Challenges for LTE and 5G

Panel Discussion

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Participants

- **Moderator:**
  - Sergei Semenov, Huawei/HiSilicon, Sweden

- **Panelists:**
  - Josef Noll, Basic Internet Foundation #Basic4All | University of Oslo (UiO) / ITS, Norway
  - Bernhard Tellenbach, Zurich University of Applied Sciences, Switzerland
  - Gerson Damanik, Satya Wacana Christian University, Indonesia

Problems of 4G

- **Technology considerations:**
  - Data traffic increases.
  - Requirements for speed, latency and capacity are increasing.
  - High volume of control information per user.
- **Business considerations:**
  - While data traffic increases, operators are facing stagnating revenues => CAPEX constraints => infrastructure manufacturers' revenue decreases.
  - Operators are looking for growth areas and ways to reduce cost.

Possible drivers for 5G

- **8K UHDTV: ~ 500 Mbps (7680 x 4320 x 30 fps)**

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- Most probably 5G rollout will be a gradual process (evolution) driven by the potential of use cases, rather than a massive spending.
- Fixed Wireless Access (FWA) is a priority case for operators followed by eMBB and IoT.

Main Enablers

- **mmWave spectrum**
- **Beamforming**

- **Opportunities:**
  - FWA:
    - should be able to provide equivalent capacity to fixed BB.
  - eMBB:
    - Dedicated networks to high value customers;
    - TV, Media
  - IoT:
    - VR/AR;
    - Self-driving cars

Challenges

- **mmWave**
  - Short range of mmWave,
  - Sensitivity to blockages,
  - Variable propagation laws:
    - Weaker diffractions due to the small wavelength => very big difference in pathloss between LOS and NLOS
  - High phase noise.
- **Beamforming**
  - High complexity
  - Pilot contamination

Challenges

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    - Satellite communications

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- **Growth of number of users and data traffic increase leads to greater importance of security aspects.**
- **Mobile operators cover less than 1% of IoT business and the projection to 2020 is 3% - 6%.**
  - But should the world of IoT belongs to mobile operators?

Panel Topics

- **Josef Noll,** Basic Internet Foundation #Basic4All | University of Oslo (UiO) / ITS, Norway
  - **5G and Sustainability?**
- **Bernhard Tellenbach,** Zurich University of Applied Sciences, Switzerland
  - **Cybersecurity aspects of 5G**
- **Gerson Damanik,** Satya Wacana Christian University, Indonesia
  - **Satellite Deployment model in Indonesia**
- **Sergei Semenov,** Huawei/HiSilicon, Sweden
  - **Phase Noise Compensation**

Phase Noise Compensation

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Phase Noise model.

- **Ideal oscillator model:**

$$\alpha_{osc}(t) = e^{j2\pi f_c t}$$

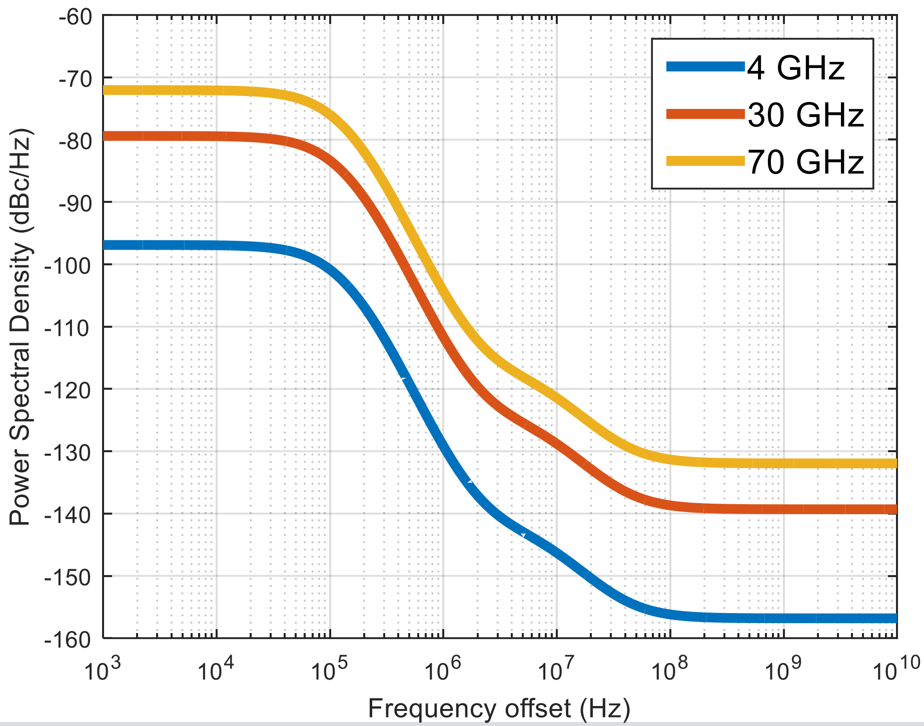
- **Noisy oscillator model:**

$$\alpha_{osc}(t) = e^{j2\pi f_c t} e^{j\phi(t)}$$

  - f_c is the carrier frequency
  - $\phi(t)$ is the phase noise
- **Phase noise (PN) reflects time-varying phase behavior of the oscillator.**
- **Simplest PN model is a free-running oscillator.**
  - PN is a Wiener process.
- **Phase locked loop (PLL) is more realistic PN model.**
  - Includes few different components, e.g. flicker noise and Wiener process.

Phase noise PSD.

- **PN is defined by its power spectral density (PSD).**
  - The oscillator PSD level increases by 20dBc/Hz per decade of increase of the carrier frequency.



PN impact on OFDM system

- **OFDM signal in time domain after IFFT:**

$$x_n = \frac{1}{\sqrt{N}} \sum_{k=0}^{N-1} X_k e^{j2\pi kn/N}, \quad n \in \{0, \ldots N-1\}.$$

  - X_k is a QAM transmitted symbol,
  - N is a DFT length
- **Signal vector of length N is appended by CP and transmitted over the channel.**
- **Received signal after CP removal:**

$$\mathbf{y} = \mathrm{diag}\left(e^{j\boldsymbol{\Phi}}\right)(\mathbf{x} \otimes \mathbf{h}) + \mathbf{w}$$

  - **h** is vector of channel coefficients,
  - **w** is noise vector
  - $\boldsymbol{\phi}$ is current PN realization $\boldsymbol{\phi} = [\boldsymbol{\phi_0}, \boldsymbol{\phi_1}, \ldots, \boldsymbol{\phi_{N-1}}]$
  - $\otimes$ denotes circular convolution

PN impact on OFDM system (2)

- **Received signal in frequency domain after DFT:**

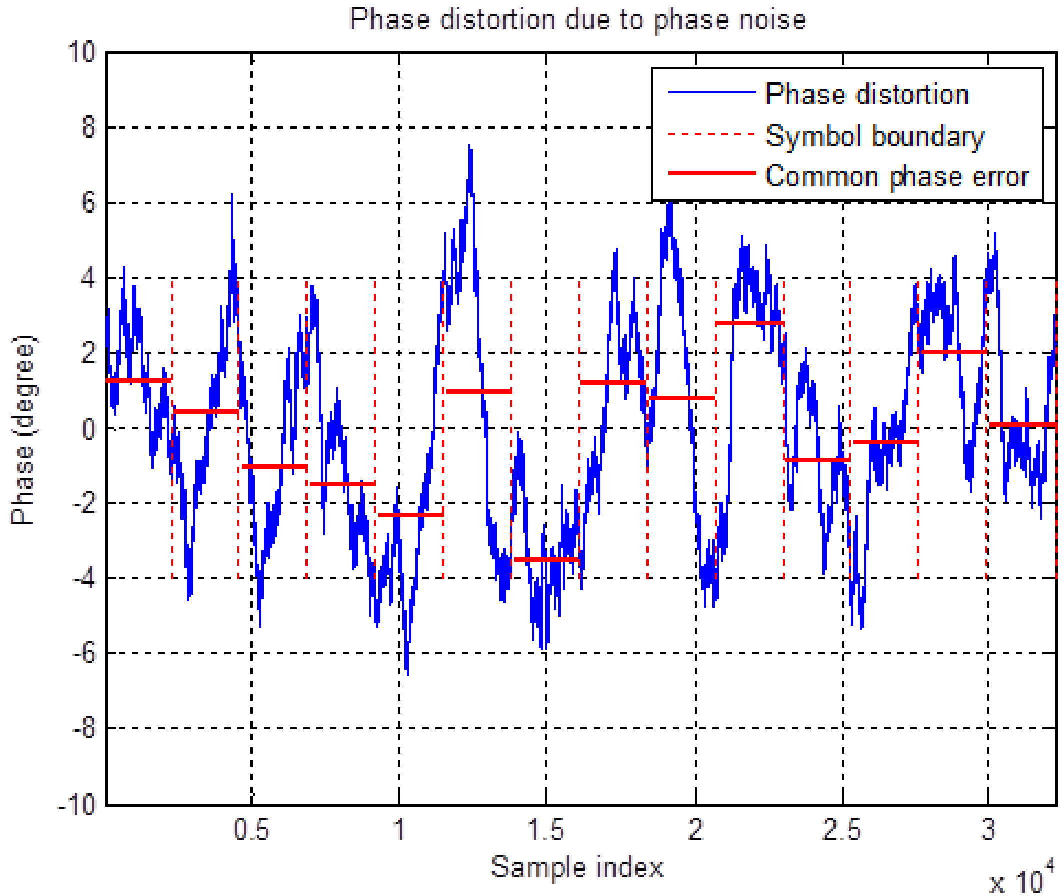
$$Y_k = X_k H_k J_0 + \boxed{\sum_{\substack{n=0,\\ n\neq k}}^{N-1} X_n H_n J_{k-n}} + W_k$$

  - J_i is the PN component in frequency domain

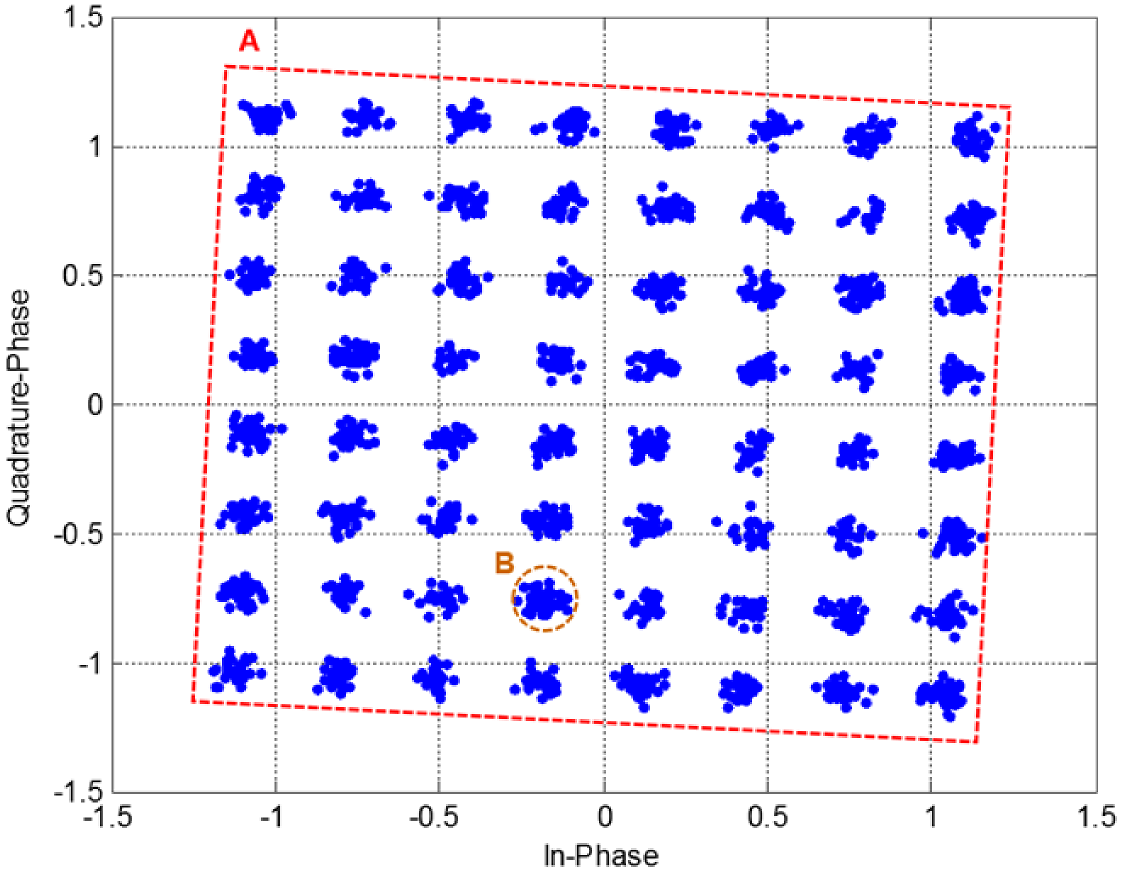
$$J_i = \frac{1}{N}\sum_{n=0}^{N-1} e^{j\phi_n}\, e^{-j2\pi ni/N}$$

- **PN can be split in 2 parts:**
  - Common Phase Error (CPE);
  - ICI

PN example in time domain



Constellation of a received symbols corrupted by phase noise

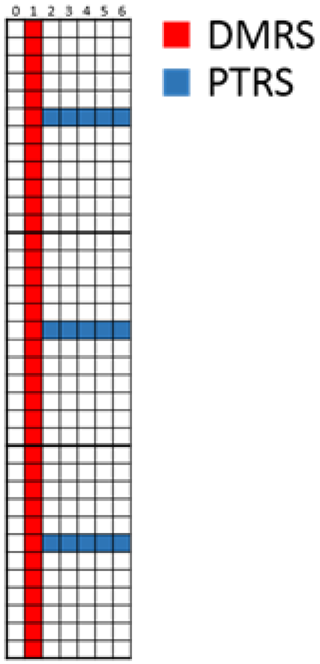


CPE compensation

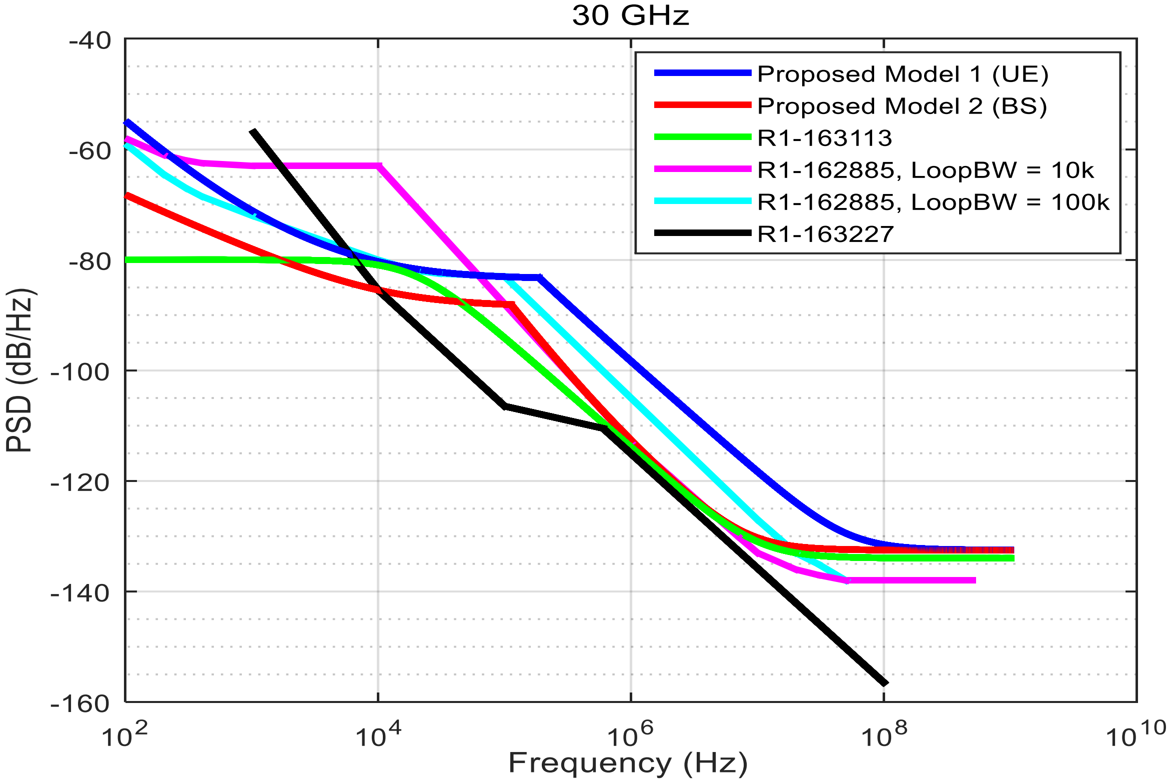
- **Currently CPE only estimation/compensation is the main direction in 3GPP.**
- **Phase Tracking Reference Symbols (PTRS).**
- **Simplest method. LS estimation:**
  - Get raw channel estimates with the help of PTRS.
  - Get LS estimate of J_0

$$\hat{J}_0 = \frac{\sum_{k \in S_P} Y_k X_k^* H_k^*}{\sum_{k \in S_P} |X_k H_k|^2}$$

  - S_P is the set of PTRS in current OFDM symbol



Different PN models



- **CPE compensation only may be sufficient or not depending on PN model.**

PN ICI compensation.

- **Complexity of PN ICI estimation is prohibitively high.**
- **Solution:**
  - Approximate PN with small amount of PN spectral components.

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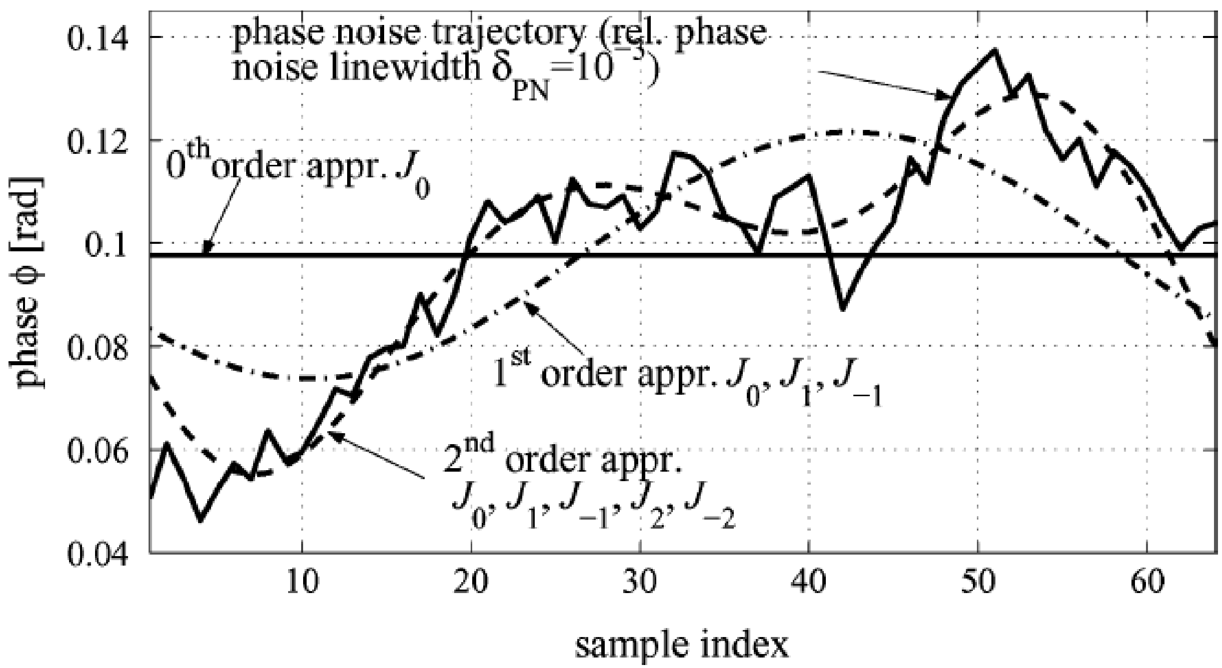

MMSE estimation

$$\begin{bmatrix} Y_{l_1} \\ Y_{l_2} \\ \vdots \\ Y_{l_P} \end{bmatrix} = \begin{bmatrix} A_{l_1} & \dots & A_{l_1+2u} \\ A_{l_2} & \dots & A_{l_2+2u} \\ \vdots & \vdots & \vdots \\ A_{l_P} & \dots & A_{l_P+2u} \end{bmatrix} \begin{bmatrix} J_0 \\ J_1 \\ J_{-1} \\ \vdots \\ J_u \\ J_{-u} \end{bmatrix} + \begin{bmatrix} \Omega_{l_1} \\ \Omega_{l_2} \\ \vdots \\ \Omega_{l_P} \end{bmatrix} + \begin{bmatrix} \mathrm{W}_{l_1} \\ \mathrm{W}_{l_2} \\ \vdots \\ \mathrm{W}_{l_P} \end{bmatrix}$$

$$A_k = X_k H_k$$

$$\mathbf{Y} = \mathbf{A}\mathbf{J}_u + \boldsymbol{\varepsilon}$$

$$\hat{\mathbf{J}}_u = \mathbf{M}\mathbf{Y}$$

$$\mathrm{M} = \mathrm{R}_{J_u J_u} \mathbf{A}^H (\mathbf{A}\mathrm{R}_{J_u J_u} \mathbf{A}^H + \mathrm{R}_{\varepsilon\varepsilon})^{-1}$$

- **High complexity but could be affordable**

Thank you

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Panel on AICT/ICIMP/ MOBILITY

Challenges for Long-Term Evolution and 5G for IoT Systems

-- Security --

Dr. Bernhard Tellenbach,
Zurich University of Applied Sciences, Switzerland

About Me


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aw
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CYBER SECURITY
CHALLENGE
Evil prevails when good humans do nothing!
CYBER ATTACKS AND DEFENSE
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Our Current Approach to Security

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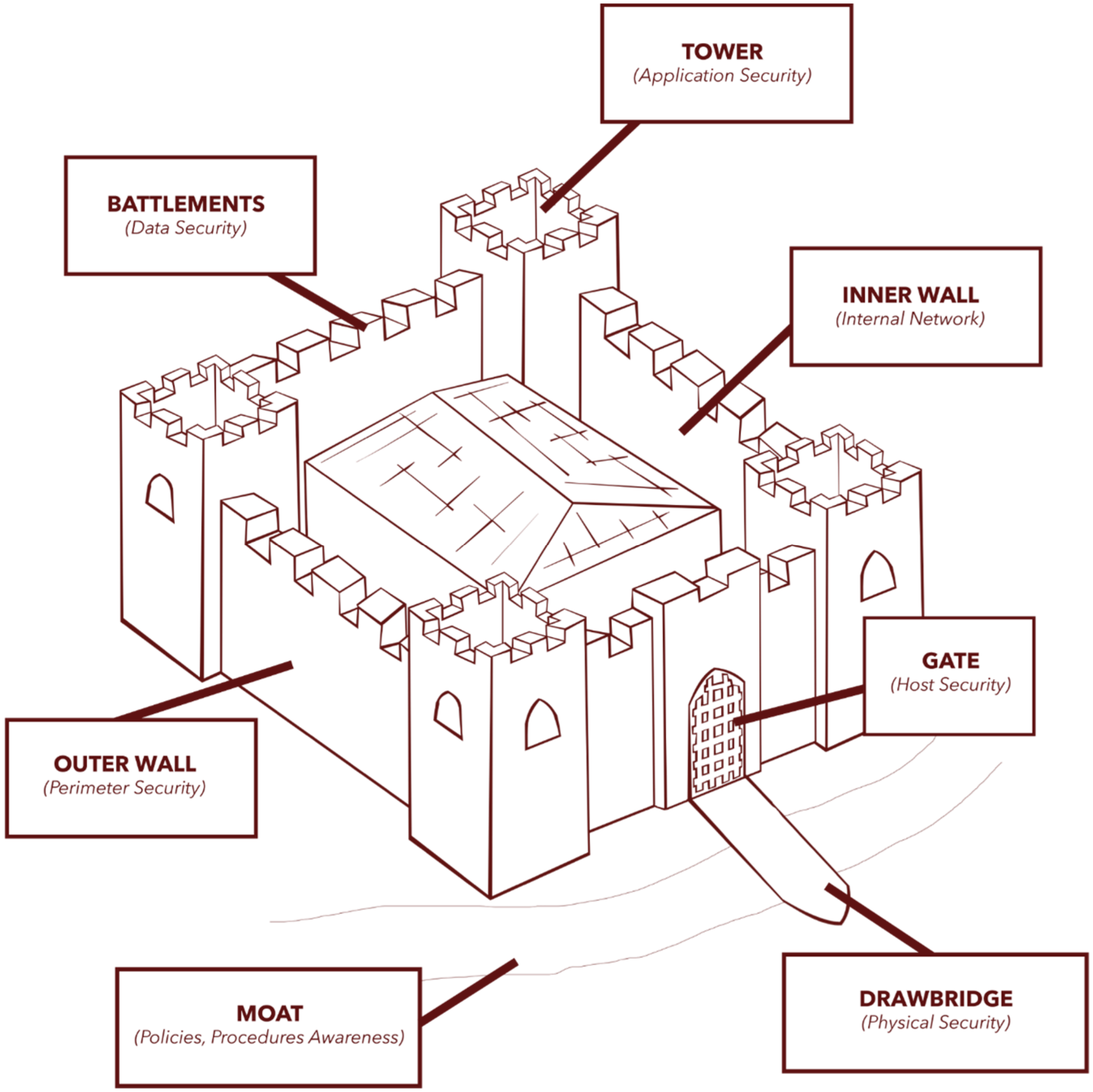
zh aw School of Engineering



Does this approach work?

Zürcher Hochschule
für Angewandte Wissenschaften
zh aw School of Engineering

OCT 26, 2009 - 18:08

The computer network of the Swiss foreign ministry has been the target of a "very professional" attac[k] … officials said on Monday evening.

Security today: Assume you've been hacked!

«We're in the dark ages of cyber security.»
[Amit Yoran, RSA president]

RSA SECURITY

DEUTSCHER BUNDESTAG

LOCKHEED MARTIN

SONY

Mis[sed A]larms and 40 Million Stolen Credit Car[d] Numbers: How Target Blew It

By Michael Riley, Ben Elgin, Dune Lawrence, and Carol Matlack | March 13, 2014

Thesis / Question (1)

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School of Engineering

- In order to stop the onslaught of continued DDOS, Ransomware and other forms of threats and attacks we must build security into next generation infrastructures and devices.
- Secure by Design must be part of our strategy moving forward
- How do we achieve this? How can it be implemented and how expensive and difficult would this be?
  - Does improve the training of our future engineers help?
  - Doe we need to extend international product liability to IT security flaws and problems caused by the products?
  - Do we have to have something like a “drivers license” for people buying and using these devices and infrastructures?

Thesis / Question (2)

- The Cybersecurity threat is dynamic; it is a constantly evolving arms race of threat and remediation where the advantage lies with the attacker.
- Can we change this or are we playing a game that we already lost? How do we have to build 5G and IoT infrastructures to avoid this?
  - Currently, vulnerable standards have a long live… (e.g., SS7)

AICT/ICIMP/ MOBILITY Panel,
Challenges for Long-Term Evolution and 5G for IoT Systems
Mestre (IT), 26 June 2017

5G and Sustainability?

Josef Noll
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Internet is a basic human right

- Is Internet access and online freedom of expression a basic human right?
- “All people should be allowed to connect to and express themselves freely on the Internet.“

- The United Nations’ Human Rights Council unanimously backed that notion in a resolution on 5July2012. All 47 members of the Human Rights Council including China and Cuba signed the resolution.

Connectivity & Affordability

- Mobile supported development
- Affordability (costs of data)
- industrial perspective (Ind4.0)

The Unconnected Market Landscape

Unique Mobile Internet Users

Population 15+ (bn)	Total	BMI	NMI	Unconnected	
Developed World	0.9	0.6	0.1	0.3	
Developing World	4.3	1.0	0.8	2.5	3.3
Total	5.2	1.6	0.9	2.8	

Penetration 15+ (%)	Total	BMI	NMI	Unconnected	
Developed World	100%	64%	[illegible]	27%	
Developing World	100%	23%	18%	59%	77%
Total	100%	30%	17%	53%	

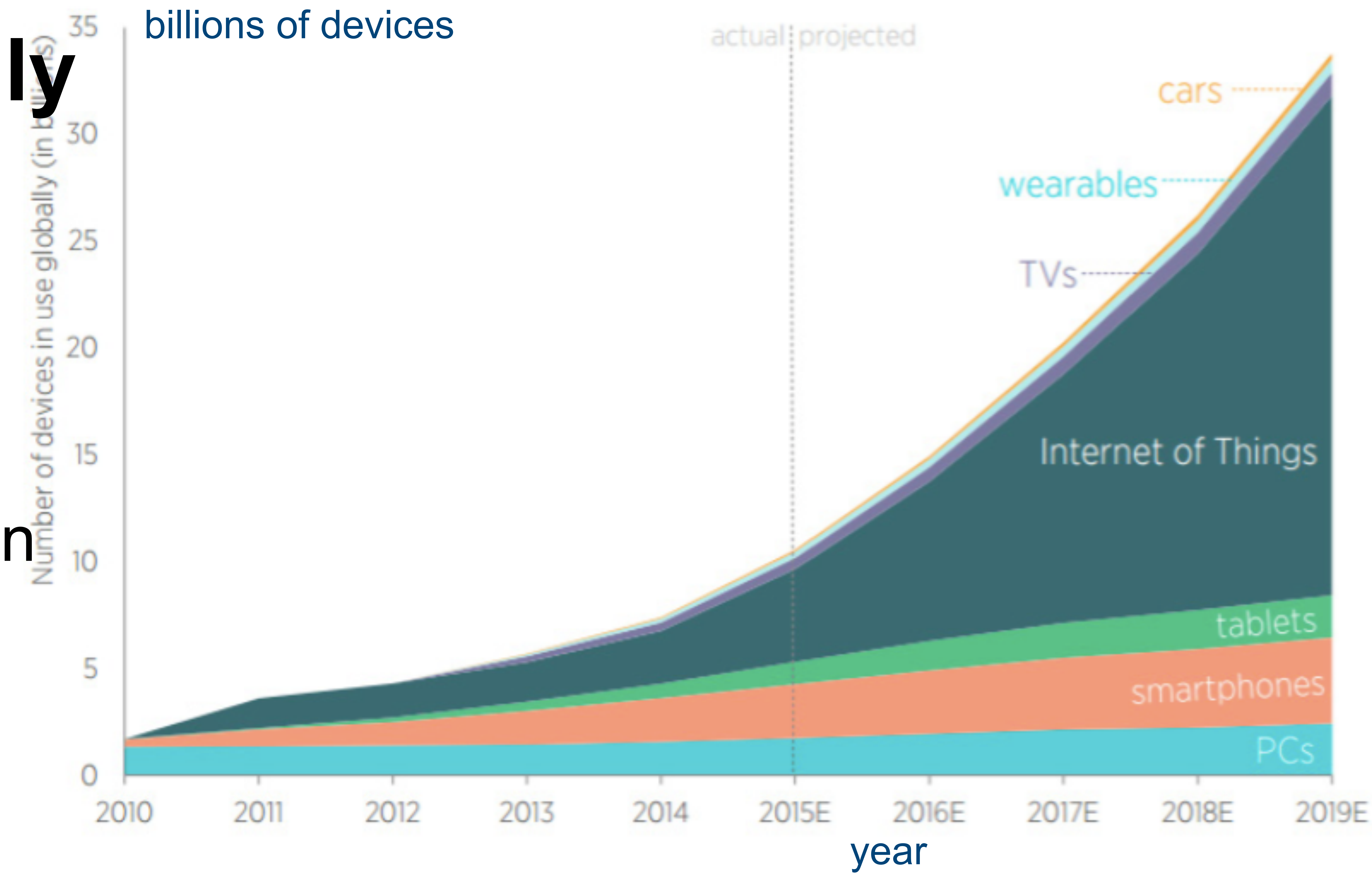
Source: GSMA Intelligence; figures reflect position at end of 2014
BMI = Broadband Mobile Internet (3G/4G); NMI = Narrowband Mobile Internet (<3G)

[Source: GSMA, Nov2015]

[Source: A. Thinner and A. Castillo, 2015]

IoT expected impact, only for "the connected"?

- Smart home appliances, "wearables", smart metering, autonomous vehicles,…
- 10 billion (2013) -> 19 - 40 billion (2019)
- total global impact: US$ 2.7 - 14.4 trillion by 2025
- **~3/4** of devices from IoT++
  ~1/4 from tablet, mobile,…



Source: John Greenough, "The Internet of Everything 2015," *Business Insider Intelligence*. Produced by Adam Thierer and Andrea Castillo, Mercatus Center at George Mason University, 2015.

5G - demand: “Connect the Unconnected”

17 PARTNERSHIPS FOR THE GOALS

[Source: GSMA, Nov2015]

Partnership for digital inclusion	
Telecom	**InfoInternet**
revenue-driven	non-profit
targeting leveraged creation	targeting no- and limited use
voice & mobile broadband	compressed text & pictures
subscription based (SIM)	free access & voucher
mobile network: coverage & capacity	Wifi-spots: health-/ community centres, schools
operator cost model	target: 0.5 US$/month
operator roll-out	NGO & community roll-out

Sustainability Goals (SDGs) and Agenda 2030

- Main Objectives of CTU

Goal: Include people with 1 USD/month for communications

Free local info
- health
- education

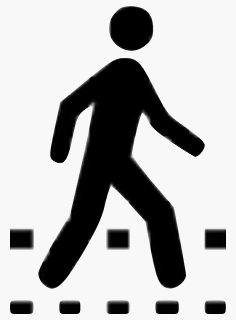
1. UN sustainability goals and Agenda 2030:

Germany has chosen this agenda as a backdrop for their entire program for the presidency, and I lead a group at the United Nations that will drive towards implementation.

We will work to ensure that the G20 goes ahead with its own specific commitments to help achieve sustainability goals.

Our contribution:

- Information for all (InfoInternet)
  - ➡ free access to text and pictures
    - the "walk on the Internet"
  - ➡ paid access to amusement
    - "Toll Roads"
- The catalyst for the SDGs



Satellite Deployment through a Two-Layer Function Model to Solve a National Supply and Demand Gap of Capacity in Indonesia

IARIA CONFERENCE, 2017

Venice, 26 June 2017

Gerson Damanik

Satya Wacana Christian University, Salatiga, Central Java, Indonesia

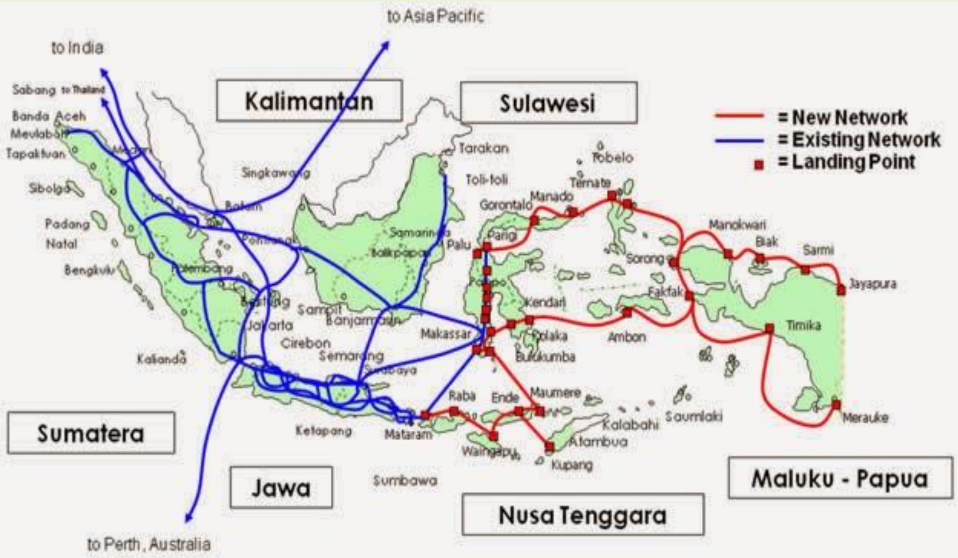
Indonesia Country Profile

The largest archipelago country : 13,466 islands (already have coordinates and registered) **source: Geospasial Information Indonesia (BIG) May 2014**

***total land area:* 1,919,440 km2 (*land:* 1,826,440 km2, *inland water:* 93,000 km2)** **source: statistics Indonesia (BPS) May 2014**

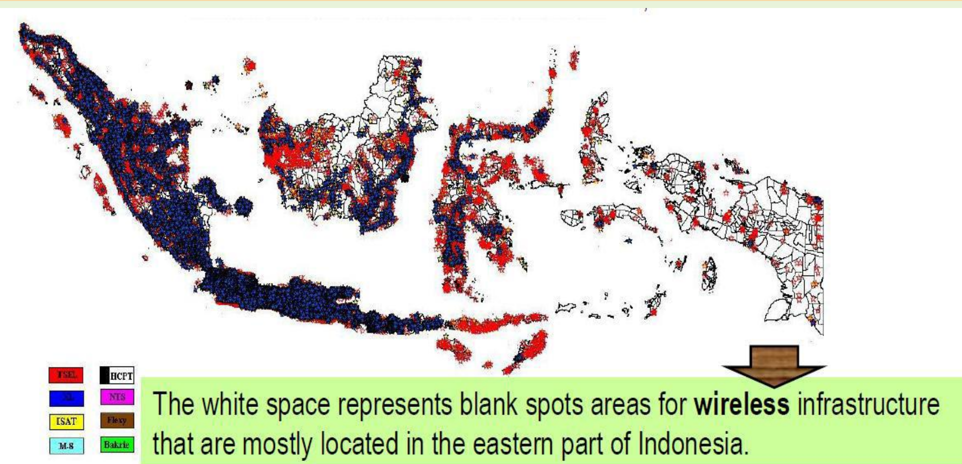
Overview: Indonesia Information Structure

Backbone Network : Fiber Optic



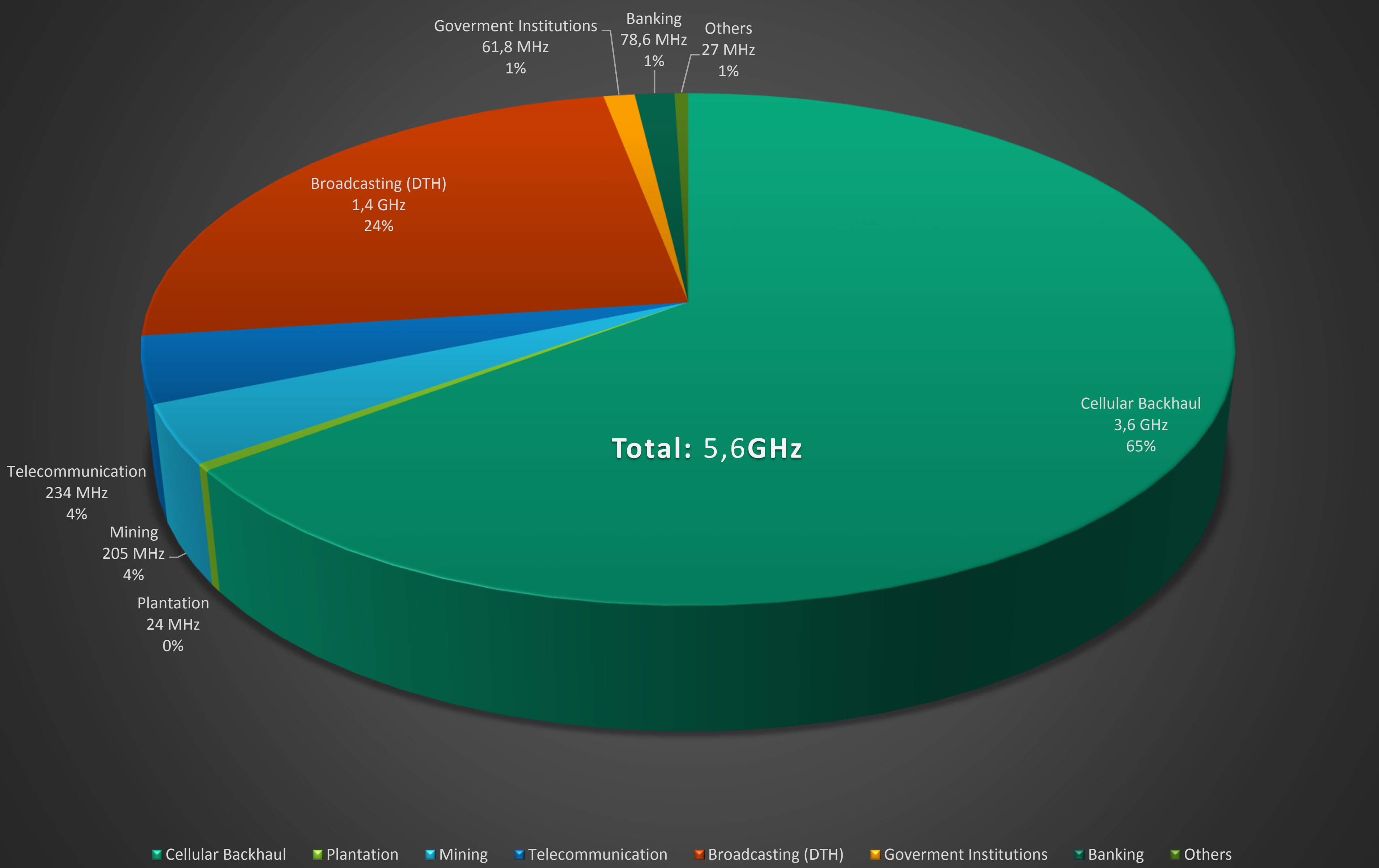
- Currently, terrestrial backbone and access network have not covered all Indonesian territory, especially in Eastern Part of Indonesia due to geographic condition
- **Satellite plays an important role in connecting Indonesian territory and serving the unserved areas**
- **Indonesia is highly dependent on satellite**

Access Network : Cellular network



C-band Specific Earth station

Overview: Foreign Satellite Usage in Indonesia



Why Satellite

- Satellite is a vital infrastructure for national security, national telecommunication infrastructure, broadcasting service, and earth observation purposes.

- Satellite is suitable with Indonesia geography.

- Indonesia satellite market showed supply and demand gap condition, where the most of satellite usage was provided by foreign satellites. There were 34 for foreign satellites used in Indonesia that served by 15 countries.

Main Problem with Indonesian Operators

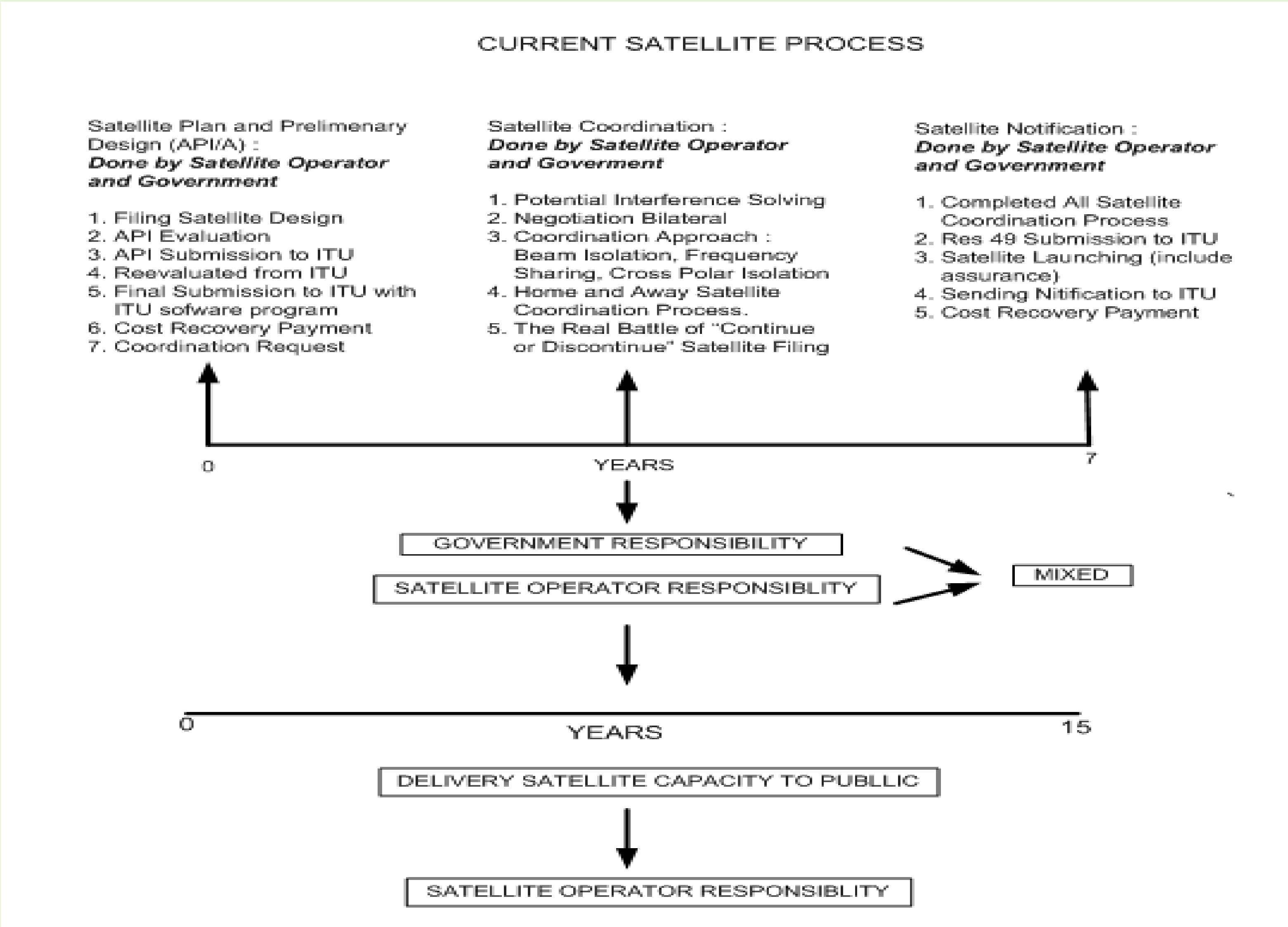
Based on the result of interview be conducted,
the problem with Indonesian satellite operators such as :

- lag of investment
- inword looking orientation
- too many national satellite operators with minimum real satellite in operate.

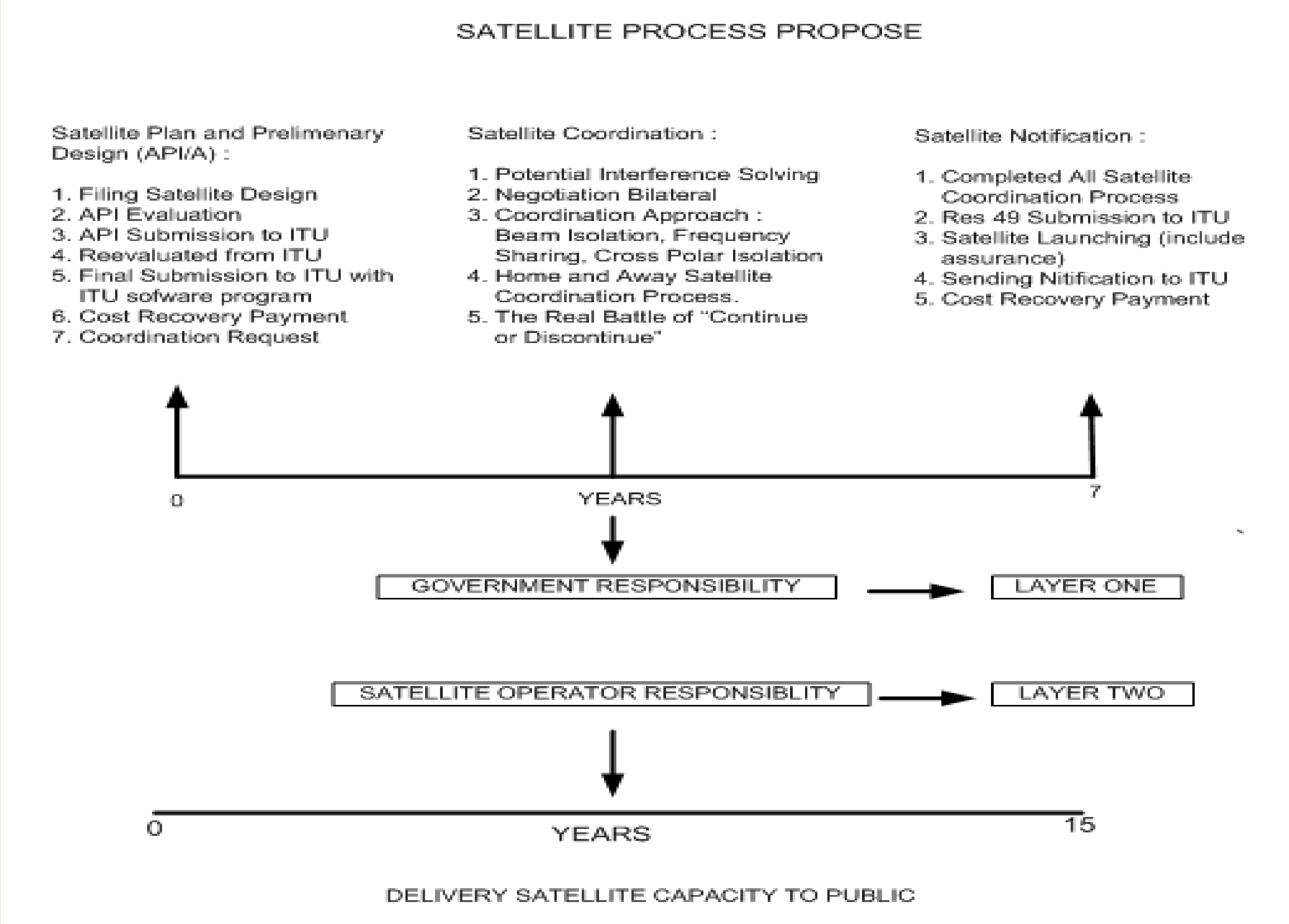
Satellite Launching Process

- Satellite planning and design according to national need.
- Submit satellite planning to ITU.
- Seeking agreement with ITU members by doing satellite coordination to get complete satellite coordination result.
- Pay cost recovery to ITU.
- Sending Res 49 (satellite launching information and others include manufacture of the satellite to ITU).
- Do negotiation with satellite manufacturer.
- Chose insurance.
- Chose satellite launcher.
- Notify satellite filing to ITU.
- Launching satellite to the orbit

Current Satellite Filing Process



Proposed Satellite Filing Process

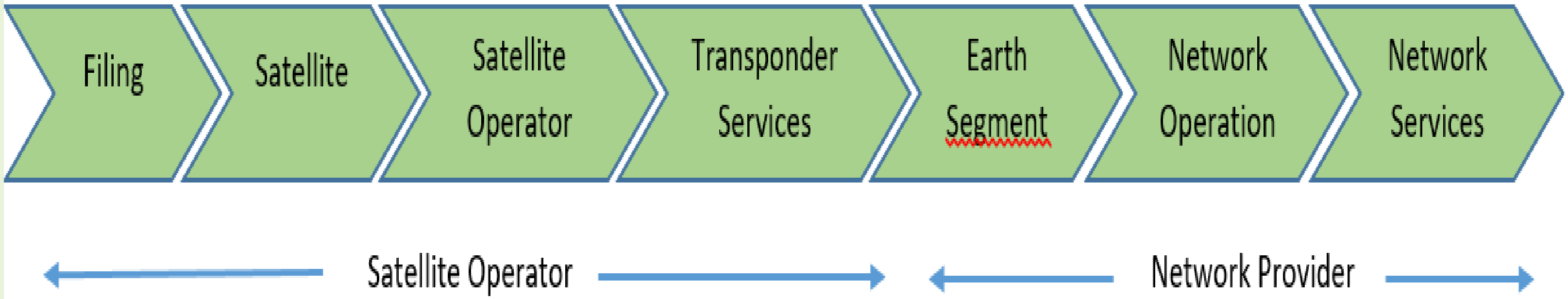


Two Layer Function Model

Satellite deployment model in Indonesia is developed by government investment budget that we called “layer one”. The whole processes should follow Radio Regulations was setted up by ITU. When “layer one” as a government function is completed and satellite capacity is ready be delivered to the users, then private companies, or government enterprises that already be selected by the government deliver that capacity.

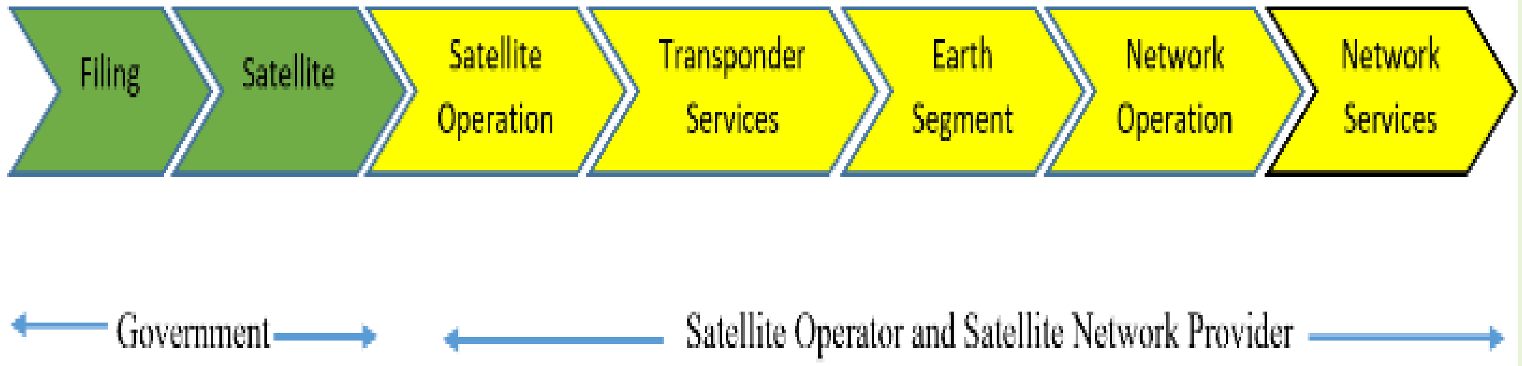
The selection of the operators could be through an auction, or others of selection method. The function of private company or government enterprises delivery satellite capacity or satellite service to their customers its called “layer two”.

Satellite Business Cycle



Satellite Business Cycle

Satellite Deployment Proposal in Indonesia



Satellite Deployment Proposal in Indonesia

Government Perspective

- Certainty of satellite capacity to all users in Indonesia, mostly to unserved area.
- Indonesia will decrease the dependence of foreign satellite capacity in the future.
- Will make Indonesia as the shaft of maritime the world.
- Government budget that used for public service to provide satellite capacity will not be negative value because any budget for capital expenditure will be back again in the time period be setted up with the operators.

Operators Perspective

- ❖ Satellite operators will do a commercial business, so they will get a value from their activity.

- ❑ If one operator or more want to be a satellite operator, they must comply with all the requirements.

- ➢ They can make their own budget or collaborate with other operators as a consortium.

Conclusion

1. Government can make a strategy to provide public service to public.
2. Complexity of the satellite filing process, fully regulated by ITU, upfront budget, there was supply and demand gap condition.
3. It is important to take a new strategy to fulfill national satellite capacity.
4. Two layer model is one of strategy of Indonesia to fulfill satellite capacity.
5. Government Function such as, satellite plan and design, satellite coordination, satellite notification, satellite launching, and satellite control.
6. Satellite operators deliver satellite capacity to users.
7. Layer one function will be done by a special Government entity.
8. Layer two as function of those operators that eligible by selection of Government.

Thank You

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