Cost Model Approach for Next Generation Emergency Call Systems
Italy Case Study

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Keywords: Emergency Call System, 112 PSAP, Rescue Services, ERO (Emergency Response Organization), Cellular Tower Network, Crash Notification, Emergency Call Unit, eCall, PSAP, Cellular Tower.

Abstract: Next generation emergency notification system after emergency call (eCall) equipped vehicle regulations with the legislation EU-2015/758 is analysed via optimal architecture selection with the study of cost modelling for the "Emergency Calls EROs Handling" model of European Emergency Number Association (EENA) which is applied in Italy, Austria, France, Germany and Norway. According to EU-Regulation 2015/758, public safety answering points (PSAPs) need to be ready for the new model system with the start date of 1st October 2017 while eCall-equipped vehicles are started to be produced at the end of March 2018. With this regulation, infrastructure and working procedure of eCall systems as well as eCall equipments and related vehicle structures will be updated or modified as an obligation. According to status of most appropriate 112 PSAPs, there may be an adaptation of manual eCall PSAPs, auto eCall PSAPs. In this paper, the optimal architecture of the system in Italy is discussed and the next generation crash notification systems for current "Emergency Calls EROs Handling" model are defined.

1 INTRODUCTION

According to International Accident and Road Database (IRTAD), numbers of road fatalities are changing between 3 and 13 for 100000 inhabitants in the IRTAD member countries (IRTAD, 2014). The countries try to decrease these fatality rates; so the new regulations are created. The main objective of this study is to define the optimal architecture of emergency call system in Italy after eCall equipped vehicle regulation, EU-2015/758 in 2018. It means there will be the next generation of current "Emergency Calls EROs Handling" model of European Emergency Number Association (EENA).

The emergency calls (eCall) system generic structure which includes both current and next generation units are described in Figure-1. The current architectures of European Emergency Number Association (EENA) are defined in Figure-2. In Figure-2, Model-1 is the current Italy infrastructure and its next generation scenarios are analysed in this paper. Moreover, the next generation architectures of Italy Infrastructure after the eCall equipped vehicle regulation in 2018 are explained in Figure-3. In all figures, the description-numbers of units are expressed as: (1) Global Navigation Satellite System to take the positioning data of the vehicle (2) which have an accident when crashing the tree (5). Next, eCall unit (3) is the device inside of the vehicle and will be an obligation after eCall equipped vehicle regulation in 2018. Cellular tower (4) processes the communication signals and transfer to the related services thanks to communication network (6). 112 PSAP (7) is the emergency call response service in the current statuses. When Manual eCall PSAP (8) is the next generation PSAP service for the accidents of the vehicles which have manual eCall device, Automatic eCall PSAP (9) is the next generation PSAP service for the accidents of the vehicles which have automatic eCall device. If the Manual eCall PSAP and/or Auto eCall PSAP is only one unit, it is described with unit (20). The Police station (15) which is used as 112 PSAP (7) is the integrated unit (10). Rescue team vehicles are defined as the unit (11) when ambulance service station is unit (14) and fire service station is unit (16). Moreover, public communication device such as mobile phone which enables to call the emergency service is unit (12) when the 112 PSAP which has an interconnected structure is the unit (13). Interconnected PSAPs are connected with each others in the same region. If

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any of them cannot response the emergency calling, the other interconnected PSAP can response it. In the next generation scenarios, the integrated control room/building which can include PSAPs, rescue services, dispatch and response units inside, is the unit (17) while the out of control room/building structure is described with unit (19). Moreover, the unit (18) is defined which is the dispatch unit for all type of rescue services. The unit (18) can be thought as the one unit and it can make the dispatches for police vehicles, ambulance vehicles and fire vehicles. If there is unit (18), there is no usage for unit (14), (15) and (16) for the vehicle accidents.

The generic eCall system embodies the accident with a vehicle (2) crashing into a tree (5) in Figure-1. After the crash, vehicle-eCall unit (3) is responsible for the activation process. If the eCall device is triggered automatically, it is called automatic eCall activation. Manual or automatic activation is enabled by vehicle ignition signal and eCall wake up signals.

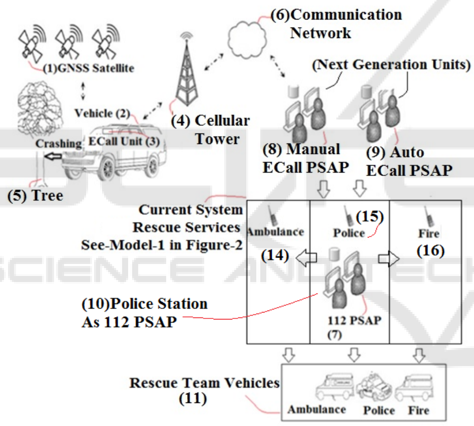

Figure 1: Generic eCall crash notification system for Italy (Current and Next Generation Units).

In this system, the supply voltage is provided by a starter battery and the boost processor creates the different types of voltages where the vehicle location is received by internal GNSS module from GNSS Satellite (1). Cellular connection is provided with internal GSM module in the eCall device (3). By the way, eCall device includes two main parts which are eCall measurement unit and Control Unit. It includes also rechargeable battery which protects the device from power losses. Airbag signal, car crashing input and related vehicle data are sent to the main processor of eCall control unit. ECall data in eCall equipped vehicle (2) will be sent to cellular tower (4) via cellular tower network. The cellular tower is chosen by its capacity, signal power of sending data and cellular tower usage. Data are transmitted to the related data entity which is defined by the service rules of digital cellular telecommunication regulation. After the data is processed in cellular tower, it is forwarded to public safety answering points with the communication network (6). By the way, eCall data are checked by (i) general description of data; (ii) code requirements and (iii) data conformance tests. Data of public safety answering points with the new structure are fitted with the operating requirements in the regulations of third party organizations. PSAPs (7, 8 or 9) inform the rescue services with the accident data; and then they forward the data sets to the rescue-vehicle teams (11). This whole accident situation needs to be fitted with the pan European eCall regulation and end to end conformance tests.

2 ECALL ARCHITECTURES

2.1 UpTo Date EENA Emergency Call Architectures

Without eCall equipped vehicle regulations, there exist six main emergency system architectures at the current status based on EU-Countries.

- Model-1: Emergency Calls EROs handling (Austria, France, Germany, Italy, Norway)
- Model-2: Filtering stage-1 PSAP and resource dispatching stage-2 PSAPs (UK, Ireland, Netherland)
- Model-3: Data Gathering by stage1 and resource dispatching by stage2 (Romania)
- Model-4:Data Gathering by stage PSAP1 and resource dispatching by stage PSAP2 in an integrated control room (Madrid, Ostrava, Belgium, Turkey)
- Model-5: ERO Independent PSAP (Finland)
- Model-6:Interconnected PSAP (Czech Republic, Bulgaria, Sweden)

These current architectures are figured in Figure 2. In this paper, the next generation of Model-1, ‘Emergency Calls EROs handling’ which is the current status of Italy, Norway, Germany, France and Austria is investigated based on Italy infrastructure.

On the other hand, there exists one more model which is not used in any country at the current status which includes control room of PSAP (17) service with 1 ERO (14 or 15 or 16 or 18). It can be called as Model-7.

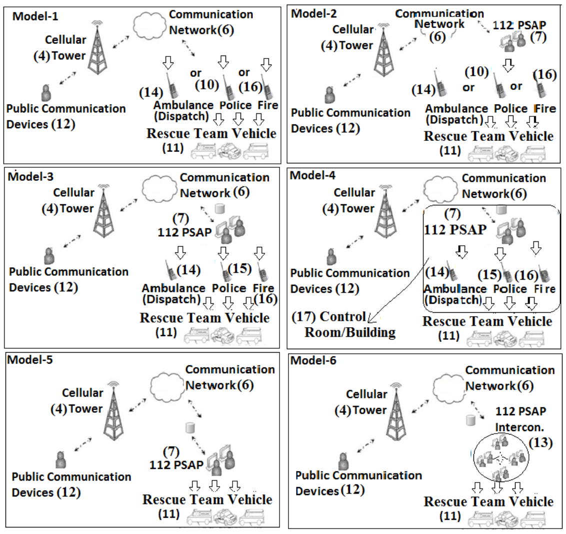

Figure 2: EENA Current Emergency Call Architectures.

2.2 Next Generation Emergency Call Architectures

After eCall legislation of the vehicles, EU-2015/758; emergency call structures need to be adapted or modified into the systems in Figure-2. New Emergency call cases are analyzed with respect to eCall receiving's. New system receiving-types are listed below:

- Type-1: 112 PSAP Receiving's (Current Status-in Figure-2)
- Type-2: 112 PSAP and Manual/Automatic ECall PSAP Receiving's
- Type-3: All PSAPs (112 PSAP, Manual eCall PSAP and Auto Ecall PSAP) Receiving's

Types are combined with current models in Table-1.

Table 1: Number of New ECall System Architectures.

Model/Type	Type-1	Type-2	Type-3
Model-1	1	0	0
Model-2	1	1	1
Model-3	1	1	2
Model-4	1	2	5
Model-5	1	3	5
Model-6	1	1	2
Model-7	1	1	2

Table-1 shows the total number of new architecture types after eCall equipped vehicle regulations.

2.3 Next Generation Emergency Call Architectures of Current "Emergency Calls EROs Handling" System (Italy)

"Emergency Calls EROs Handling PSAP" model was explained in Figure-2 with Model-1 in which its infrastructure does not include any PSAP service externally due to the fact that one of Rescue Service is working as PSAP. According to Model-1 infrastructure property, 33 Architecture types in Table-1 can be filtered. After the variant filtration, 12 architectures can be applied to Italy which has the "Emergency Calls EROs Handling PSAP" model. The optimal 6 of 12 architectures via cost models are analyzed and decided with the simulation, which is shown in Figure-3. The details of simulation study are explained in Part-3.

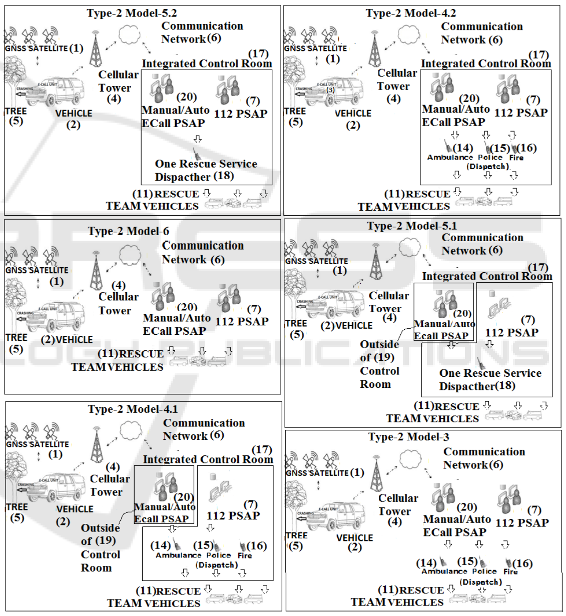

Figure 3: Possible New ECall System Architectures for "Emergency Calls EROs Handling PSAP" Model.

In Figure-3, Type-2 Model-5.2 has an integrated control room concept (17) includes manual/auto eCall PSAP (20) and 112 PSAP (7) with one rescue dispatch unit (18) when Type-2 Model-4.2 includes the same PSAP types (7, 20) with all rescue units (14, 15, 16). Next, Type-2 Model-6 includes only two PSAPs as Manual/Auto eCall PSAP (20) and 112 PSAP (7) in which both giving responses to emergency calls and making dispatches to the rescue service vehicles (11). Type-2 Model-5.1 has the 112 PSAP for call-response and one rescue service unit (18) for the dispatch process in integrated control room/building (17) when Manual/Auto Ecall PSAP (20) is out side of the Control Room (19). Type-2 Model-4.1 has the same structure with Type-2 Model-5.1, but the only the difference is that includes the all rescue services (14, 15, 16) in the integrated control room (17). Finally, Type-2 Model-3 has Manual/Auto eCall PSAP (20) and 112 PSAP (7) for call response and making dispatches with rescue stations (14, 15 and 16).

Taking these architectures into consideration, they will be analysed with respect to: (i) intelligent vehicle system, (ii) eCall component in the vehicle, and (iii) infrastructure system costs in Part-3; then the study result will be evaluated in Part-3.4 and Part-4.

3 OVERALL COST MODEL

3.1 Terms and Definitions

The logical approach in the cost model is associated with the vehicle specifications (30, 31), eCall component (33) and eCall system infrastructure (32) is shown in Figure-4.

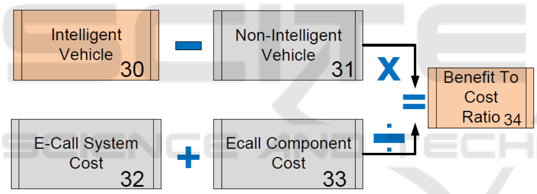

Figure 4: Cost-Model Approach.

In Figure-4, intelligent vehicle is defined as intelligent vehicle safety system includes the smart technologies for pre-crash, post-crash and crashing.

ECall is a post crash item and it will be analyzed in this study. Other technologies in the vehicles will be investigated with equipment rates which show the percentage rate of vehicle technology increasing year by year. As it is shown in Figure-4, the benefit is analysed with the difference of smart vehicle (30) and vehicle without smart properties (31). It includes all status such as transportation, vehicle technology rates, saving life in accidents etc. Next, System cost defines the infrastructure costs (32) of whole system which is described in Figure-1. Finally, E-Call component (33) is the device integrated to the vehicle. The calculation with the function of benefit (process 30 and 31) and total consumption (32, 33) enables to see the benefit to cost ratio (34).

First of all, vehicle process (30, 31) definitions will be explained as it is shown in Figure-5.

General vehicle system in Figure-5 describes the vehicle system for both intelligent vehicle (30) and non-intelligent vehicle (31). The only differences between them are the parts; 39 (Accident Severity), 43 (Time Cost) and 41 (Accident Cost).

Benefits come from these parts for post-crash eCall items such as life savings, time savings. Vehicle system is investigated with three groups which are data and maps, subsystems and total costs. Data and maps are the inputs of the systems which are 35 (equipment rate), 36 (vehicle mileage), 37 (collision probability), 38 (speed and fuel data) and 39 (accident severity).

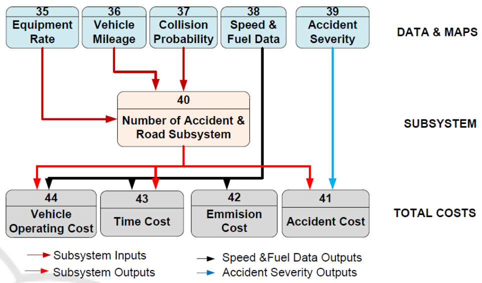

Figure 5: General Vehicle System (30, 31).

Subsystem is defined with item-40 which includes the calculations of number of accident and road conditions. All these subsystem and inputs create the total costs which are 41 (Accident Costs), 42 (Emission Costs), 43 (Time Costs) and 44 (Vehicle Operating Costs).

Ecall component cost (33) defines the equipment costs which are adapted to the vehicle after the regulations.

Ecall system costs explain the infrastructure cost of whole eCall system and it can be summarized with Figure-6.

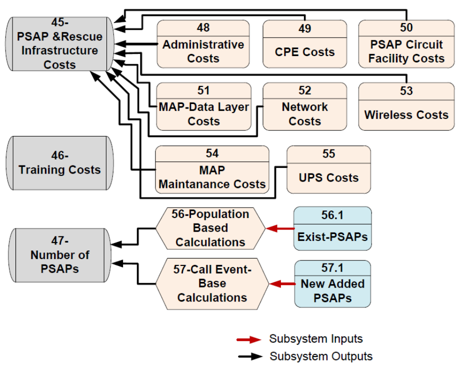

Figure 6: Infrastructure System Costs (32).

There are 3 main subgroups in Figure-6. These are 45 (PSAP & Rescue Infrastructure Costs), 46

(PSAP & Rescue Persons' Training Costs) and 47 (Number of PSAP workers). Item-45 includes 8 subsystems which are 48 (administrative costs), 49 (Customer Premise Equipment Costs), 50 (PSAP Circuit and Facility Costs), 51 (Map & Data Layer Costs), 52 (Network Costs), 53 (Wireless Costs), 54 (Maintenance Costs) and 55 (Unit Power Supply Modules Costs).On the other hand, number of PSAPs (47) are calculated by two methods; population-based (56) and call-event based (57). Population-based calculation provides the exist-PSAPs data when call-event base calculations enable next generation PSAPs such as Manual, Automatic eCall PSAP.

When item-48 in Figure-6 defines the personal costs of services, item-50 calculates the1 event prices and office costs. In addition, map and data layers (51) are the software programme requirements of the worker computers and workstations. Next, network costs (52) define the all database and charges about frame relay network when item-53 is the wireless communication network.

3.2 Intelligent Vehicle Safety System

General overview of the vehicle system in all system structure is defined at last section 3.1 with Figure-4 and Figure-5. In this section, all parts will be investigated in details.

-Equipment Rate (35)-

Equipment Rate is the rate of vehicle stock (VS) divided by equipped vehicle stock (EVS) as it is shown in f1. Equipment rate in the vehicle defines the smart technology rate of the vehicle.

$$Eq.Rate = (EVS/VS)*100 \qquad (f1)$$

Eq. Rate is explained for EU-25 Countries year by year by ACEA. Equipped vehicle stock depends on old registered vehicle stock (EVS') and diffusion rate (dR) which describes the technology difference between intelligent vehicle and non-intelligent vehicle. EVS formula is shown in f2.

$$EVS = EVS' + dR \qquad (f2)$$

The author calculation with the data support of ACEA-report shows that 2015 year Eq. Rate is 46 percent when it is 76 percent in 2020.

-Vehicle Mileage (36)-

Vehicle Mileage is calculated by carrying good or passenger in transportation. Country transportation data which is for Italy in this paper is calculated by author with the data support of world transport report. When passenger transportation is 478 MKm in 2018, good transportation is about 98 MKm and vice versa.

-Collision Probability (37)-

It is the function of collision types and driver reactions. The Collision Study of Enke Probability is applied in this paper which includes three types of collisions with the probability data. These are collisions at intersections, oncoming traffic collisions and rear end collisions. When minimum data in the cost model is 0.1 % at collisions at intersections, maximum data is nearly 75 % at oncoming traffic collisions.

-Speed & Fuel Data (38)-

Driving statistics in the study of Andre'1999 with the road types such as rural, urban and motorway are applied to this cost model and its simulation with two factors; road type and vehicle type. When minimum and maximum values for all vehicles in urban ways are between 23 and 49 km/h, it is between 39 and 87 for passenger cars and light duties in rural ways. Next, rural way rates for heavy duty vehicles are between 40 and 77 km/h. Finally, the motorway rates for light duty and passenger cars are between 91 and 109 km/h when it is between 76 and 84 km/h for heavy duties.

-Accident Severity (39)-

Accident severity is analysed in three sections; slight injury, severe injury and fatality rates.
This rate is calculated by author with the data support of e-merge project in 2004. It enables to see that intelligent vehicle fatality rates can be decreased to 0.9 from 1 which enables to save life and decrease big amount of costs. This decrease may cause to increase the severe injury or slight injury rates from 1 to 1.1. But its consumption cost is not high. According to IRTAD Annual Report, unit cost of fatality is around 1503000 € when severe injury unit cost is 197000 € in Italy. Next, slight injury unit cost is about 17000 € in Italy. It shows the cost difference between fatality unit cost and injury unit costs.

-Number of Accident and Road Subsystem (40)-

Accident rates are analysed via being EU-Countries or EU-Accending countries. Accident risks are defined with the table-2.

In this paper, the roads of Italy which has the "Emergency Calls EROs handling" model are 487,700 km includes 6700 km of express ways is rated in the simulation via being rural, urban and motorway.

-Total Vehicle Costs (41, 42, 43, 44)-

Accident Costs (41) are calculated by the multiplication inputs of accident cost unit rates (defined in speed section), accident severity (39) and number of accidents (40).

Table 2: Risk of Accident in Different Road Categories (Author Calculation with the data support of European Commission 2003a report).

Country	Road Type	Accident Risk (per Billion-Km)
EU-25 Best Perform	Motorway	2-4
	Rural	2-5
	Urban	3-5
EU-25 Worst Perform	Motorway	9-15
	Rural	12-15
	Urban	15
EU-Accending	Motorway	10-20
	Rural	13-22
	Urban	17-24

Moreover, operating costs (44) are measured by operating basic costs and fuel consumption costs. Operating basic cost is calculated by multiplication of fixed-operating costs with vehicle mileages (36). Fixed-operating costs are the unit rates of vehicles such as 9.16 €/100km for cars, 14.19 €/100 km for trucks, 45.90 €/100 km for busses. Fuel costs are enabled by two sections: (i) annual rate of road-fuel consumption in the country, which will be 29.416 10^9Liters in Italy in 2018 and it was 30.408 10^9liters in 2015. It is multiplied with Fuel consumption constant which is 10 in the calculation and these all numbers are divided by fuel consumption factor. This factor is decided by Lam Formula and its default value is 0.0075. (ii) Second section is calculated by the multiplication of annual rate of country-fuel consumption which is 29.416 10^9Liters in Italy in 2018 and fuel consumption unit rate. Fuel consumption unit rate is decided by fuel volume type (net or gross) and fuel type (gasoline or diesel). It is 0.189 €/litres for diesel and 0.185 €/litres for gasoline.

Next, time cost (43) is calculated by vehicle mileage calculated in road subsystem (40) is divided by speed function (38).

Finally, emission cost (42) is calculated with the multiplication of total fuel consumption in the roads which is 29.416 10^9Liters in Italy in 2018, emission cost unit rate, emission constant (9.54 for gasoline and 9.45 for diesel) and emission factor. Emission cost unit rate is reviewed via CO2 and NOx. CO2 unit rate is 0.205 €/1kg-CO2 when Nox price is announced by European Commission ExternE programme. Finally emission factors are provided by emission handbooks.

3.3 Infrastructure System Cost (32)

Infrastructure system cost which is defined in Figure 4 is formulated in f3.

$$ISC = \left(\frac{dr*(1+dr)^{bt}}{((1+dr)^{bt})-1}\right)*OSc*np)+Tc \qquad (f3)$$

In f3, ISC is infrastructure system cost when OSc describes the overall system cost. Next, np is the number of PSAP while Tc is the training costs of emergency service workers. By the way, dr is discount rate and bt is the depreciation period. Discount rate is assumed as 3% when depreciation period is about 8 years.

Numbers of PSAP calculations are explained with NENA Standarts which describes the population 0-19000 with small size PSAP, 19000-100000 with Medium size PSAP and 100000-140000 with large size PSAP. In addition, The author calculation with the data support of NENA standards and its membership report shows that small size PSAP includes the workers between 7 and 11, medium size PSAPs include the workers between 12 and 20, and large size PSAPs include the workers between 21 and 50. With these information, total population of Italy which is 61.336 Million is rated via being county and city; then *current np* in f3 (56.1) is calculated. Moreover, total call events due to the accidents after ecall equipped vehicle regulations are enabled by IRTAD road-accident annual report 2014 for Italy to decide the newcomer calls due to the accidents; and then these events enable to calculate new PSAP numbers (*next generation np*) and PSAP worker numbers (npw). Italy road accidents in 2012 are 186726 in the report and these events are rated with author calculation to decide the number of new PSAP and its workers in Italy. As a conclusion, number of PSAPs and number of PSAPs' workers in the current system and in next generation system are calculated with population of Italy (56) and accident-events (57) in IRTAD road safety annual report with the author calculation.

PSAP training costs (Tc) are measured with the unit costs of EU-Expenses which enable the unit costs of meals, accommodations and travels. The unit costs are multiplied with number of PSAP workers (npw) and results are defined for total cost.

OSc in f3 which is defined in Figure-6 is explained with its 8 subsystems. Administrative costs are decided by the conversion of number of eCall events (nce) to number of PSAP workers (npw). 'nce' is 186726 in IRTAD 2014 report which is 2012 data. 'npw' conversion is created by author calculations with the process mentioned after f3. Administrative costs are in f4.

$$Ad = (npw*Lc*wh*(nad+ntd))+msc \qquad (f4)$$

In f4, Ad is the administrative costs, npw is the number of PSAP workers, Lc is the hourly labour cost, wh is the working hour, nad is the number of available days, ntd is the number of training days and msc is the membership prices in Italy.

Map and Data Layer Costs (51) in OSc includes the software prices of call takers' and dispatchers' computers. It includes purchase costs, map-upgrade costs, replacements and software maintenance costs.

Network costs (52) in OSc are the frame relay network, its equipment and terminal line costs.

UPS Costs (55) in OSc covers uninterrupted power supply modules of PSAPs which has the costs of module hardware and its maintenance.

Wireless communication costs (53) in OSc include wireless equipments, wireless service charges, databases, pseudo automatic number identification charges and accuracy testing.

PSAP Circuit and Facility Costs (50) in OSc is contented by emergency call-event costs and office costs if there is any new-opened offices. Unit costs of events in a minute is rated between 0.3 € and 0.6 € when the wrong calls are between 0.1 € and 0.2 €. Nevertheless, workstation places are calculated with the unit costs of 400 € and 600 € per m^2 for EU-Countries with the supporter data of NENA member state report. Moreover, workstation areas are defined between 34 to 76 m^2 per small size PSAPs, 85 to 380 m^2 per middle size PSAPs and 340 to 969 m^2 per large size PSAPs.

3.4 Cost Model Simulation Results: Possible next Generation "Emergency Calls EROs Handling" Model, Italy

All architectures and cost models are analysed in Matlab/Simulink environment with the related properties: (i) fuel types are investigated by being diesel or gasoline (ii) fuel volume is net volume, (iii) emission standards are EU-6, (iv) eCall event time duration between 1.5 minute and 2 minutes, (v) driver reaction in the accident probability between 0.5 second and 3 seconds, (vi) fuel consumption parameters via Lam Formula, (vii) unit price of ecall components between 100 € and 150 € with 8 years bt and 3 % dr, (viii) PSAP bt is 20 years with 3 % dr, (iix) working hour rates between 8 and 12 hour, (ix) worker cost calculations with EU-agency rules, (x) unit costs are rated by NENA membership reports, (xi) equipment rates are measured with ACEA rates, (xii) Country populations are loaded from World Bank real data, (xiii) transportation is analysed with being good or passenger for all type of vehicles, (xiv) simulation is analysed with the year 2018 data (xv) all type of ways (rural, urban and motorway) are analyzed with all type of injuries; slight, severe and fatality.

Simulation in Matlab/Simulink environment is studied in three subgroups:

- Status in Urban Way with Slight Injuries in Italy
- Status in RuralWay with Severe Injuries in Italy
- Status in Motorway with Fatalities in Italy

In Figure-7, next generation architectures which are explained in Part-2.3 in Figure-3 are studied in the simulation in Matlab/Simulink environment. With its simulation results, they are sequenced with respect to their benefits and low system costs. BCR is the benefit to cost ratio and analyzed for all three subgroups. APV is the annuity Present Value defines the net benefit for new eCall notification system. APV is the calculation of whole benefit in the system described in Figure-4. The last section of Figure-7 is the overall system costs which define the costs of current status in Italy emergency services and the new architecture units' annual cost.

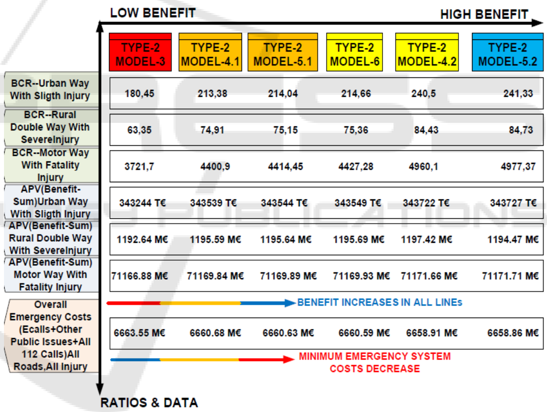

Figure 7: Simulation Results of Architecture Cost Model.

In Figure-7, BCR and APV values for three subgroups has the best value in Type-2 Model-5.2. Type-2 Model-4.2 is the second option of next generation architecture for "Emergency calls EROs handling" in Italy. Next, Type-2 Model-6 can be the third alternative to apply. Benefit to Cost Ratio is changing between 180 and 241 for slight injuries in urban ways when it is between 63 and 84 for severe injuries in rural ways. Moreover, benefit to cost ratio is high as between 3721 and 4977 for fatalities in motorways which shows the importance of saving life and the difference of accident cost unit rates described in Part-3.2. When APV is changing between 343244 T€ and 343727 T€ in urban ways, it is between 1192.64 M€ and 1194.47 M€ in rural ways. Next, it is between 71166 M€ and 71171 M€ in motorways. On the other hand, overall emergency costs are between 6663.55 M€ and 6658.86 M€ in all hands. (T€=10^3 €, M€= 10^6 €)

As a conclusion, Italy can choose the next generation architecture with the sequence below: (i)The best option: Type-2 Model-5.2; (ii) 2nd Option: Type-2 Model-4.2; (iii) 3rd Option: Type-2 Model-6; (iv) 4th Option: Type-2 Model-5.1; (v) 5th Option: Type-2 Model-4.1 (vi) Worst- option of these optimal six architectures: Type-2 Model-3.

4 CONCLUSION & FUTURE WORKS

This paper advises the optimal solution of next generation architecture for “Emergency Calls EROs Handling” Model. Its architecture selection is described in Part-2.3 in Figure-3 and cost model simulation results are explained in Figure-7. Its optimal solution is Type-2 Model-5.2 in Italy after ecall equipped vehicle regulations in 2018.

Future work can describe the next generation eCall system architectures of other EU-Countries to give an advice for the optimal architecture selection.

Future work can make deep-dive on the response and dispatch types with the simulation of call-taker and dispatcher behaviour. This type of study enables to see the time and life saving rates in details.

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