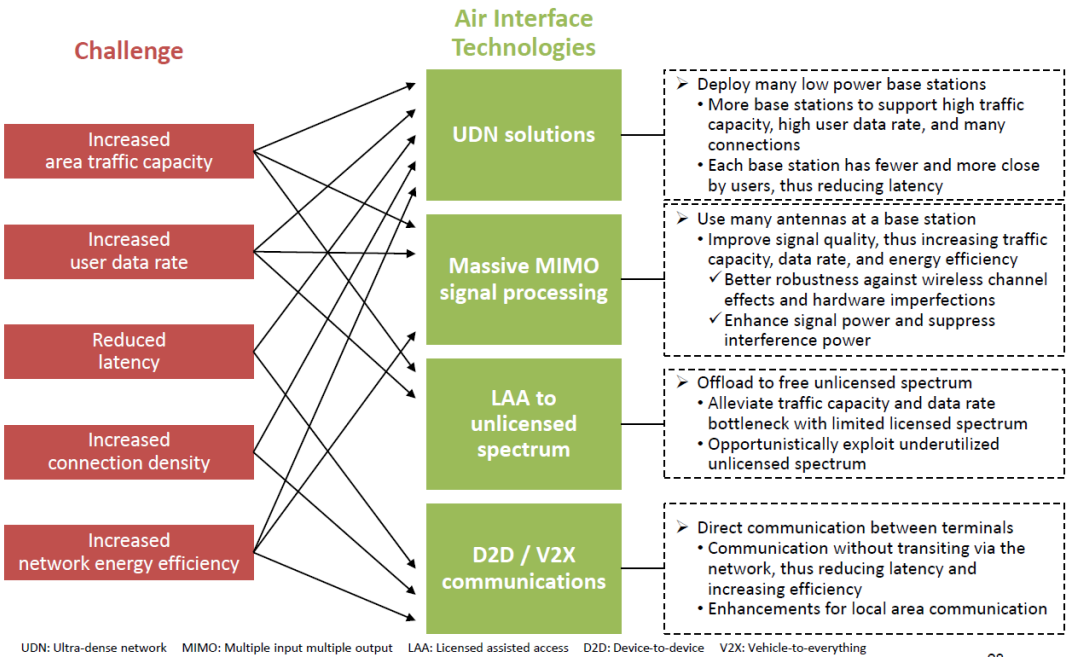
- **Interim outcomes (e.g. patents, demos and reference designs) enrich partners competences**



目前已展開的研發活動如下圖：其中參與 D2D & NB-IOT 的 trial 以及與 Future Forum 撰寫 UDN 白皮書，算是比較突出的部分。



ASTRI's 5G Research Focus 如下圖。從 ASTRI 的戰略來看，ASTRI 準備利用 Virtualized BBU (Baseband Unit)，當成 MEC (Mobile edge computing), UDN (ultra densed Network), Network Slicing 和 multi-RAT aggregation 的核心。



從 use case 1 到 use case 4, 即知 ASTRI 想要利用他們 vEPC 的虛擬化經驗，加上 Baseband 的能力，致力於 MEC, UDN 等產品。

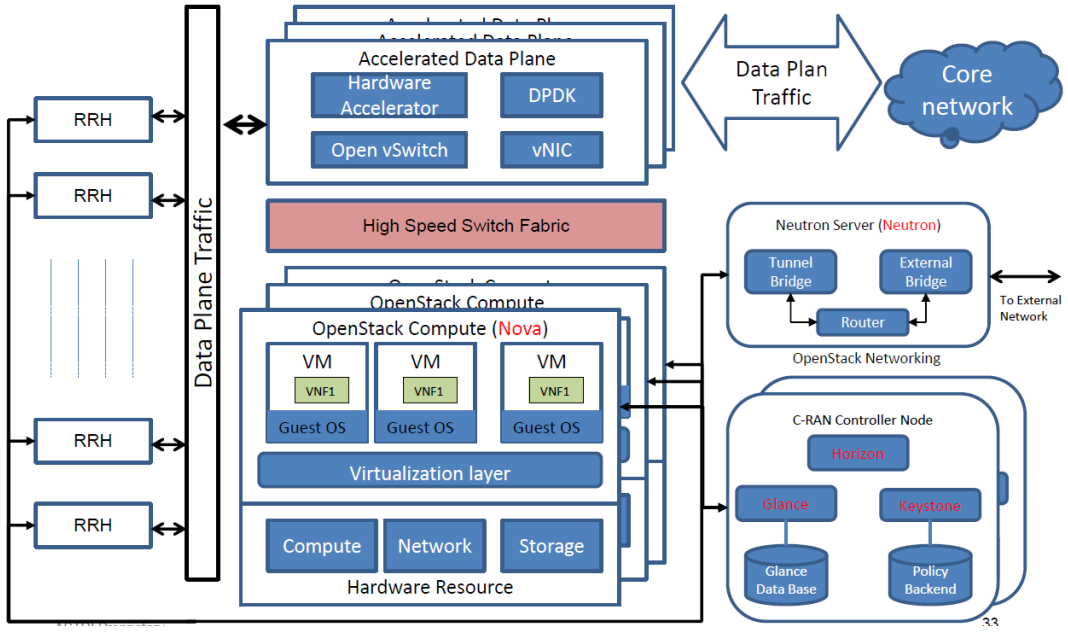
ASTRI's NGN BBU pool

ASTRI NGN solution is based on GPP.

Features.	ASTRI NGN BBU
Server platform	Intel x86 IA architecture on Artesyn MaxCore HA
OS/Virtualization	Windriver with Open-stack
Remote unit platform	RRH with FPGA
Application	Mini-CRAN (96 sectors)
Standard	3GPP Rel-10
Bandwidth	5, 10, 15, 20 MHz
Duplexing	TDD & FDD in same code base
# of users	256 users per sector 16 UEs/TTI
Cell Size	10 - 100 km
Mobility	160 km/h - 500 km/h
Throughput	DL: 300Mbps per sector UL: 150Mbps per sector
MAC scheduling	RR, PF, QoS
UE support	Category 1, 2, 3, 4, 5, 6
Synchronization	GPS, 1588v2
Advanced features	Aggregation: CA /LAA/ LWA Interference management: TM7/8 beamforming, DL/UL SU_MIMO, Joint transmission and Joint receive without antenna calibration Voice: VoLTE (SPS with DRX, ROHC) Platform: HA, VM life-migration UDN Mobility: Mobility Tracking, UE content sharing, Centralized SON

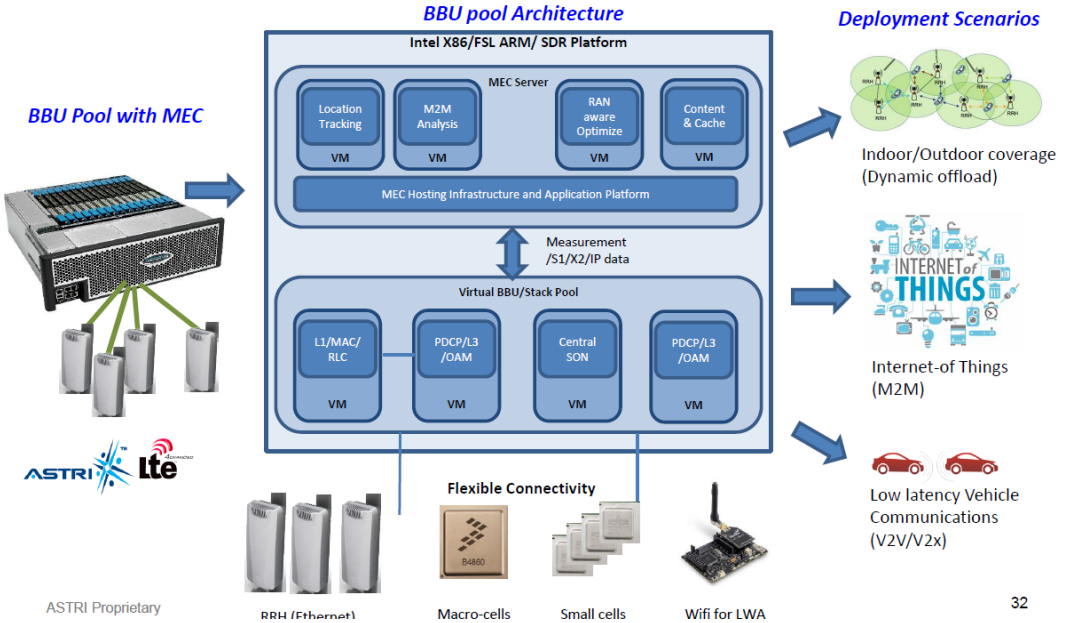
OpenStack Implementation on BBU pool

- ASTRI's BBU pool virtualization is based on OpenStack Architecture



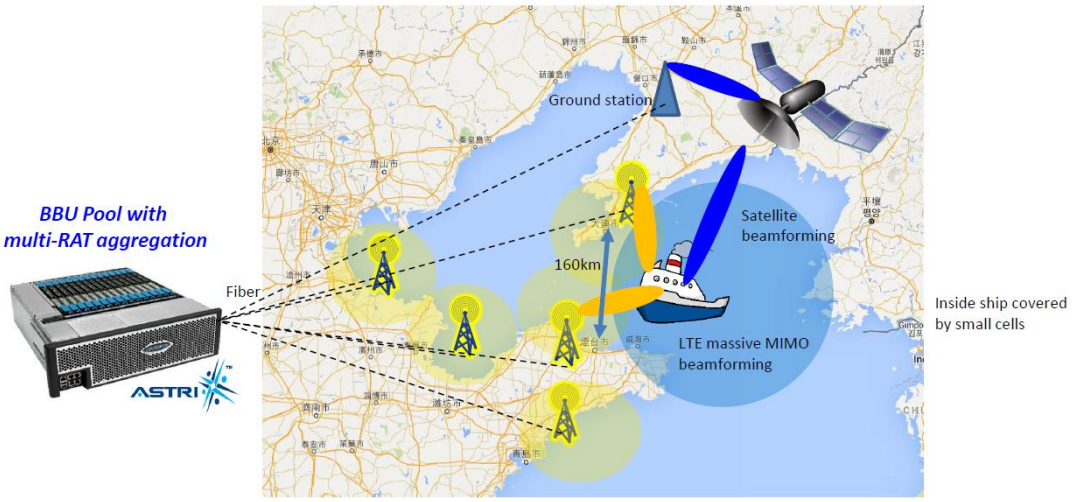
Use Case 1: BBU pool with MEC

- ASTRI's BBU pool supports Mobile Edge Computing (MEC)
  - Suitable for different deployment scenarios, e.g. indoor and outdoor, M2M and V2X
  - Support Multi-RAT e.g. WiFi/LTE/LAA/LWA/TVWS



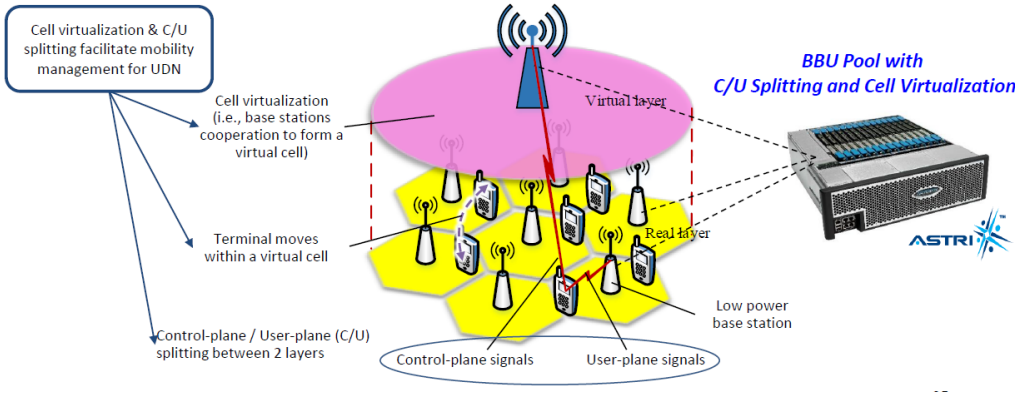
Use Case 2: Satellite-Ground Communications

- **ASTRI's BBU pool supports multi-RAT aggregation (e.g. Private network)**
  - Flexible deployment of multiple cells for coast coverages. (100km coverage)
  - Massive MIMO to enhance coverage. (100 antennas for x10 distance coverage)
  - Satellite-ground station integration on BBU pool (improve handover latency, mobile edge applications)



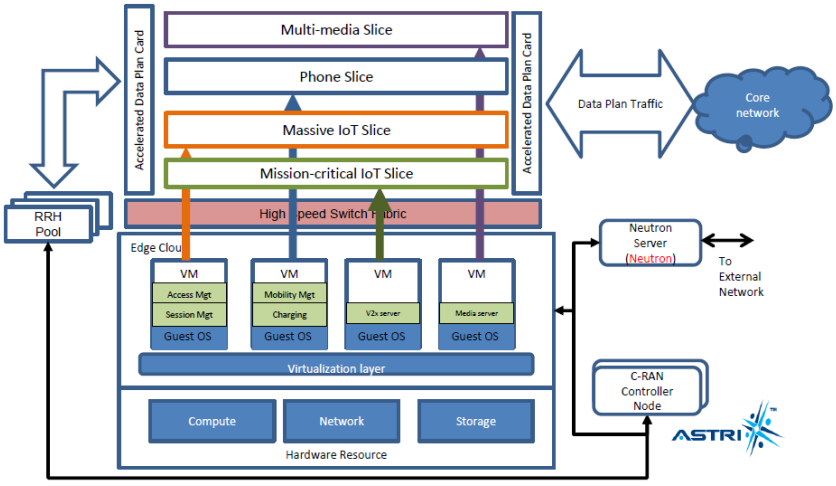
Use Case 3: 5G UDN

- **ASTRI's BBU pool supports ultra-dense network (UDN) in 5G**
  - Terminals move frequently across base station coverage areas impacting quality of experience
  - Co-channel base stations create mutual interference
- **ASTRI IPs and reference design**
  - Mobility management based on control/user plane **(C/U) splitting** and **cell virtualization**
    - ✓ Algorithms for reducing handover rate and signaling overhead
    - ✓ Algorithms for UE mobility tracking
  - Interference mitigation, i.e., reduced message exchange, cell on/off



Use case 4: Network Slicing

- **ASTRI's BBU pool supports Network Slicing in 5G**
  - Each network slice layer can utilized different **accelerated computation resources** to serve a variety of devices with different characteristics and needs, i.e. four network slices
    - Multi-media Slice – High capacity and video cache
    - Phone Slice – High mobility
    - Massive IoT Slice – Massive connection gateway
    - Mission critical IoT Slice – Low latency and high reliability



- **ASTRI EPC & NFV 技術**

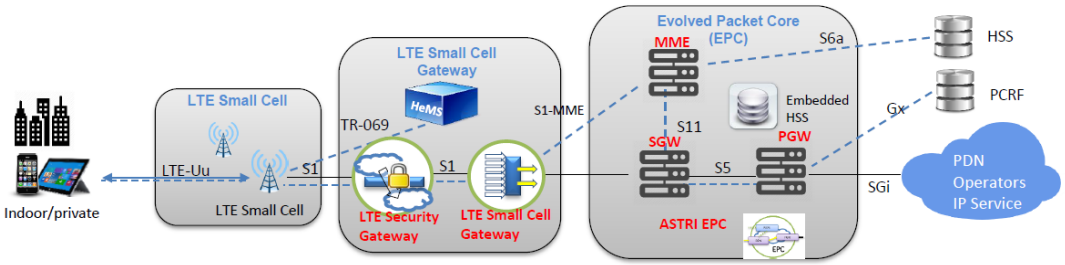
ASTRI 致力於 Networking Software 約有八年的時間。早年從網管出發，慢慢發展核心網路 EPC 的產品，而其 EPC 已有武漢地鐵等採用。而智利雲端技術和 DPI DPSK 技術的研發，目前也有 vEPC 的產品。

ASTRI Networking Software (NSOFT) Team Overview, 目前約有 20 餘人。

- Expertise & Core Competence
  - Wireless (LTE, WiFi) Networking Software (e.g. LTE core network) since 2008
  - IP Protocol Stacks
  - Network Management Systems
  - Internet-of-Things (IoT) Management
  - Network Virtualization (e.g. NFV…)
- ・Objectives & Strategy
  - Commercial grade software R&D & license to industry (e.g. telecom equipment vendors, solution vendors)
  - Complement to Wireless vendors (e.g. LTE smallcell) to complement their offerings
  - Engage closely with eco-systems (operators, forums) to market technologies

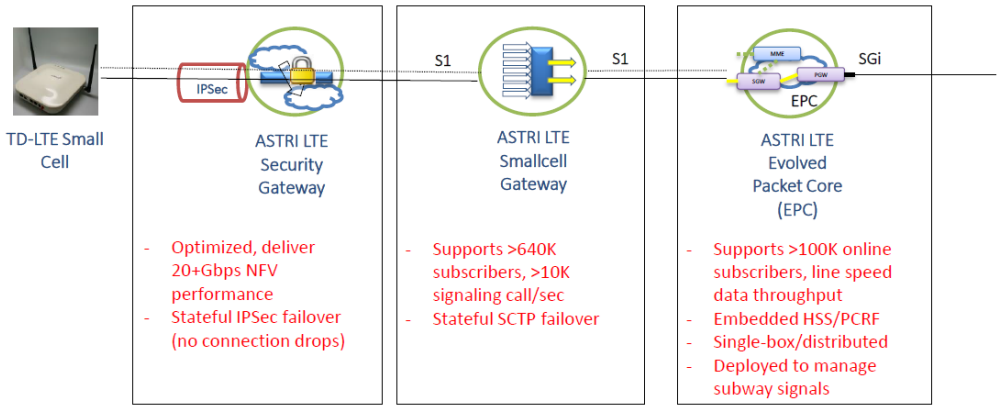
ASTRI's mobile core network software portfolio:

- Evolved Packet Core (EPC)
- LTE Security Gateway
- LTE Small Cell Gateway
- Network management system
- FastGate–ASTRI's multicore packet processing software (EPC, and gateways enabling module)



ASTRI has developed core software technologies in both signaling and data plane for LTE core network elements.
Target applications are:

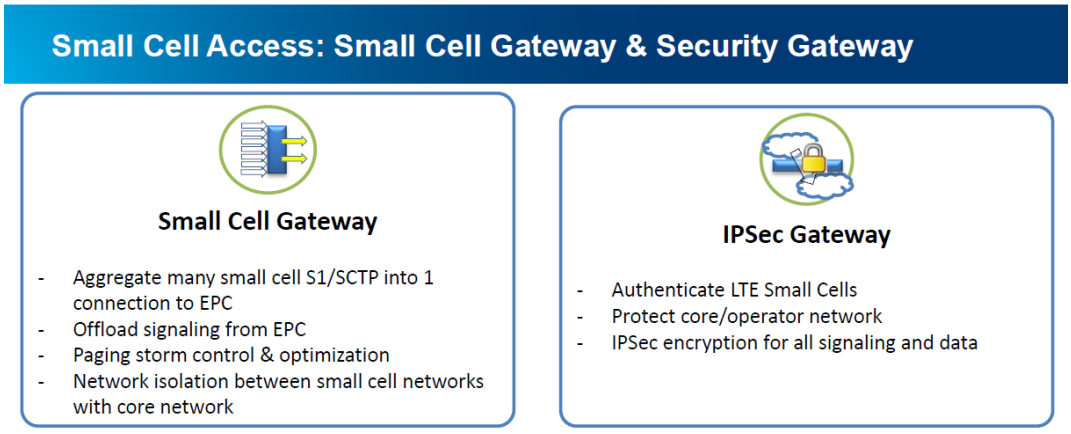
- public networks (e.g. Smallcell Gateway)
- private/enterprise/special purpose networks (e.g. EPC, Management System).



由上圖數字可知，ASTRI 的技術已趨近產品化，是值得學習的。而根據下面的 Spec，ASTRI 事實上已整合 Openstack 和 OPNFV 等功能。

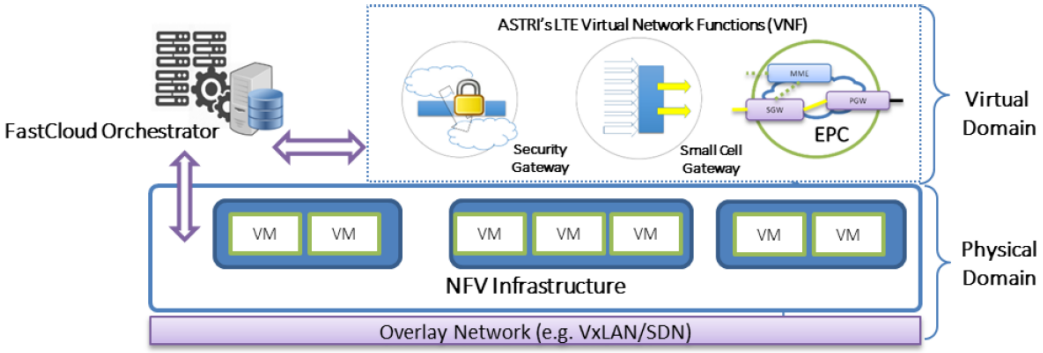
- 4G-LTE green-field data services, 3GPP standards compliant (R9/R10)
- Commercially available & deployed: in trials and live networks
- Flexible Deployment:
  - Embedded HSS: support SIM authentication
  - Embedded Policy control: for various QoSservices
  - Single Box EPC& Distributed: MME, SGW, PGW deployable in single box/distributed
- Virtualization: NFV support coming! supports WR Titanium Cloud, Intel ONP 1.3, OPNFV Arno..
- Extremely Cost Effective:
  - x86 hardware: supports 20K+ users, 10+Gbps (< USD$3K hardware)
  - ATCA hardware: also supports
- ASTRI Owned Technologies:
  - FastGate: High performance multi-core protocol stacks (protocols

- HA Framework: No interruptions of sessions & services during failover
- Software architecture & 3GPP procedures



- Small Cell Gateways aims to simplify, and reduce complexity and loading to LTE EPC in operators network.
- Performance: support >640K online subscribers (NFV based), 20Gbps+ IPSec Throughput
- High Availability: SCTP and IPSec session are statefully maintained (i.e. no need to re-establish) during failover, this is **critical** for LTE mobile networks (otherwise, subscribers call will drop)

根據 ASTRI 在 EPC & Small Gateway 的基礎，ASTRI 近年更發展 NFV 方面的技術。



ASTRI NFV LTE Core Network consists of:
- LTE Virtual Network Functions – EPC, Security Gateway, Small Cell Gateway
- FastCloud Orchestrator – Agile deployment and management of VNFs and network configurations
- Interface with and support commercial and community NFV infrastructure

而 ASTRI 認為 NFV Market Trends (for LTE -> 5G)有

- Agility: NFV/SDN is part of 5G for creating a highly flexible network, utilizing general purpose hardware, increase resource utilization and reusability. Network configurations is service/application driven and programmatically configured via Orchestration.
- NFV target future evolution: Existing LTE infrastructure providing traditional mobile service (voice & data) already in place. NFV can reduce the deployment cost, but unlikely replaces existing infrastructure.
- Network Slicing: NFV has high value in new services (e.g. IoT, 5G, LTE for enterprise) with different network requirements. Different customized virtual networks will exist simultaneously and without interfering with each other.
- Open Platform: establishes extensible and modular system architecture for virtualization, e.g. OpenStack, OpenDayLight, ONOS. Open source communities evolves in an extremely rapid manner. No more “lock-in”, “closed systems” in future.
- Virtual EPC Applications:
  - Network Slicing: creating isolated
  - Service Differentiation(using Service Function Chaining –SFC to steer user traffic)
  - C/U (Control/User) plane distribution(distributed U-Plane to distribute traffic loading), e.g. virtualized data plane located in central office
  - Latency/bandwidth differentiation: using SFC & SDN, optimized network path (even for different services of the same user) can be realized: e.g.
  - Video traffic can be offloaded at the network edge (to CDN)
  - Low latency traffic may utilizes the shortest path

其 Key R&D Areas:

- Performance (achieved): 20Gbps IPSec, 40Gbps EPC throughput
- High Availability (achieved): software based, with SCTP/IPSecstatefulfailover, no impacts to users and services (achieved)
- Orchestration: initial version of simple orchestration of FastCloudorchestrator, future to enhance automation, and support more deployment scenarios.
- In-house a virtualized network: as test bed for day-to-day NFV operations, and verifying various system/network topologies. Including integration

而 ASTRI NFV 的 roadmap 將由目前的 vEPC (NFV) 出發，沿著 service chaining 朝向 MEC 邁進。

- NFV: create virtualized LTE mobile core, with deployment agility
- SFC (Service Function Chaining): enable service awareness in virtualized LTE mobile core, and optimize infrastructure utilization
- MEC (Mobile Edge Computing): enabling low latency communications/applications, location awareness, faster analytics (e.g. IoT). Application enablement.

ASTRI MEC 的戰略是 ITenabled CT

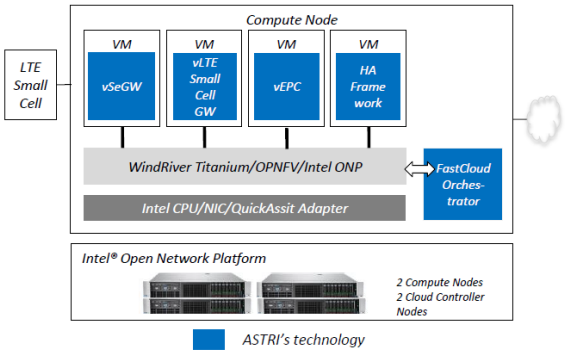
- Vision: Develop/Integrate MEC micro-cloud (in addition to MEC server), to enable service aware and application enabling mobile systems.
- Objectives:
  - CT Building Block: i) networking SW from EPC/Small Cell Gateway/IPSecfrom ASTRI, ii) open source frameworks (e.g. OVS, OpenStack) as building blocks
  - IT Building blocks: offering computing resources.
  - Services: to facilitate MEC, e.g. RAN info, location,

目前 ASTRI 在 NFV 已跟 Intel 體系有很深的合作，包括參加 Intel Network Builder program，移轉 EPC 給 Intel 做內部使用，跟 wind River 體系有很深的合作，致力於 EPC/vEPC 的優化。

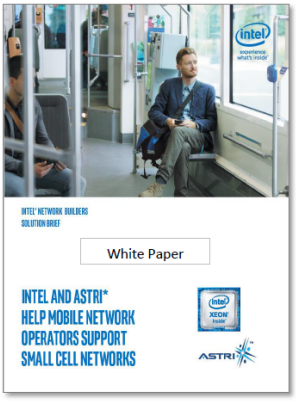
ASTRI Network Function Virtualization Solution

ASTRI Key Technologies:

- Virtual Network Functions (VNFs) on Open NFV Platform: **vEPC, vSecurityGateway, and vLTESmallCellGateway**
- **FastCloud Orchestrator**, enabling network configuration in a few clicks
- High Availability (HA) for carrier-grade solution
- Partner of Industry ecosystems (Intel, WindRiver, OPNFV)

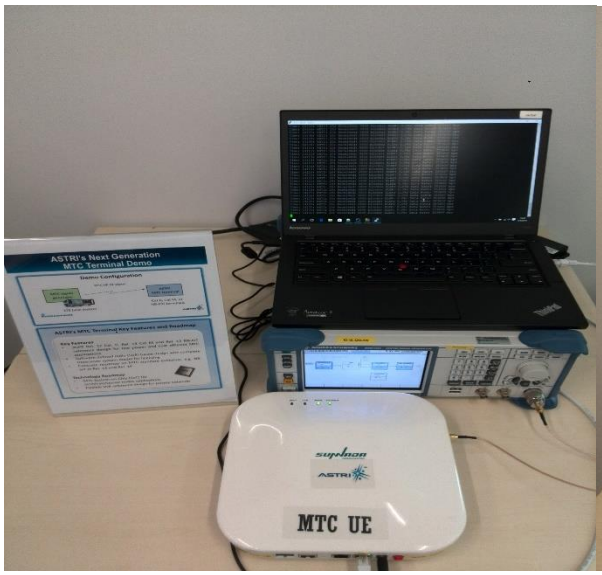


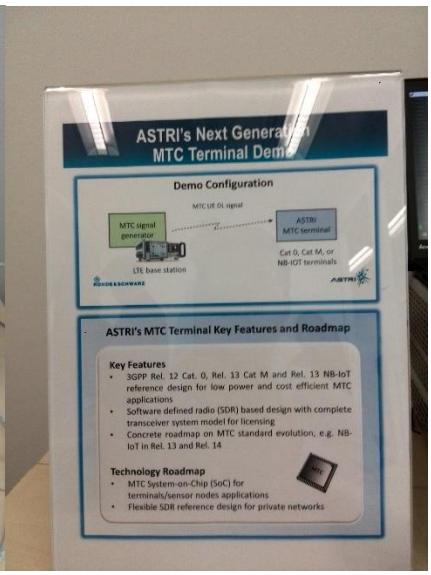
Intel® Network Builders PARTNER



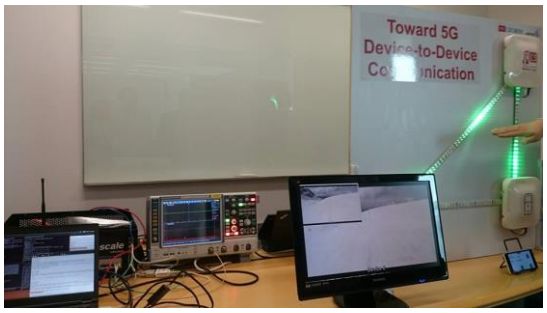
- 活動照片

圖一、與資策會同仁參觀應科院成果展示





圖二.MTC 終端成果



圖三、 eNB 的 D2D 連線展示

圖四、vEPC 於 IoT 應用展示

叁、參訪團員名單

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3.李永台	資策會智通所無線中心　副主任
4.陳仕易	資策會智通所無線中心　主任
5.陳香君	資策會智通所　工程師
6.王資雅	資策會智通所　工程師

肆、參訪心得

此次因資策會的邀請，參加香港應科院(ASTRI) 5G 通訊國際合作參訪，發現 ASTRI 目前 LTE L1 和 EPC/vEPC 已嶄露頭角,已建立國際的 Visibility。其研發特色是

- 與國際大廠介接綿密，包括 Intel, NXP 等都有深厚的合作關係
- 與業界合作密切，其預算必須有 40%來自業界
- 與 operator 關係密切,包括致力於 Nano Cell 的發展,參加國際的 Trial 等等

而 ASTRI 的研發策略是

- 以 signal processing 和 DPI/EPC 為主
- L2/L3, SoC 或 NFVI 平台由 partner 提供
- 未來將致力於 Cloud Base MEC(含 BB pool) 以及 Service chaining 和 MEC 發展

這種與國際 Eco-system 串聯的研發策略是值得我們參考的

伍、建議事項

無