

# Identifying Loopholes in Emergency Response Plans with STECA. An Application.

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# Need to effectively manage crises and disasters

- Develop contingency plans based on standards.
- The disaster plan is the principal connection between the disaster planning activity and the disaster response. *(Perry, 2004)*
- Most plans are lengthy with the philosophy to anticipate every possible event. This is not possible. *(Perry, 2004)*
- Give a false sense of safety or preparedness.
- Thus, the systems which are formed based on these plans occasionally fail to perform as desired.



# The problem

- Identifying loopholes in response plans after a disaster has occurred.



**I should have thought about that**

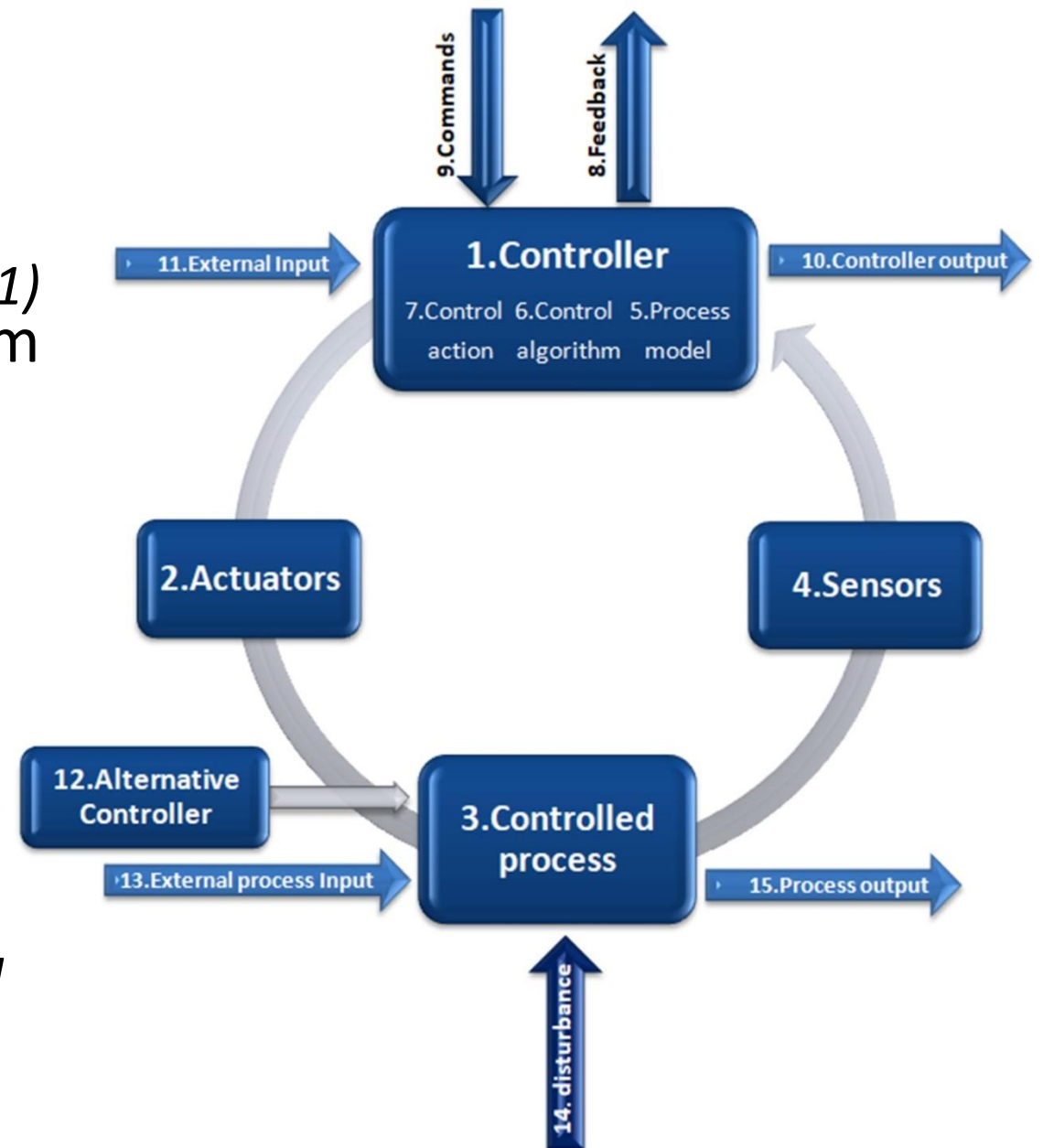
# STECA method

## *Systems Theoretic Early Concept Analysis*

According to **STAMP** (Leveson, 2004, 2011) safety is an emergent property of system and treats safety as a control problem.

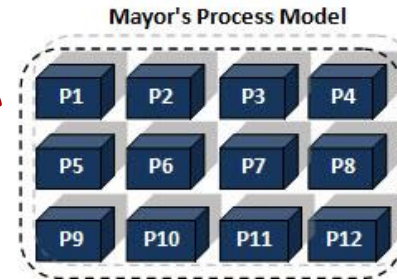
### Three Phases

1. *Hazard identification and derived safety constraints*
2. *Systematic Control Model Development*
3. *Systems-Theoretic Analysis of Model*

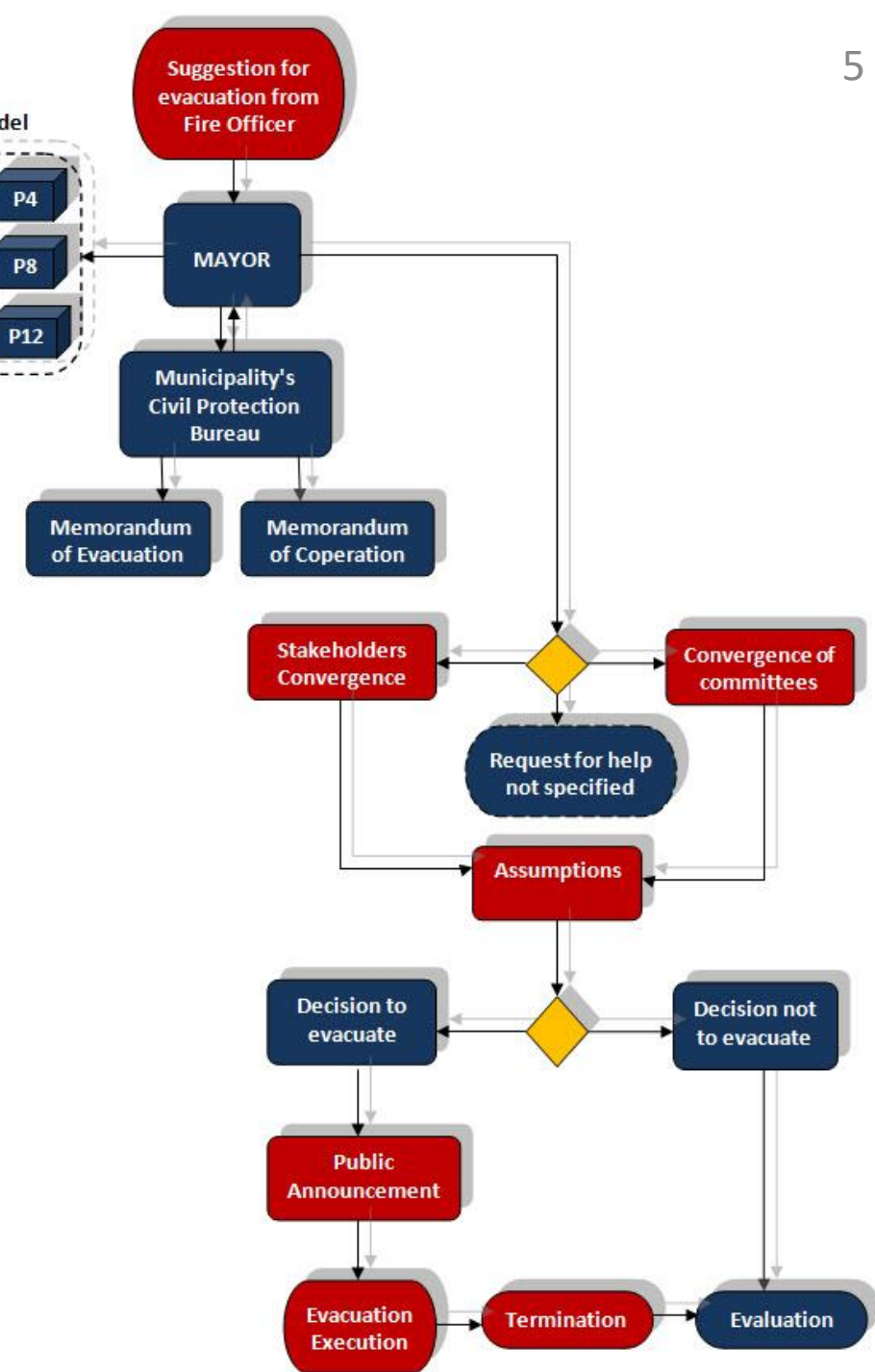


# Application of STECA

## *A Case Study*



STECA was applied to the plan issued by the General Secretariat of Civil Protection of Greece and concerns the evacuation process which takes place during a dangerous forest fire as shown in the flow chart.



# Phase 1

## *Hazard identification and derived safety constraints of the system*

- [H-1] Evacuation is not applied when required.
- [SC-1] The system must perform the evacuation when required.
- [H-2] The area is not effectively evacuated.
- [SC-2] The system must perform the evacuation effectively when required.

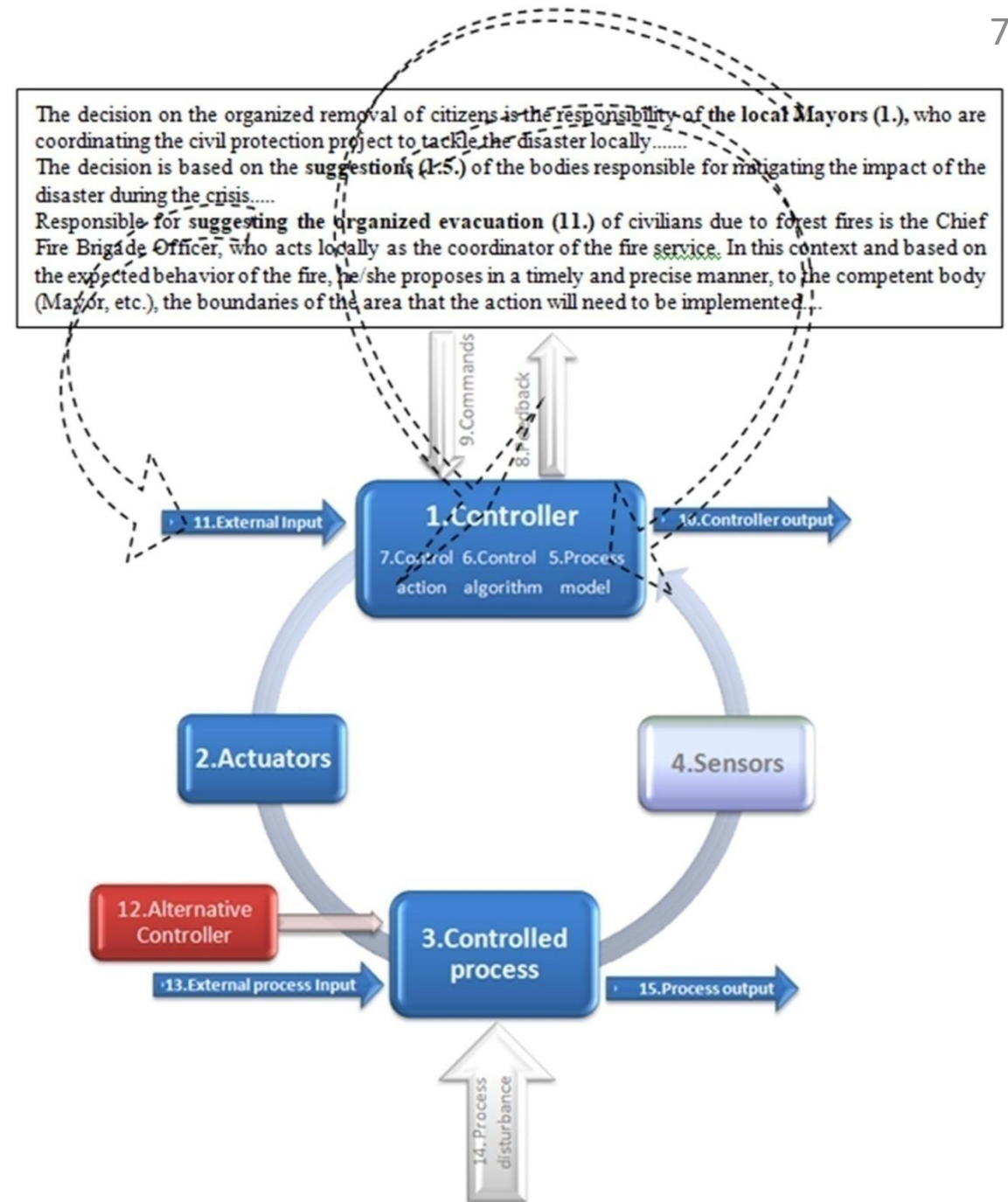


# Phase 2

## Systematic Control Model Development

### • *Identification of Control Concepts*

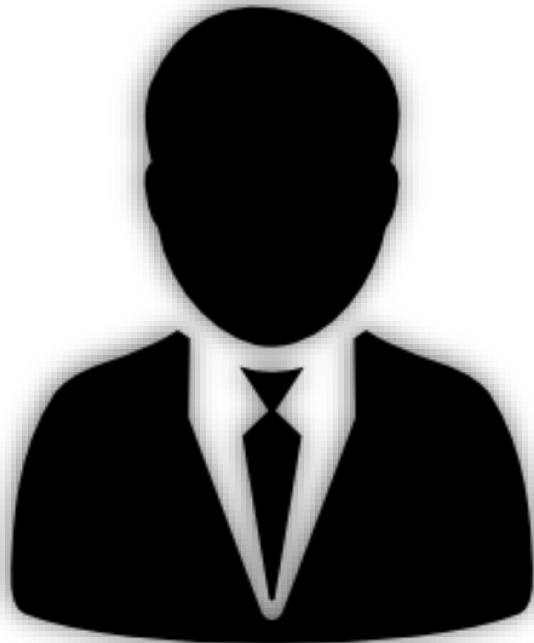
During this step the text that constitutes the plan is analyzed (parsed).



# Systematic Control Model Development

Table with entities in the Control Loop  
after parsing.

**Mayor as Controller**



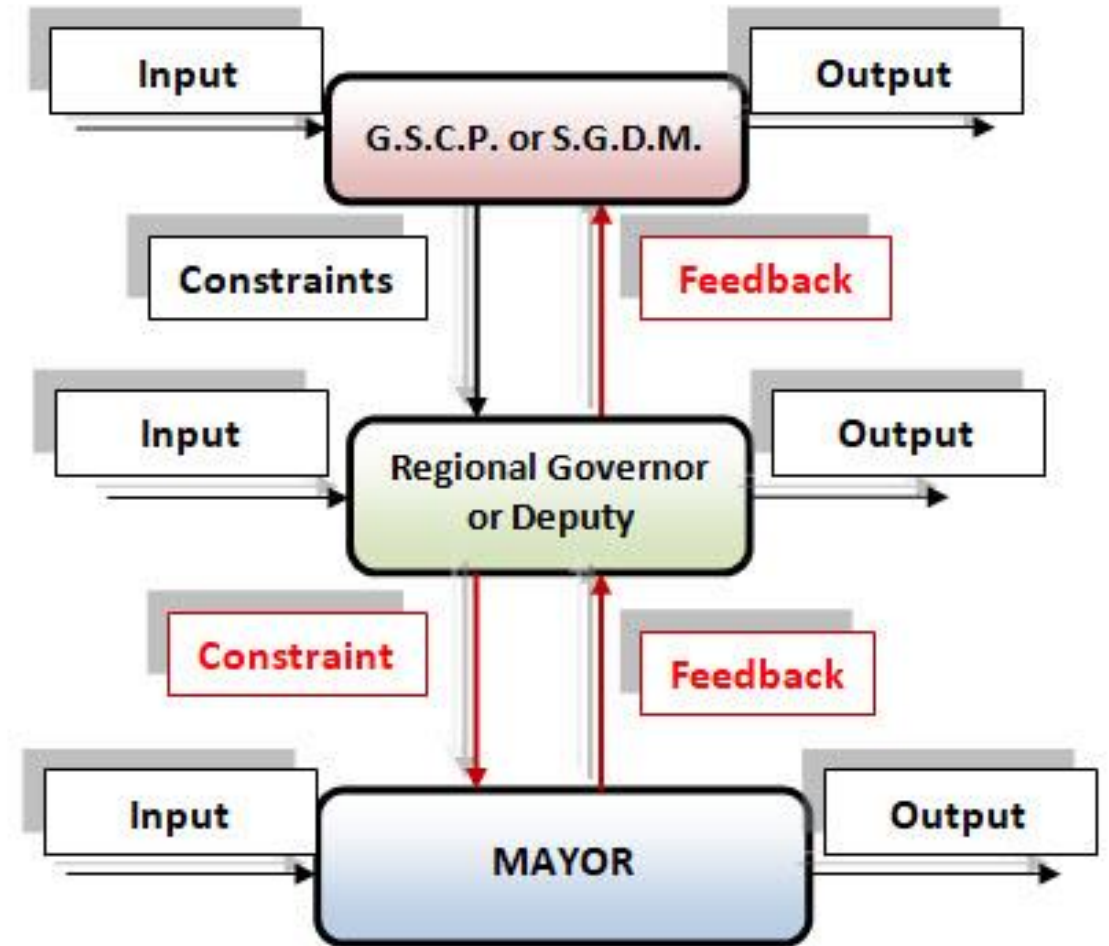
S/N	Entity	Description	8
1	Controller	Mayor: 1.Coordination 2.Meeting with stakeholders 3.Convergence of MLCC 4.Evacuation decision 5.Announcement to the public 6.Evacuation order	
2	Actuator	Police, Employees, Port Authorities	
3	Cntl'd Process	Organized removal of citizens from the area which is estimated to be threatened by an evolving or imminent disaster due to forest fire	
4	<b>Sensor</b>	<b>Not mentioned</b>	
5	Process Model	Decision variables P1 to P12	
6	Cntl Algorithm	<ul style="list-style-type: none"> <li>➤ The risk of staying in is greater than the risk of evacuating (if <math>R_s &gt; R_e</math> then Evacuate)</li> <li>➤ Ensure timely organization of safe evacuation (if TimeEvac = true then evacuate else not evacuate)</li> <li>➤ Early provision of means of transportation for evacuation (if Trans = true then evacuate else not evacuate)</li> <li>➤ Securing communications between stakeholders</li> </ul>	
7	Control Actions	<ul style="list-style-type: none"> <li>➤ Order to inform citizens about evacuation (announcement)</li> <li>➤ Evacuation order</li> </ul>	
8	<b>Controller Status (feedback)</b>	<b>Not mentioned</b>	
9	<b>Control Input (constraints)</b>	<b>Not mentioned</b>	
10	Controller Output	Announcement to the public through local media	
11	External Input	Fire Brigade Coordinating Officer 1. Suggestion for evacuation 2. Boundaries of the area to be evacuated	
12	Alt Controller	Regional Governor or Deputy Governor, General Secretary of Civil Protection or Secretary General of Decentralized Management	
13	Process Input	Evacuation of Nursing Institutions, Children's Country camping sites, Holy Monasteries, Archaeological Sites, Hotel Units, Army and Security Forces Facilities	
14	<b>Process Disturbance</b>	<b>Not mentioned</b>	
15	Process Output	Evacuation of people, assets etc.	



# Systematic Control Model Development

## • *Control Information Synthesis into System Hierarchy*

In systems theory it is inappropriate to analyze individual control loops and then make a determination about the overall behavior of the system (Fleming, 2015).



**Red Color Indicates Missing Elements i.e. Hierarchical Control Actions and Feedback of the Process**

# Phase 3

## Systems-Theoretic Analysis of Model

Identification of potential causal factors to losses and to possible hazardous scenarios. Classification of hazardous scenarios into three groups:

- Due to incomplete control loop
- Due to gaps or conflict in safety-related responsibilities
- Due to lack of coordination or consistency among multiple controllers

To analyze these scenarios, the analyst asks questions such as

- a. Are the control loops complete?
- b. Does each control loop satisfy a Goal Condition, Action Condition, Model Condition, and Observability Condition?
- c. Are the system-level safety responsibilities accounted for, or are there gaps?
- d. Do control agent responsibilities conflict with safety responsibilities?
- e. Do multiple control agents have the same safety responsibility(ies)? etc to analyze the system (Fleming, 2015).



# Safety Constraints or Loopholes

[H-1] Dangerous Scenario A.2: The Field Officer of the Fire Brigade does not make suggestion for evacuation in time.

Scenario A.2.1:

He cannot communicate with the Mayor

*Causal Factors:*

- The Mayor is missing or has health problems or his phone does not work.
- There is no predetermined way of direct communication between these two.

Scenario A.2.2

The Field Officer does not know whom to address to in the absence of the Mayor (eg Deputy Mayor? Regional Governor? Deputy Regional Governor? etc.)

*Causal Factors:*

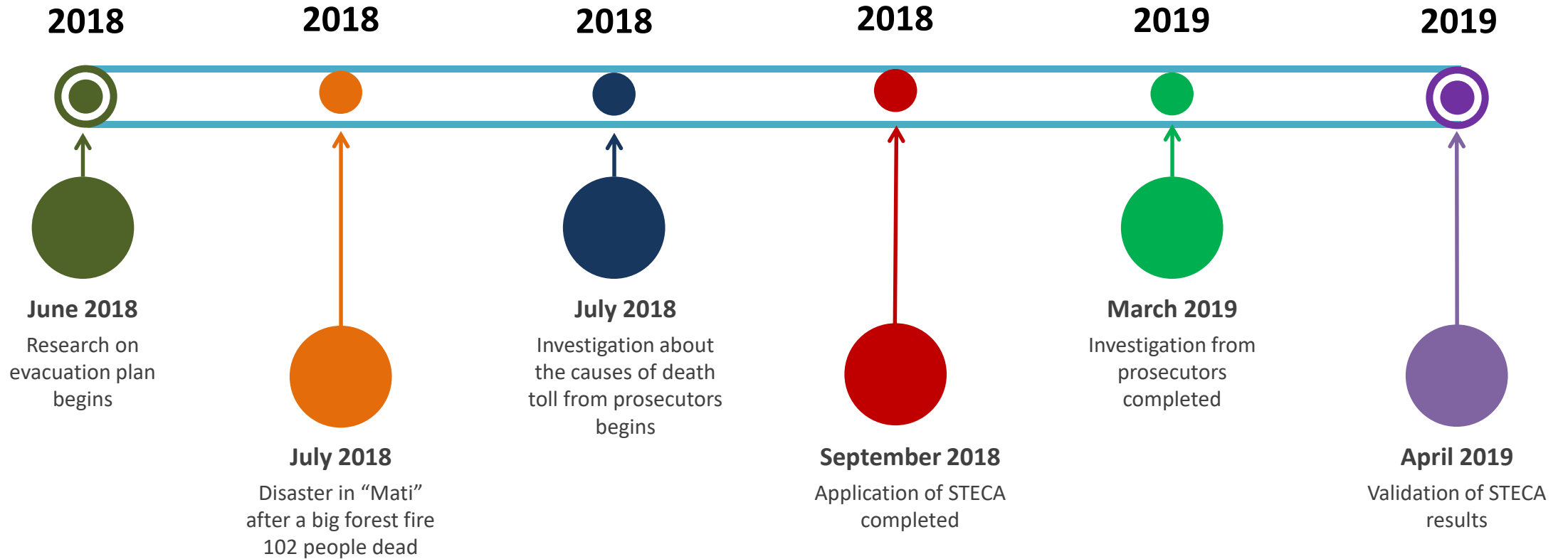
- It has not been predetermined who replaces the Mayor in case of absence

## **Improved Safety Constraints [SC] or loopholes**

[SC-A.2.1] An alert or communication system between the Mayor and the Fire Brigade Service must exist.

[SC-A.2.2] The Field Officer must know who replaces the Mayor in a successive or a hierarchical manner.

# Timeline of Research Validation



# Results & Conclusion

- STECA identified thirty one loopholes
- Fifteen (two of which coincide with the same safety constraint) out of the thirty one identified loopholes were validated by the findings of the prosecutors after the tragedy in "*Mati*" area in Athens-Greece.
- STECA identified sixteen additional loopholes.
- Conclusion: STECA can be used to evaluate emergency plans and to effectively identify important missing elements.
- Innovation: STECA for the first time is used in the **context of crisis management.**



# Limitations

- Quality analysis: The method does not show numerical values/indicators that can be used to measure and calibrate the gaps that exist in emergency response plans.
- The method should apply whenever there is an update of the plan.
- Requires participation of system experts to help with the analysis.



# Validation Results (STECA -Prosecutor Findings)



S/ N	Safety Constraints	F1 Gap Theory- practice	F2 Coordination problems	F3 Time	F4 Communication	F5 Lack of cooperation	F6 Public announcement	F7 Disorderly evacuation	F8 Problems with the chief of ground forces	F9 Control action	F10 Lack of feedback			
1	SC1.1	All safety constraints apply	A d d i t i o n a l S T E C A i m p r o v e m e n t											
2	SC1.2		A d d i t i o n a l S T E C A i m p r o v e m e n t											
3	SC1.3									Common				
4	SC1.4		A d d i t i o n a l S T E C A i m p r o v e m e n t											
5	SC1.5		A d d i t i o n a l S T E C A i m p r o v e m e n t											
6	SC1.6		A d d i t i o n a l S T E C A i m p r o v e m e n t											
7	SC1.7		A d d i t i o n a l S T E C A i m p r o v e m e n t											
8	SC2		A d d i t i o n a l S T E C A i m p r o v e m e n t											
9	SC3		A d d i t i o n a l S T E C A i m p r o v e m e n t											
10	SC4.1						Common							
11	SC4.2						Common							
12	SC4.3						Common							
13	SC5.1		A d d i t i o n a l S T E C A i m p r o v e m e n t											
14	SC5.2		A d d i t i o n a l S T E C A i m p r o v e m e n t											
15	SC5.3		A d d i t i o n a l S T E C A i m p r o v e m e n t											
16	SC6					Common								
17	SC7		A d d i t i o n a l S T E C A i m p r o v e m e n t											
18	SC8										Common			
19	SC9		A d d i t i o n a l S T E C A i m p r o v e m e n t											
20	SC10							Common						
21	SC11.1		A d d i t i o n a l S T E C A i m p r o v e m e n t											
22	SC11.2		A d d i t i o n a l S T E C A i m p r o v e m e n t											
23	SC12								Common					
24	SC13								Common					
25	SC14		Common										Common	
26	SC15		Common											
27	SC16		Common											
28	SC17					Common						Common		
29	SC18		A d d i t i o n a l S T E C A i m p r o v e m e n t											
30	SC19		A d d i t i o n a l S T E C A i m p r o v e m e n t											
31	SC20		A d d i t i o n a l S T E C A i m p r o v e m e n t											

# Basic Findings of Prosecutors After the Tragedy in "Mati" Area, Greece



S/N	Finding	Description
F1	Gap between theory and action	In theory everything worked very well, but in practice virtually nothing worked as planned, and the whole management was spasmodic, without any coordination.
F2	Coordination problems	Image of total confusion and absolute lack of coordination between the ones responsible
F3	Time	If the decision to evacuate had been taken at 17:00 pm, the chances of organized removal would have been "extremely positive".
F4	Communication	Absolute lack of communication.
F5	Lack of co-operation	Lack of co-operation of the stakeholders involved.
F6	Public announcement	The absence of any information to the residents of the area, who were left to burn alive.
F7	Disorderly evacuation	Under the circumstances, even disorderly evacuation would be preferable.
F8	Problems with the chief of ground forces	"complete confusion and ignorance of the real situation and the image of the fire front in the various settlements", "they did not know who the fire chief was any time"
F9	Control action	They attribute to the police a "formal" state of readiness prior to the fire, which "was only at the level of forecasts and documents, without actually being executed".
F10	Lack of feedback	The Region authorities had to ask for all the information needed to form an image of the situation.



# Safety Constraints (All Controllers) 1

S/N	Safety Constraints	Description
1	SC 1.1	The Field Officer of the Fire Brigade must have proven good knowledge of the procedures provided by the General Secretariat of Civil Protection
2	SC 1.2	The Field Officer of the Fire Brigade should know whom he/she should address to and make his/her suggestion for evacuation
3	SC 1.3	The Field Officer of the Fire Brigade should be able to act as a manager on multiple occasions and processes
4	SC 1.4	The Field Officer of the Fire Brigade should be able to act quickly and in a very short period of time
5	SC 1.5	The Field Officer of the Fire Brigade should be well aware of the area in which He/She serves and the natural boundaries of the Municipalities and Regions
6	SC 1.6	The Field Officer of the Fire Brigade should know who successively replaces the Mayor or the Regional Governor
7	SC 1.7	The Field Officer of the Fire Brigade should know which senior hierarchical unit he/she will address to and make his/her suggestion for evacuation if communication is not feasible
8	SC 2	It is necessary that the plan ensures who is ultimately the one to whom the Fire Brigade Officer will make his/her suggestion for evacuation: to the Regional Governor or to the Deputy Governor?
9	SC 3	It should be clearly stipulated who is responsible for the Evacuation Decision (if needed): the Secretary General for Civil Protection or the Deputy Secretary General of Decentralized Management and also when and to which of those two persons the Field Officer of the Fire Department will make his/her suggestion for evacuation
10	SC 4.1	An alert-communication system between the Mayor, the Fire Service Dept., the members involved and the members of the Coordinating Committees. (including their replacements) should apply

11	SC 4.2	An alert-communication system between the Regional Governor or the Deputy Governor, the Fire Service Dept., the members involved and the members of the Coordinating Committees. (including their replacements) should apply
12	SC 4.3	An alert-communication system between the members of the Central Coordinating Committee (including their replacements) should apply
13	SC 5.1	A special meeting place in the Municipality or a mobile one should be determined in advance
14	SC 5.2	A special meeting place in the Region or a mobile one should be determined in advance
15	SC 5.3	A special meeting place in the Regional Unit or a mobile one should be determined in advance
16	SC 6	The response time of the system is a critical factor and the minimum time required for taking the decision for the evacuation process should be determined
17	SC 7	For the service agents involved in the evacuation process, working in a 24 hour basis in shifts, should apply during the whole year
18	SC 8	The progress of Civil Protection Agency's work (and also the staffing) should be checked (a) by the Mayor at regular intervals (b) by the Regional Governor or the Deputy Governor at regular intervals because it is a critical Agency
19	SC 9	One of the key stakeholders in the meeting should be an environmental agency that will be able to measure the atmosphere, smog, air particles, etc.
20	SC 10	It is necessary to ensure the "common language" (training in the competence of the other stakeholders) between the bodies with different competencies

# Safety Constraints (All Controllers) 2



21	SC 11.1	It is necessary to ensure in the contingency plan who is the superior hierarchical unit of the Mayor and also to ensure that there is an interaction (orders, feedback, etc.) between the hierarchical superior and the Mayor
22	SC 11.2	It is necessary to ensure in the contingency plan who is the superior hierarchical unit of the Regional Governor or the Deputy Governor and also to ensure that there is an interaction (orders, feedback, etc.) between the hierarchical superior and the Regional Governor or the Deputy Governor
23	SC 12	A system of alerting the public by the use of technology (mobile phones, loudspeakers, etc.) should be established
24	SC 13	A Memorandum of Cooperation with the Media should be foreseen.
25	SC 14	The controllers (Mayor, Regional Governor, Deputy Governor, etc.) in order to be able to co-ordinate the parties involved, should have direct information from a specific person or persons (sensor) about the evolving situation of the evacuation at any time
26	SC 15	The controllers (Mayor, Regional Governor, Deputy Governor, etc) should in some way be given the possibility of giving direct orders to other bodies who are responsible to execute during the evacuation process
27	SC 16	An on-the-spot coordinator should be appointed to be able to give direct instructions to workers of different Bodies in order to achieve better coordination
28	SC 17	In the contingency plan, after taking into account the "time" factor, individual times should also be determined to achieve the purpose of the evacuation. Also, different scenarios should be considered: "If available Time < Required Time then go to contingency plan B.
29	SC 18	In advance, a specific way of communication and coordination should also be identified with those responsible of the facilities inside the evacuation area (Nursing Institutions, Children's Excursions, Camps, Holly Monasteries, Archaeological Sites, Hotel Units, Armed Forces and Police Corps Units)
30	SC 19	At the members of the stakeholders, the responsible ones for the livestock of the evacuated area should also be added
31	SC 20	A Memorandum of Actions should be drawn up providing for actions on livestock



**ΔΗΜΟΚΡΙΤΕΙΟ  
ΠΑΝΕΠΙΣΤΗΜΙΟ  
ΘΡΑΚΗΣ**

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# Thank you!

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