

# Μάθημα

## Τεχνοοικονομική ανάλυση δικτύων


### Λειτουργικό Διαχειριστικό και Κόστος Συντήρησης

Δρ. Δημήτρης Κατσιάνης

---

Εθνικό και Καποδιστριακό Πανεπιστήμιο Αθηνών  
Τμήμα Πληροφορικής και Τηλεπικοινωνιών  
Τομέας Επικοινωνιών και Επεξεργασίας Σήματος

1



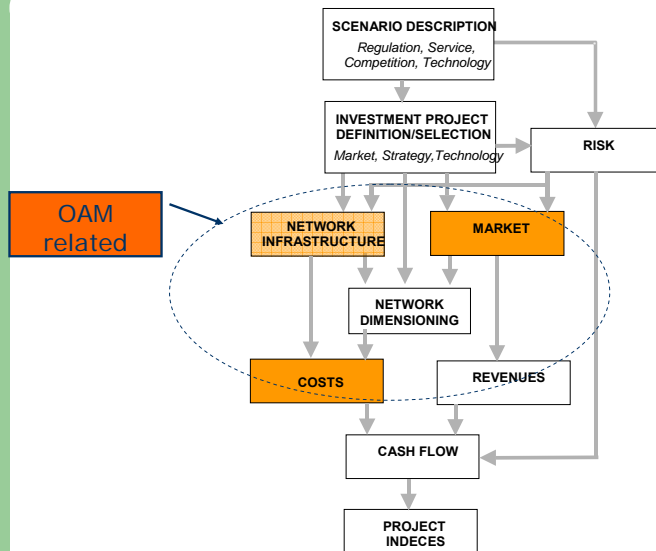
## Περιεχόμενα

- Λειτουργικό Διαχειριστικό και Κόστος Συντήρησης
- Operation, Administration and Maintenance Cost (OA&M)
- OPEX (Operational Expenditures)
  - Ανάλυση παραγόντων
  - Σημαντικότεροι παράγοντες
  - Σημασία υπολογισμών OAM
  - Παράδειγμα

2

ΕΚΠΑ - Τμήμα Πληροφορικής & Τηλεπικοινωνιών Δρ. Δ. Κατσιάνης Τεχνοοικονομική Ανάλυση Δικτύων

## Το λειτουργικό κόστος στην μοντελοποίηση της ανάλυσης επενδύσεων



3

ΕΚΠΑ - Τμήμα Πληροφορικής & Τηλεπικοινωνιών

Δρ. Α. Κοτσώνης Τεχνοοικονομική Ανάλυση Δικτύων

## CAPEX - OPEX

- Το CAPEX μπορεί να οριστεί ως τα έξοδα που σχετίζονται με την υλοποίηση του έργου (network infrastructure) ή την επέκτασή του
  - subject to depreciation
  - residual value
- Η ανάλυση του CAPEX βασίζεται γενικά σε φυσικές και λογικές απαιτήσεις του δικτύου
  - Construction of a network
  - implementation of new network elements
  - acquisition of software (or hardware) systems etc...
- Το OPEX ορίζεται ως τα αναγκαία έξοδα για τη λειτουργία της επιχείρησης (running the business) ή του δομικού στοιχείου
  - Keep the services active and running.
  - not subject to depreciation.
  - no residual value.

4

ΕΚΠΑ - Τμήμα Πληροφορικής & Τηλεπικοινωνιών

Δρ. Α. Κοτσώνης Τεχνοοικονομική Ανάλυση Δικτύων

## CAPEX - OPEX (2)

- Ο διαχωρισμός μεταξύ CAPEX και OPEX δεν είναι πάντοτε πολύ καλά ορισμένος
- Ειδικά κάποια έξοδα που σχετίζονται με software είναι πάνω στη διαχωριστική γραμμή
- Παραγγελίες hardware και software συστημάτων είναι πάντα CAPEX,
- Operation και maintenance (manpower κόστος) και κόστος αδειών (license) μπορεί να θεωρηθεί είναι OPEX.

5

ΕΚΠΑ - Τμήμα Πληροφορικής & Τηλεπικοινωνιών

Δρ. Δ. Κατσάνης Τεχνοοικονομική Ανάλυση Δικτύων

## Running Cost

Έξοδα Λειτουργίας Γενικά

Running costs = OA&M cost + provision cost  
+ churn cost + decommissioning cost +  
leased facilities cost etc

6

ΕΚΠΑ - Τμήμα Πληροφορικής & Τηλεπικοινωνιών

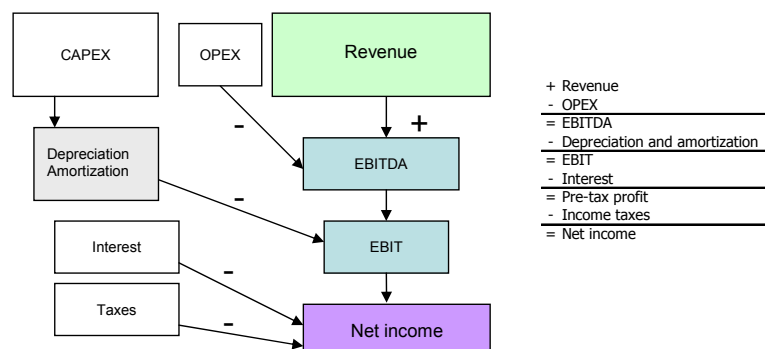
Δρ. Δ. Κατσάνης Τεχνοοικονομική Ανάλυση Δικτύων

## Κόστος κύκλου ζωής (Life Cycle Cost)

- Το Κόστος κύκλου ζωής προσδιορίζεται ως το άθροισμα όλων των επενδύσεων **και των λειτουργικών εξόδων**. Δηλαδή αντιπροσωπεύει το **συνολικό κόστος της κατασκευής** και της λειτουργίας του δικτύου (OPEX) καθ' όλη τη διάρκεια της περιόδου μελέτης.
  - sum of all discounted CAPEX and OPEX.

7

## OPEX in Project value



8

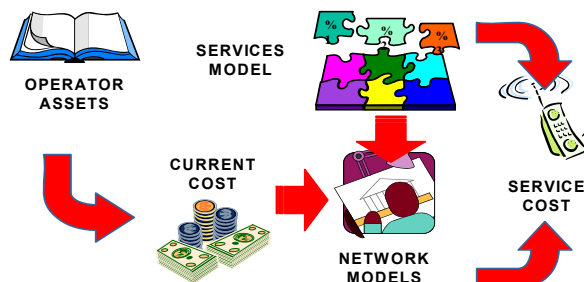
## OPEX TOP Down & Bottom Up

- Top-Down, Έχει ως εκκίνηση τα κόστη τα οποία υποδεικνύονται στο γενικό σύνολο και ακολουθεί την παραγωγική διαδικασία της εταιρίας ώστε να τα κατανείμει στις εξόδους - (κατώτερα επίπεδα)
- Bottom-Up, ξεκινά από τις εξόδους (υπηρεσίες) οι οποίες πρόκειται να προσφερθούν και καθορίζει την παραγωγική δομή (Δίκτυο) η οποία είναι ικανή να το επιτύχει.
  - Τα κόστη έχουν προκύψει από τη διαδικασία διαστασιοποίησης, με βάση τις απαιτήσεις (demand)
- Στην Τεχνοοικονομική ανάλυση θεωρούμε ότι «ταιριάζει» καλύτερα η Bottom – Up προσέγγιση για τον Υπολογισμό του OPEX

9

## Κοστολογικά υποδείγματα (1/2)

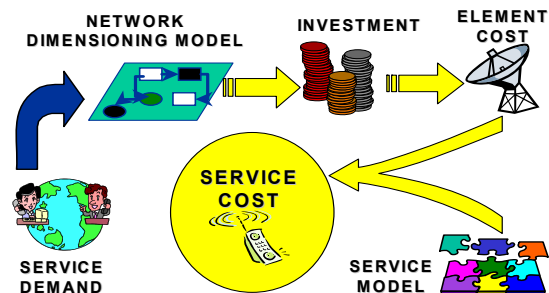
Υπόδειγμα «top-down»



10

## Κοστολογικά υποδείγματα (2/2)

### Υπόδειγμα «bottom-up»



11

ΕΚΠΑ - Τμήμα Πληροφορικής & Τηλεπικοινωνιών

Δρ. Α. Κατσάνης Τεχνοοικονομική Ανάλυση Διεκτίμησης

## OPEX Elements

- Τα στοιχεία που θα παρουσιαστούν περιλαμβάνουν καλύπτουν όλους τους πιθανούς ρόλους
  - service operator, network operator, service integrator, content provider κλπ.
- Εφαρμόσιμα σε όλα τα επιχειρηματικά τηλεπικοινωνιακά μοντέλα (παλιές και νέες υπηρεσίες)
  - mobile, fixed
- IT (Information Technology) κατανέμονται σε πολλές δραστηριότητες και πολλά μπορεί να γίνουν outsourcing

12

ΕΚΠΑ - Τμήμα Πληροφορικής & Τηλεπικοινωνιών

Δρ. Α. Κατσάνης Τεχνοοικονομική Ανάλυση Διεκτίμησης

## Main OPEX elements

1. Maintenance of equipment and components
2. Equipment and software licenses, Maintenance outsourcing
3. Sales and marketing, Customer acquisition
4. Customer provisioning
5. Customer care
6. Charging and billing
7. Service management
8. Network management
9. Product/platform development
10. Rental of physical network resources
11. Roaming
12. Interconnection
13. Yearly cost of radio spectrum licenses
14. Regulation
15. Content

13

ΕΚΠΑ - Τμήμα Πληροφορικής & Τηλεπικοινωνιών

Δρ. Α. Κατσάνης Τεχνοοικονομική Ανάλυση Διεξόδων

## Maintenance of equipment and components (1)

- Includes all the recurrent costs that are periodically necessary for undisturbed network and service operation.
- Includes both preventive maintenance and reparation
- Reinvestment due to outdated equipment is treated as CAPEX. Reinvestment means a change to a newer version of equipment, usually with higher functionality.
- Decommissioning cost (removing of old equipment) might be counted as OPEX or be included to CAPEX.

14

ΕΚΠΑ - Τμήμα Πληροφορικής & Τηλεπικοινωνιών

Δρ. Α. Κατσάνης Τεχνοοικονομική Ανάλυση Διεξόδων

## Maintenance cost example

- M1 - Represents the cost of repair parts. This component is driven by the investments.
- M2 - Represents the cost of repair work.

$$M_i = (M_1 + M_2)_i \\ = \frac{V_{i-1} + V_i}{2} \cdot \left( P_i \cdot R_{class} + P_i \cdot \frac{MTTR}{MTBR} \right)$$

$V_i$  is the equipment volume in year  $i$

$P_i$  is the price of cost item in year  $i$

- $R_{class}$  is the maintenance cost percentage (to be defined)

$P_i$  is the cost of one working hour

MTTR is the mean time to repair for the cost item in question (to be defined)

MTBR is the mean time between failures for the cost item in question (to be defined)

15

## Equipment and software licenses, maintenance outsourcing (2)

- This includes e.g. yearly expenses from the operator to the equipment provider after buying the equipment (maintenance agreement and periodic licence costs).
- Annual fees and/or Upgrades based on:
  - Working time for upgrade (upgrade time)
  - Frequency of upgrades (FOU)
  - Number of network elements to visit
- Software maintenance cost = annual cost (driver: customers, nodes, traffic etc) and/or
- Software maintenance cost = upgrade time \* working time costs \* FOU \* number of network elements to visit

16



### Sales and marketing, Customer acquisition (3)

- This element is intended to cover both retail and wholesale businesses.
  - Marketing, Advertising, Campaigns
    - very case dependent
      - wholesale for a few customer vs. retail for mass market
    - Consists of the
      - manpower costs - marketing staff working for the relevant case times the average manpower cost
      - costs of buying media time for advertising.
    - Marketing cost = cost per potential customer \* size of potential customer base
    - Relevant to Customer acquisition cost vs Churn rate
  - SLA (Service level agreement) negotiation
    - depend on the length of preparation and negotiation and manpower cost.
  - Subsidisation (provisions to e.g. handset vendors)
    - Subsidisation cost = number of new (subsidized) customers \* subsidy cost per customer

17

### Customer provisioning (4)

- Customer registration
- Installation and reinstallation (by churn) of customer
- Activation of customers devices
- Provisioning includes also initial service configuration, disconnecting a customer, deleting data from customer base etc.
- The average installation/reinstallation cost can have some learning effects i.e. reduce over time because of economies of scale.
  - E.g Provisioning cost = (customers\_year\_end - customers\_year\_begin + churned customers) \* provisioning cost of one customer
  - Provisioning of one customer might be  $P(t) = n(t)^{-\alpha} \cdot P_0$

18

## Customer care (5)

- Customer service, handling of complaints etc
- Help desk operation
- CRM (customer relationship management) operation
- May often be outsourced, can be based on personal and/or IT-systems.
- E.g. Customer care cost = average number of customers per year \* customer care personnel per customer \* yearly manpower cost

19

## Charging and billing (6)

- Data collection, etc.
- Charging
- Billing
- Accounting and controlling (regular reporting to the higher level management)
- Charging and billing cost = average number of customers per year \* unit cost(t)
- unit cost(t) ->(price per customer)

20

## Service management (7)

- Product management (responsible person)
- Supervision and monitoring of services and quality
- SLA management
  
- $\text{Cost} = \text{management cost for service1} + \text{management cost for service2} + \dots \text{etc}$

21

## Network management (8)

- Faults, Configuration, Accounting, Performance, and Security management (FCAPS)
- Supervision and control of network elements
- Operation Support Systems (OSS) operation
- Network management cost =  $F(\text{number of personnel, number of network management systems, number of network elements})$

22

## Product/platform development (9)

- Network planning
- Service design and development
- SLA design
- Product/platform development cost = F(number of engineers, number of services, complexity of existing and new services)

23

## Rental of physical network resources (10)

These elements are very relevant to service providers or virtual operators that do not own network platforms, or infrastructure, but rent it from others. Also traditional operators often have to pay for some of these.

- LLU (local loop unbundling)
- Wholesale (e.g. DSL access)
- Leased lines
- Dark fiber
- Co-location, hosting
- Mast for base stations
- Mobile access
- SAN (Storage area network)
- Dependent
  - Number of customer (LLU Buildings, ADSL Wholesale)
  - Traffic (leased lines)
  - Number of sites (mast for base stations)

24

## Roaming (11)

- Roaming agreement and settlement cost:
  - The cost incurred in negotiating and managing the roaming agreements and financial settlements.
- Global roaming test:
  - The cost incurred in conducting interoperability tests for roaming across multiple networks and technologies.
- VHE (Virtual home environment) maintenance:
  - The cost incurred for the maintenance of the VHE, essential for providing the same personalized profile across multiple networks and terminals for an inbound subscriber.
- Roaming costs = cost per inbound subscriber \* total number of inbound subscriber + cost per outbound subscriber \* total number of outbound subscribers

25

## Interconnection (12)

- The interconnection costs include mainly termination charges levied by a network operator responsible for completing a call or session originated in another network.
- The main driver is interconnecting traffic volumes
- Interconnection costs = (cost per traffic unit) \* (total inbound traffic – total outbound traffic)
- Prices are often different in different directions (e.g. in incumbent/non-incumbent case). Interconnection costs can also vary based on geographical location such as national and international connections.

26

## Radio spectrum licenses (13)

- Yearly cost for frequency licenses for UMTS, WiMAX etc
- Some regulatory regimes allow the possibility of leasing the spectrum owned by an operator to a third party.
  - e.g.the leasing of spectrum by an MVNO from a network operator could be possible. Here, the spectrum leasing cost incurred by an MVNO is considered as an OPEX whereas the cost incurred by the network operator in purchasing that license is considered as CAPEX
- yearly fixed fee or fee for the entire duration of license.

27

## Regulation (14)

- Cost for collecting information and reporting to the regulator
- Additional cost due to the impact of changes in regulatory decisions
- Fines based on regulator decisions
- E.g personnel costs involved in regulatory reporting and information collection as well as the costs involved in complying with the regulatory decisions.

28

## Content (15)

- This is the cost in purchasing licenses from a third party (content owner) for content distribution.
  - number of licenses and number of users of the content
- Includes also other payments to a third party
  - maintenance of content distribution and rights management systems.

29

## Company specific OPEX elements

- General management of the company
- Research & Development
- Law department
- Economy department
- Human resources (HR)
- General IT support

30

## OA&M Process (example)

Telecommunication layer	Maintenance processes	Operational processes	Administrative processes
Customer care management	<ul style="list-style-type: none"> <li>Problem handling (power plug out of GPE, i.e. modem)</li> </ul>	<ul style="list-style-type: none"> <li>Marketing &amp; sales (services)</li> <li>Usage data collection</li> <li>Customer databases</li> </ul>	<ul style="list-style-type: none"> <li>Customer billing (invoicing)</li> </ul>
Service & Service management	<ul style="list-style-type: none"> <li>Service fault management</li> </ul>	<ul style="list-style-type: none"> <li>Service set-up &amp; configuration</li> <li>Service churn / release</li> <li>Service quality management</li> <li>Rating and discounting</li> <li>Service QoS management</li> </ul>	
Network and system management	<ul style="list-style-type: none"> <li>Network maintenance &amp; restoration</li> </ul>	<ul style="list-style-type: none"> <li>Network &amp; systems databases (Inventory &amp; data management)</li> <li>Network provisioning</li> <li>Network performance management</li> </ul>	
Network elements & system element	<ul style="list-style-type: none"> <li>Element maintenance (Failed component repairing)</li> </ul>	<ul style="list-style-type: none"> <li>Network configuration (network provisioning), reconfiguration and restoration</li> <li>Monitoring / Controlling</li> <li>Fault management (detection, decision)</li> <li>Preventive maintenance (batteries, lightning, ...)</li> <li>Security management</li> <li>System &amp; equipment powering</li> <li>Cleaning (equipment)</li> </ul>	<ul style="list-style-type: none"> <li>Marketing &amp; sales (network services)</li> <li>Billing and payment of third parties (other operators, or services like energy consumption)</li> </ul>
Physical network and infrastructure (cables, ducts, cabinets, buildings)	<ul style="list-style-type: none"> <li>Broken cables</li> <li>Broken or damaged infrastructure</li> </ul>	<ul style="list-style-type: none"> <li>Cleaning (building, ducts)</li> <li>Building lighting</li> <li>Building / equipment cooling &amp; heating</li> <li>Infrastructure management (database, GIS)</li> </ul>	<ul style="list-style-type: none"> <li>Right of way (right to use private property, for laying network equipment like ducts, cables or cabinets): fee payment, renewal of arrangement</li> </ul>



31

## Maintenance Process

Maintenance process	Cost factors (drivers)	Driving parameters
Service maintenance	<ul style="list-style-type: none"> <li>Manpower</li> <li>Customer care system</li> </ul>	<ul style="list-style-type: none"> <li>Duration of maintenance process (customer care, and advise)</li> <li>Number of customers</li> </ul>
Network maintenance	<ul style="list-style-type: none"> <li>Manpower</li> <li>Replaced equipment</li> </ul>	<ul style="list-style-type: none"> <li>Mean time between failure</li> <li>Duration of maintenance process</li> <li>Cost of the element</li> <li>Network size / Nb. of elements</li> </ul>

32



## Operational Process

Operational process	Cost factors / drivers	Driving parameters
Service management	<ul style="list-style-type: none"> <li>• Manpower</li> <li>• Service management system</li> </ul>	<ul style="list-style-type: none"> <li>• Nb. of customers</li> </ul>
Provisioning	<ul style="list-style-type: none"> <li>• Manpower</li> </ul>	<ul style="list-style-type: none"> <li>• Sales volume</li> </ul>
Network operation	<ul style="list-style-type: none"> <li>• Manpower</li> </ul>	<ul style="list-style-type: none"> <li>• Network size</li> <li>• operating system efficiency</li> </ul>
Powering (Network operation)	<ul style="list-style-type: none"> <li>• Energy consumption</li> </ul>	<ul style="list-style-type: none"> <li>• cost of energy</li> <li>• equipment power consumption</li> </ul>
Building cleaning (Infrastructure)	<ul style="list-style-type: none"> <li>• Manpower</li> </ul>	<ul style="list-style-type: none"> <li>• Size of the building</li> <li>• Specific network element</li> </ul>
Heating (Infrastructure)	<ul style="list-style-type: none"> <li>• Energy consumption</li> </ul>	<ul style="list-style-type: none"> <li>• Heated surfaces / volumes</li> </ul>

33

## Administration Process

Operational process	Cost factors / drivers	Driving parameters
Service billing	<ul style="list-style-type: none"> <li>• Manpower</li> <li>• Service management system</li> </ul>	<ul style="list-style-type: none"> <li>• Nb. of customers</li> <li>• Type of billing : pre-paid (cash), post-paid (bill), credit card, ...</li> </ul>
Building and infrastructure administration	<ul style="list-style-type: none"> <li>• Bill payment (power, water, cleaning, ...)</li> </ul>	<ul style="list-style-type: none"> <li>• Number of building</li> <li>• Number of commercial/service partners</li> </ul>

34

## OPEX elements

1. Maintenance of equipment and components
2. Equipment and software licenses, maintenance outsourcing
3. Sales and marketing, Customer acquisition
4. Customer provisioning
5. Customer care
6. Charging and billing
7. Service management
8. Network management
9. Product/platform development
10. Rental of physical network resources
11. Roaming
12. Interconnection
13. Yearly cost of radio spectrum licenses
14. Regulation
15. Content
16. Company specific OPEX elements?

Selection per Case Study

35

ΕΚΠΑ - Τμήμα Πληροφορικής & Τηλεπικοινωνιών

Δρ. Α. Κατσάνης Τεχνολογική Ανάλυση Διεκτίμηση

## e.g. OPEX in Mobile Cases

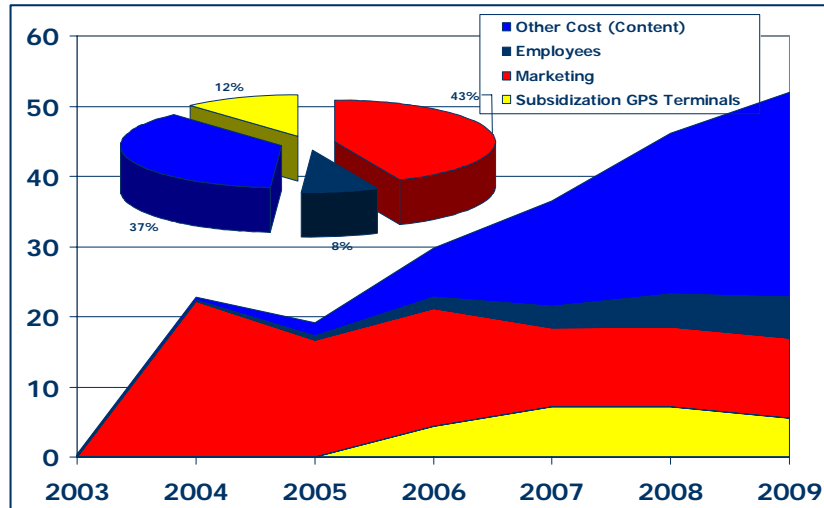
- Empirical Data
  - Network related elements 20%
  - Marketing and sales related elements 26%
  - Customer service related elements 15%
  - IT and other product support and development 13%
  - Interconnection and roaming costs 26%
- Estimation
- OPEX in 3G to be 19-34Euros monthly per subscriber
  - Start of the Project 34?
  - End of the Project 19?

36

ΕΚΠΑ - Τμήμα Πληροφορικής & Τηλεπικοινωνιών

Δρ. Α. Κατσάνης Τεχνολογική Ανάλυση Διεκτίμηση

## OPEX LBS case results



37

ΕΚΠΑ - Τμήμα Πληροφορικής & Τηλεπικοινωνιών

Δρ. Α. Κατσάνης Τεχνολογική Ανάλυση Διεύθυνση

## Literature Reviews

1. Broadband Access Networks Introduction strategies and techno-economic evaluation Edited by L.A. IMS Published within the Telecommunications Technology And Applications Series by Chapman & Hall 1998 ISBN 0 412 82820 0
2. Investment Decisions: The certainty case in Copeland, T E, Weston, J F. Financial Theory and Corporate Policy. Addison-Wesley Publishing Company, Reading Massachusetts, 1992.
3. Arthur Andersen, "Accounting separation in the context of Open Network Provision". Draft Guidelines prepared for the DGXIII of the European Commission. Oct 97.
4. <http://www.optcomm.di.uoa.gr/ecosys/> (ECOSYS project, deliverable 6,2005)

38

ΕΚΠΑ - Τμήμα Πληροφορικής & Τηλεπικοινωνιών

Δρ. Α. Κατσάνης Τεχνολογική Ανάλυση Διεύθυνση