Cybersecurity Essentials and Management for Energy Sector

CSP001_C_E

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Acknowledgement

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- *Project Agreement no. 101083594*

Topic-3: Energy Sector Threats and Vulnerabilities

Overview

- Identify and categorise common energy cybersecurity threats, such as malware, ransomware, phishing, and social engineering
- Recognise the specific vulnerabilities that energy systems face, including outdated software, weak passwords, and unpatched vulnerabilities
- Energy sector specific threats and vulnerabilities include targeted attacks on SCADA systems, smart grids, and other critical energy assets
- Understand the role of human error and insider threats in energy cybersecurity

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Common threats in energy systems

- In 2013, ENISA launches the report "*Smart Grid Threat Landscape and Good Practice Guide*" with a comprehensive study about threats in Smart Grids
- However, the number of threats has risen sharply in recent years, as reflected both by
  - The attack matrix given by MITRE ATT&CK, and
  - ENISA annual reports about the threat landscape in the diverse fields

Source: ENISA, "Smart Grid Threat Landscape and Good Practice Guide", December 2013
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  - The attack matrix given by MITRE ATT&CK, and
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- Based on these sources, we classify the threats in this sector using the traditional **AIC + A**
  - Availability
  - Integrity
  - Confidentiality
  - Authentication

Source: ENISA, "Smart Grid Threat Landscape and Good Practice Guide", December 2013
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Common threats in energy systems

- More specifically, "**AIC + A**" threats refers to:
  - **(A) Availability**: Denial of Services (DoS) or lack of proper use of assets
  - **(I) Integrity**: Modification of legitimate assets of the system or generation of fake data or configurations
  - **(C) Confidentiality**: Unauthorized access to legitimate assets of a system, containing private or sensitive information
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- For AIC+A, we will explore three different trends
  - **Traditional threats** that still arise in power systems
  - **Recent threats** in power systems
  - **Future threats** in power systems

COMMON TAXONOMY

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  - **Traditional threats** that still arise in power systems
  - **Recent threats** in power systems
  - **Future threats** in power systems
- The affected targets may be:
  - **Energy** - infrastructure / grid
  - **Control** – cyber-physical components
  - **User/organisation** – sensible information

Traditional threat trends in power systems

Current threat trends in power systems

Future threat trends in power systems

Traditional threat trends in power systems

Current threat trends in power systems

Future threat trends in power systems

Common threats to AIC+A in power systems – *Traditional trends*

- Some of the most common and traditional threats in power systems are as follows:

Traditional threats	Description	A	I	C	A	Affects to / final impact: Energy	Control	User
Causal threats	Any unintentional threat caused by an unforeseen exploitation of a failure/error, natural disaster, or an **undeliberate human action**	X	X	X		**X**	X	X

  - Given that human errors is seen as one of the most potential threats in the coming years, we will see in more detail in the point "***Understand the role of human error and insider threats in energy cybersecurity***"

Source: ENISA, "Smart Grid Threat Landscape and Good Practice Guide", December 2013, URL: https://www.enisa.europa.eu/publications/smart-grid-threat-landscape-and-good-practice-guide

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Nefarious activity, abuse	Any malicious action that may address penetration, intrusion, authorisation use/access to assets, impersonation, manipulation of assets, falsification of data, data leakage, DoS or infection	X	X	X	X	X	X	X

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Eavesdropping, interception, hijacking	Any activity that entails interception in the communications, Man-in-the-Middle (MitM), reconnaissance, information gathering, relays of messages, etc.		X	X	X		X	X

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Traditional threat trends in power systems

Current threat trends in power systems

Future threat trends in power systems

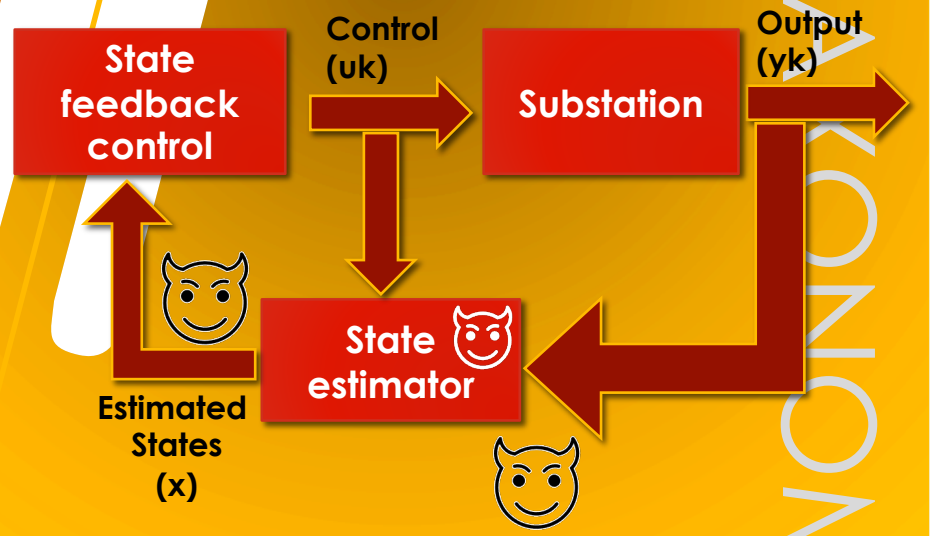
COMMON TAXONOMY

Common threats to AIC+A in power systems – *Current trends*

- More recent threats include:

Current threats	Description	A	I	C	A	Affects to / final impact: Energy	Control	User
False Data Injection (FDI) attacks	Any falsification about the control state to alter the performance of the infrastructure. This may range from the falsification of C&C packets to inject fake meter measurements to the state estimations		X			X	X	X
Stealthy FDI attacks	Any FDI action but in a stealthy manner		X			X	X	X

- There are some FDI attack strategies, which are based on:
  - **Power flow**: Attack models aim to change the linearity of the power flow
  - **Architecture**: FDI attacks modify measurements received and manged by state estimator/s. In centralized systems, the target is the state estimator (1 single element)
  - **Methodology**: Modification of measurements depending on the level of knowledge of the context, such as topology information, grid topology, or data models applied (e.g., ML and its inference)



Source: H. T. Reda, A. Anwar, A, N. Mahmood, Z. Tari, "A Taxonomy of Cyber Defence Strategies Against False Data Attacks in Smart Grids", ACM Computing Surveys, 55(14s), 1-37, 2023

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Stealthy FDI attacks	Any FDI action but in a stealthy manner		X			X	X	X
Malware	Software intended to manipulate the normal operation of systems, without the knowledge or authorisation of the users who own those systems	X	X	X	X	X	X	X

  - There are many types of malware: virus, worms, trojans, ransomware, …
  - The goals of the malware may be very varied, from the exfiltration/disclosure of sensitive information to isolation or destruction of critical assets (e.g., controllers)

Source: ENISA, "ENISA Threat Landscape 2023", 2023,
URL: https://www.enisa.europa.eu/publications/enisa-threat-landscape-2023

Common threats to AIC+A in power systems – *Current trends*

- **Virus**: a self-replicating software code that, when executed, 'spreads' in the system, massively infecting other software components, mainly executables – it is required human intervention
- **Worm**: is also a self-replicating software code but without the need for human intervention
- **Trojan / backdoor**: a hidden malware, whose codes are not able to self-replicate their actions or infect other programs, but are executed and controlled remotely by malicious entities to achieve privilege escalation, information leakage, modification of services and data, etc.
- **Ransomware**: malicious code designed to block access to the system until a ransom is paid for it (obtaining the session key and encryption conditions)
  - The technique focuses on encrypting information on the system

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Social engineering	Techniques to psychologically disclosure of sensitive information for penetration or intrusion such as security credentials or access mode			X	X		X	X

- There are many techniques to extract private information such as credentials: **phishing** / **spear phishing** (via the e-mail), **vishing** (via the phone), **HTTPS phishing** (forward to fake website), **pharming** (malware that forwards to the victim to a fake website), **angler phishing** (fake social media posts), etc.

Source: ENISA, "ENISA Threat Landscape 2023", 2023, https://www.enisa.europa.eu/publications/enisa-threat-landscape-2023
Source: FORTINET, "19 Types of Phishing Attacks, Different Types of Phishing Attacks", https://www.fortinet.com/resources/cyberglossary/types-of-phishing-attacks, 2024

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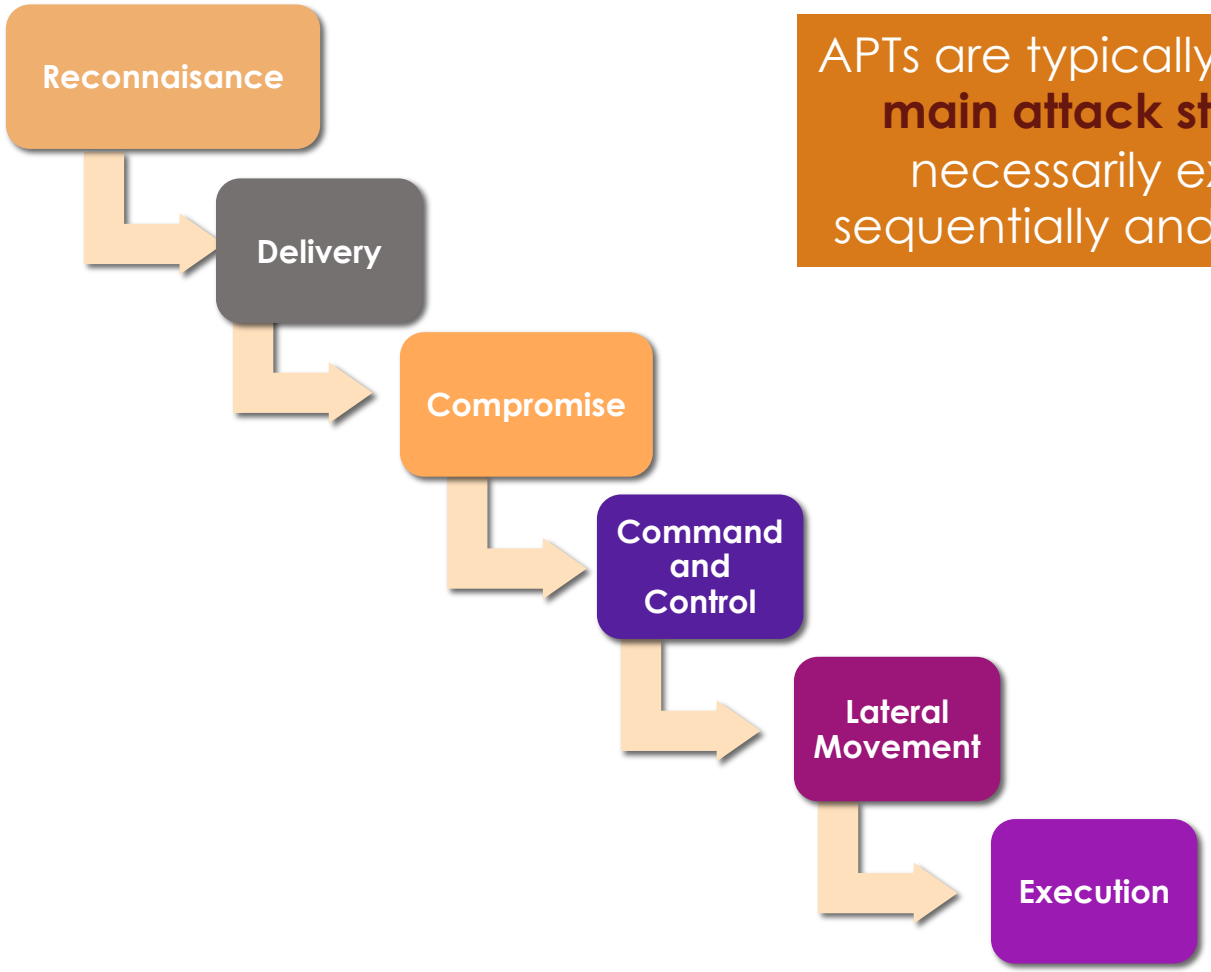
Advanced persistent threats (APT)	An APT is a sophisticated attack, normally executed by resourceful adversaries over a long time period; the aim is to destroy critical devices or exfiltrate sensitive data	X	X	X	X	X	X	X

  - APTs are focused on combining multiple attack vectors that include the exploitation of **zero-day vulnerabilities**, together with "**stealthy**" and evasive techniques

Common threats to AIC+A in power systems – *Current trends*



APTs are typically based on **6 main attack stages**, not necessarily executed sequentially and all of them

Source: J. E. Rubio, R. Roman, C. Alcaraz, and Y. Zhang, "Tracking Advanced Persistent Threats in Critical Infrastructures through Opinion Dynamics", European Symposium on Research in Computer Security (ESORICS 2018) vol. 11098, pp. 555-574, 2018

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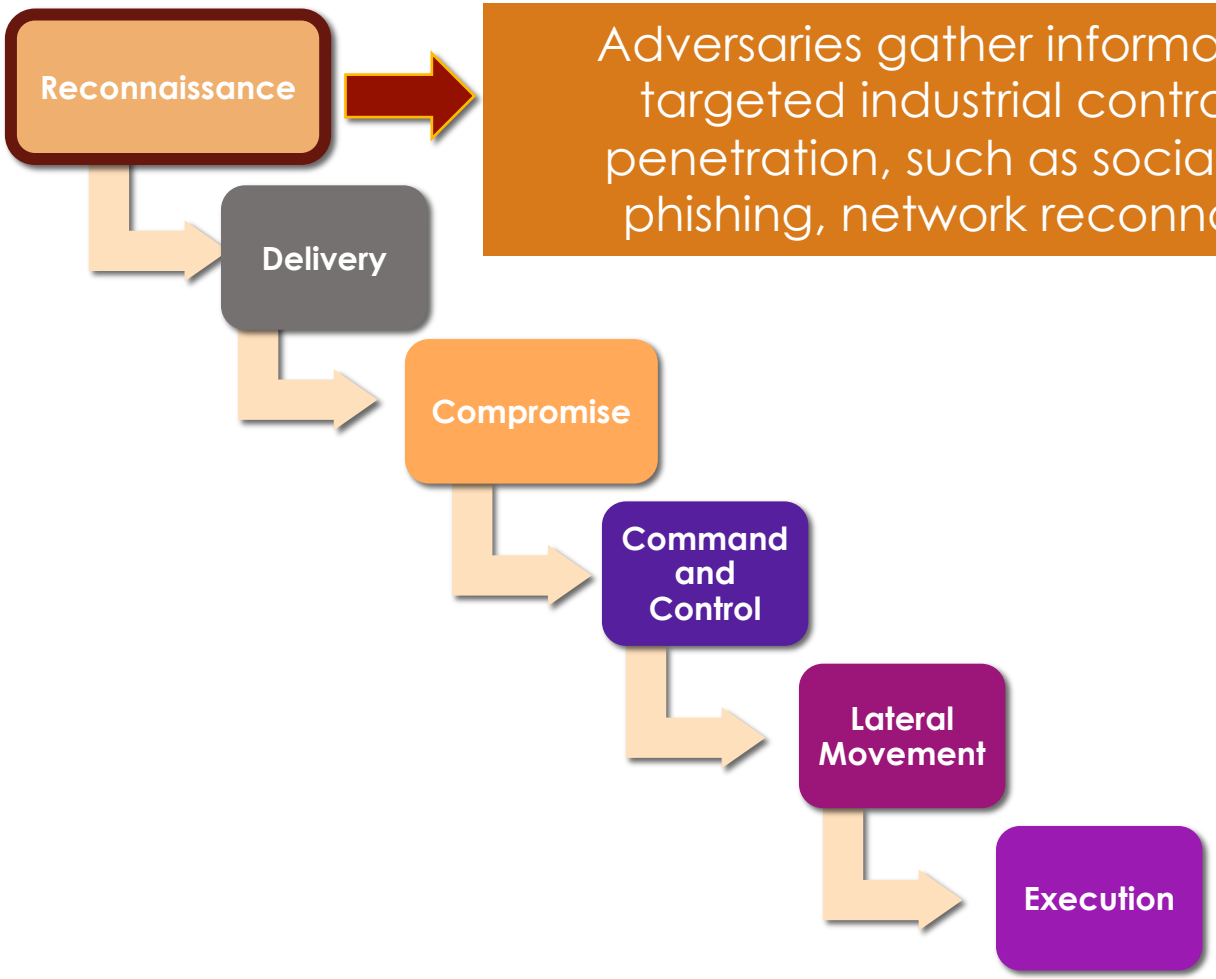

Adversaries gather information about the targeted industrial control network for penetration, such as social engineering - phishing, network reconnaissance, etc.

Source: J. E. Rubio, R. Roman, C. Alcaraz, and Y. Zhang, "Tracking Advanced Persistent Threats in Critical Infrastructures through Opinion Dynamics", European Symposium on Research in Computer Security (ESORICS 2018) vol. 11098, pp. 555-574, 2018

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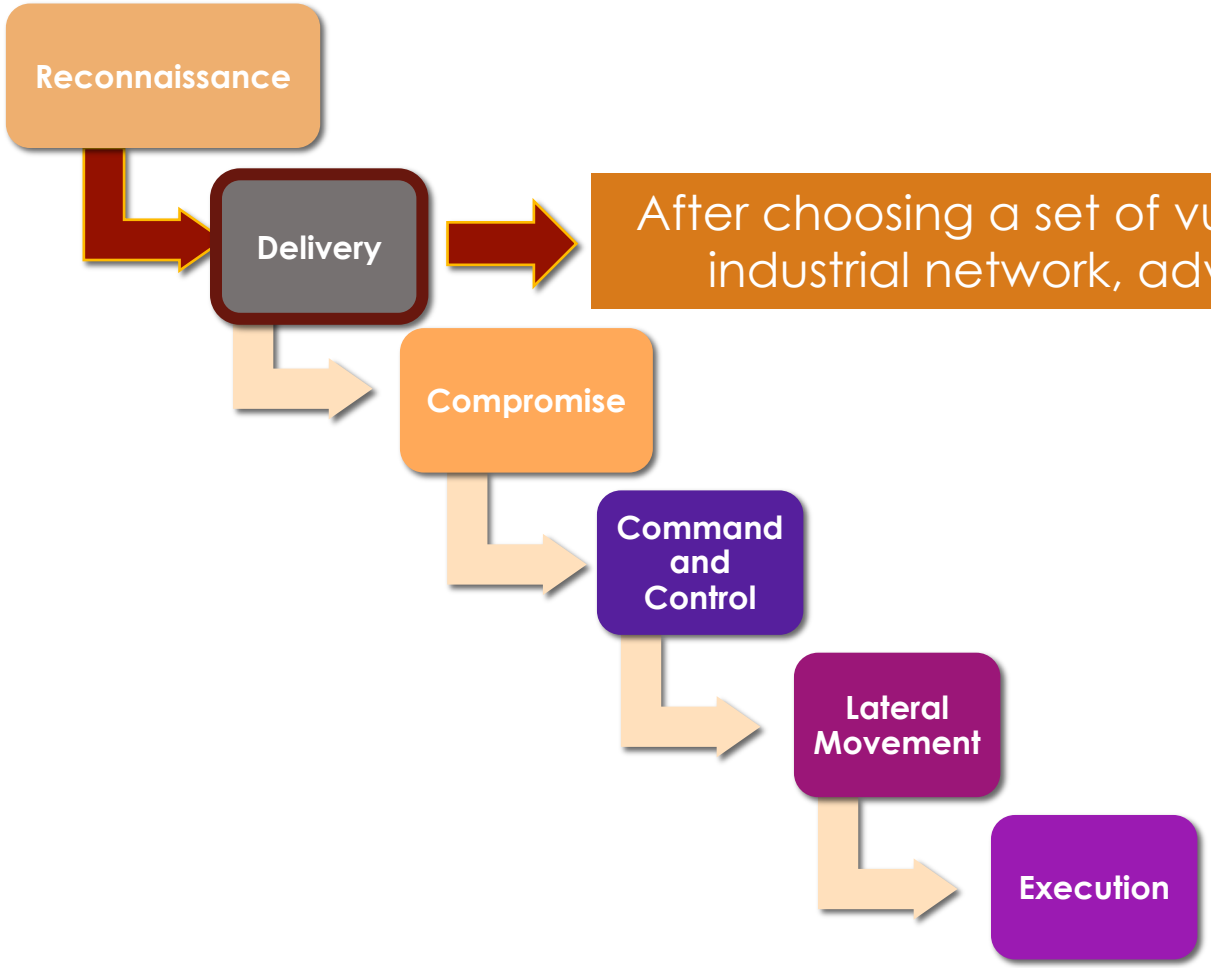

After choosing a set of vulnerable nodes at the targeted industrial network, adversaries deliver the malware

Source: J. E. Rubio, R. Roman, C. Alcaraz, and Y. Zhang, "Tracking Advanced Persistent Threats in Critical Infrastructures through Opinion Dynamics", European Symposium on Research in Computer Security (ESORICS 2018) vol. 11098, pp. 555-574, 2018

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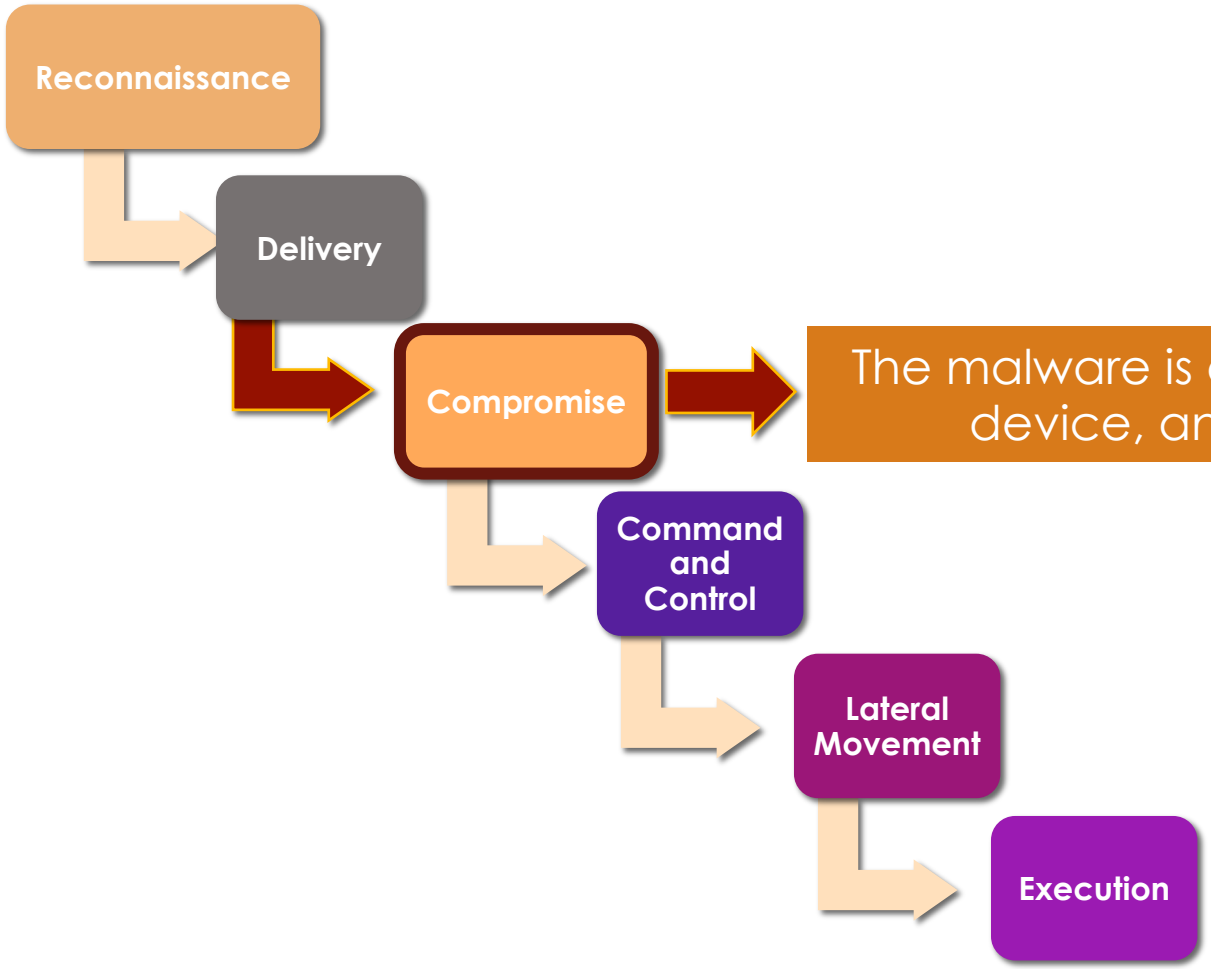
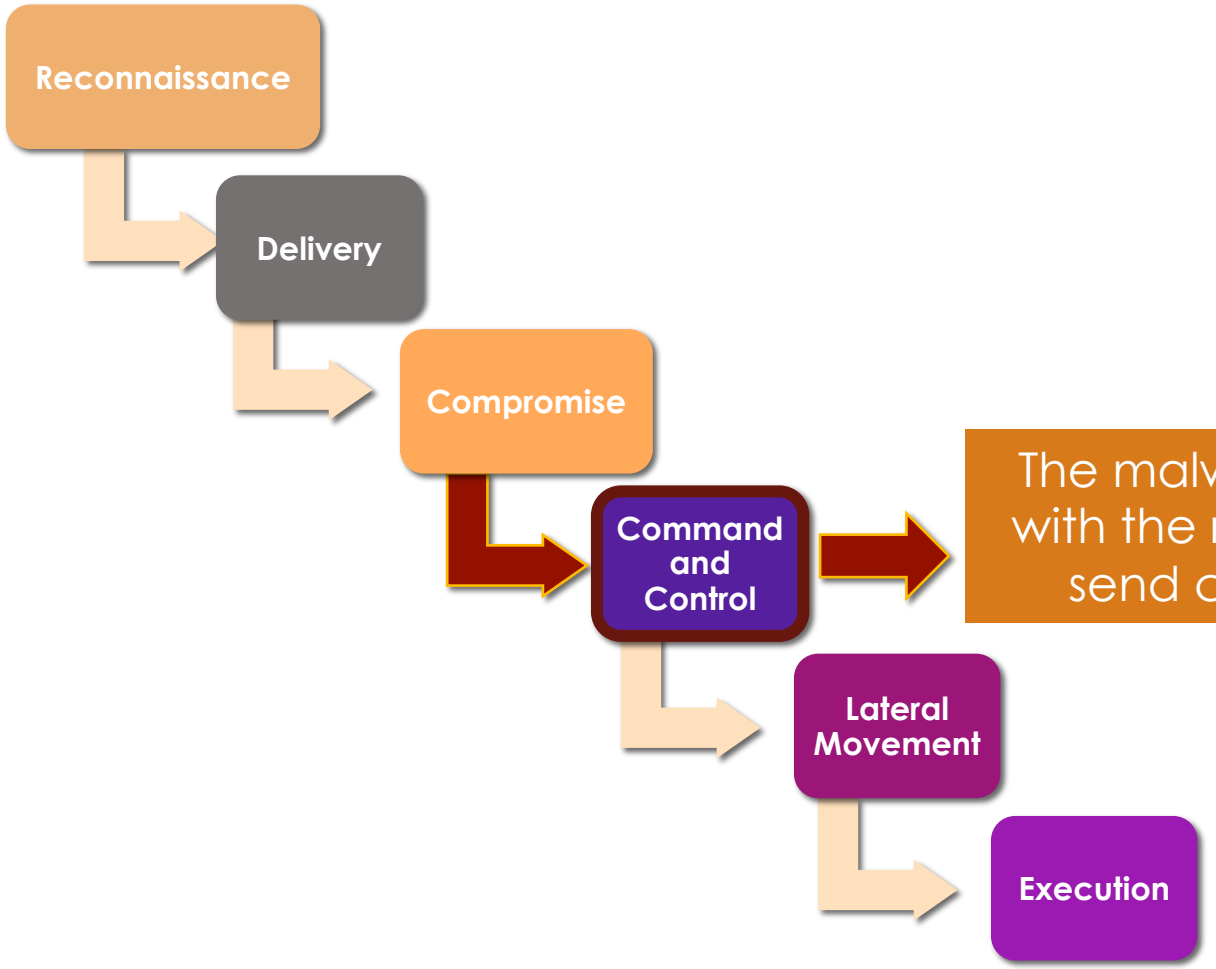


The malware is executed in the targeted device, and takes control of it

COMMON TAXONOMY

Source: J. E. Rubio, R. Roman, C. Alcaraz, and Y. Zhang, "Tracking Advanced Persistent Threats in Critical Infrastructures through Opinion Dynamics", European Symposium on Research in Computer Security (ESORICS 2018) vol. 11098, pp. 555-574, 2018

Common threats to AIC+A in power systems – *Current trends*



The malware opens a communication channel with the remote attacker, which will be used to send commands, extract information, etc.

Source: J. E. Rubio, R. Roman, C. Alcaraz, and Y. Zhang, "Tracking Advanced Persistent Threats in Critical Infrastructures through Opinion Dynamics", European Symposium on Research in Computer Security (ESORICS 2018) vol. 11098, pp. 555-574, 2018

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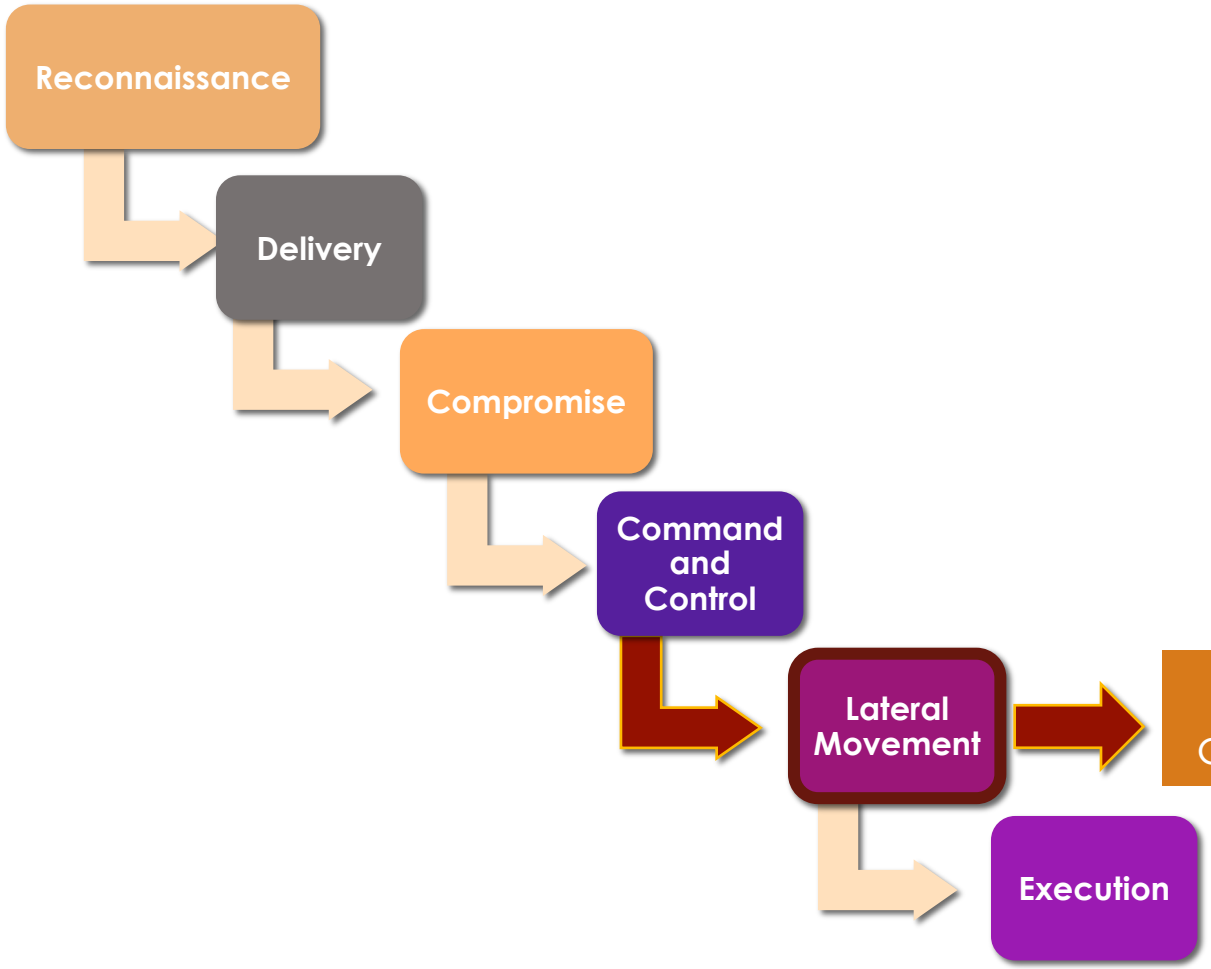

The malware searches other devices to compromise while collecting sensitive information

COMMON TAXONOMY

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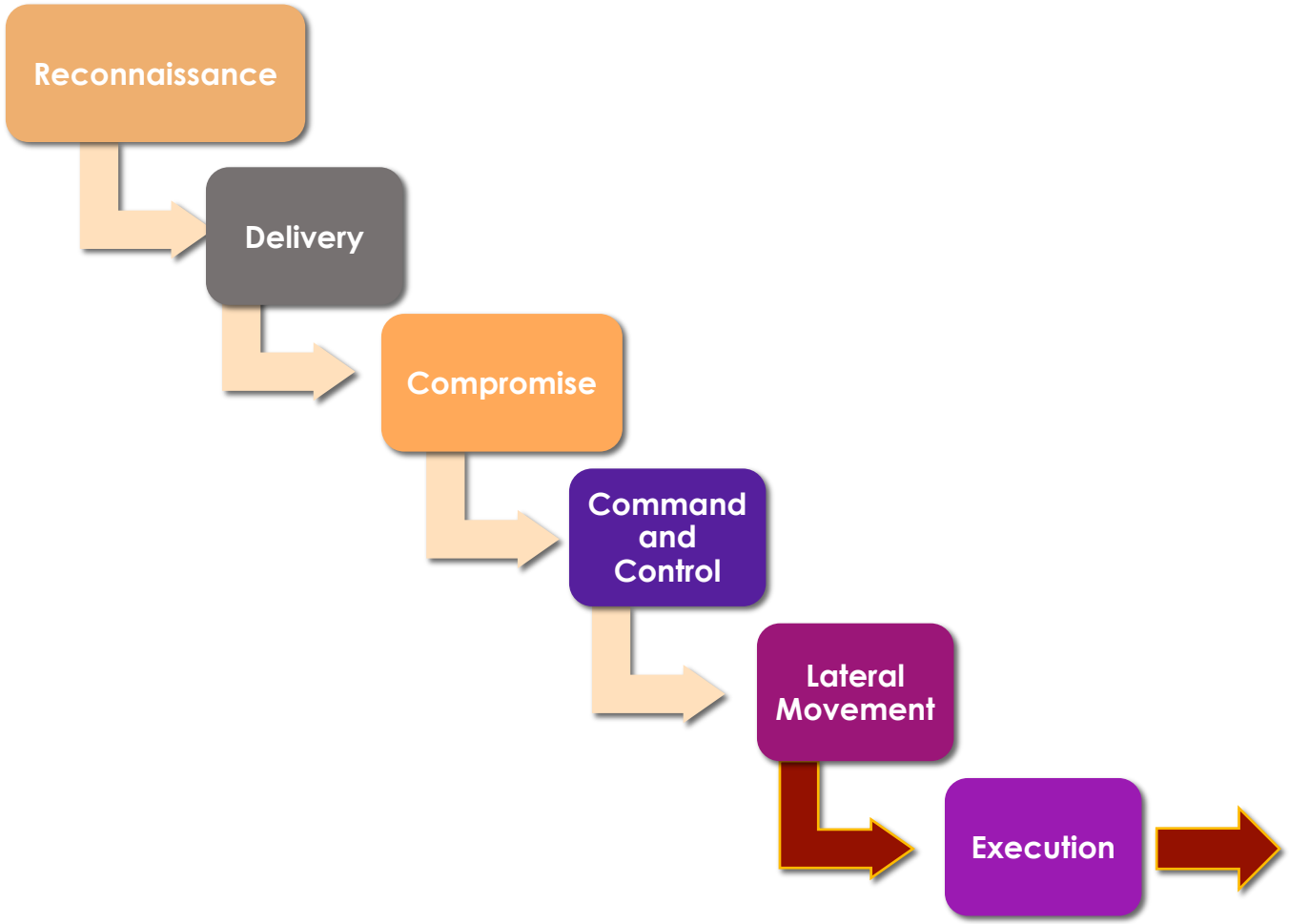
Common threats to AIC+A in power systems – *Current trends*



The malware finally performs the attack against the industrial network, which involves the **extraction of sensitive data or the destruction of resources**

Source: J. E. Rubio, R. Roman, C. Alcaraz, and Y. Zhang, "Tracking Advanced Persistent Threats in Critical Infrastructures through Opinion Dynamics", European Symposium on Research in Computer Security (ESORICS 2018) vol. 11098, pp. 555-574, 2018

Common threats to AIC+A in power systems – *Current trends*

- In order to keep the persistence, the **movements and actions** (e.g., C&C) must be performed **from a stealthy manner**
  - Keeping patience, avoiding abrupt actions/movements, hiding malicious actions/data,...
- There are many attack techniques that disclose information, recognise the environment, or exfiltrate information to other external sites, such as:
  - **Side channel**: analyse data signals in communication channels to physically derive sensitive information transmitted from a network peer to another one
  - **Covert channel**: manipulate targets (e.g., via a malware) and camouflage C&C orders in packets or signals in order to exfiltrate information such as sensor measurements, or send commands to actuators

COMMON TAXONOMY

Common threats to AIC+A in power systems – *Current trends*

- MITRE ATT&CK also provides the tactics and techniques corresponding to MITRE ATT&CK® Matrix for ICS
- As illustrated in the figure, the attack tactics coincide (in the majority) with the kill chain of an APT-type attack

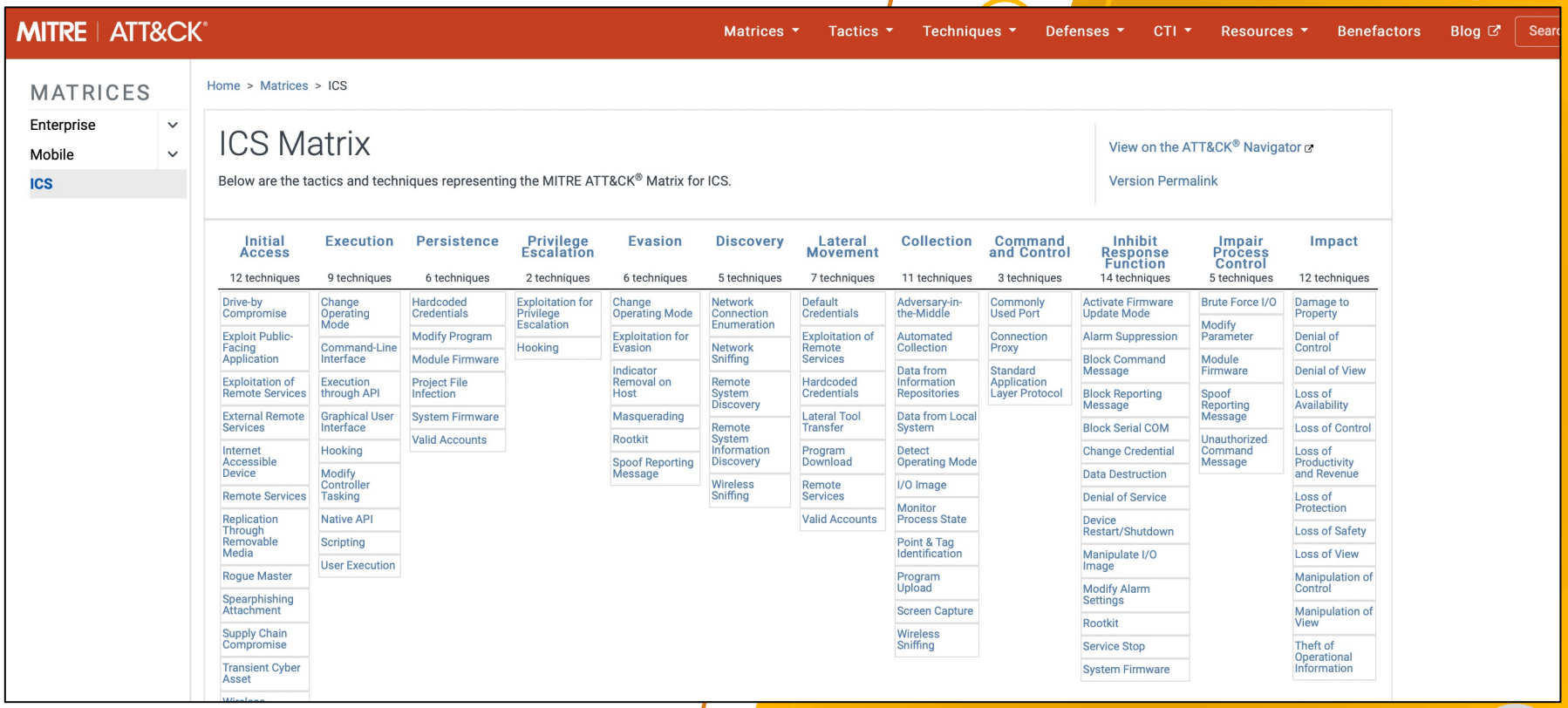


Figure source: MITRE ATT&CK
URL: https://attack.mitre.org/matrices/ics/, 2024

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Advanced persistent threats (APT)	An APT is a sophisticated attack, normally executed by resourceful adversaries over a long time period; the aim is to destroy critical devices or exfiltrate sensitive data	X	X	X	X	X	X	X
Supply chain compromise	Any corruption in the supply chain may compromise the integrity of the software and hardware dependencies, and their trustworthy	X	X	X	X	X	X	X

Source: ENISA, "ENISA Threat Landscape 2023", 2023,
URL: https://www.enisa.europa.eu/publications/enisa-threat-landscape-2023

Traditional threat trends in power systems

Current threat trends in power systems

Future threat trends in power systems (Threats 2030)

COMMON TAXONOMY

Common threats to AIC+A in power systems – *Future trends*

- ENISA's report on "*Identifying Emerging Cyber Security Threats and Challenges for 2030*" forecasts some potential threat trends for 20230

					Affects to / final impact		
Foreseen threats	**A**	**I**	**C**	**A**	**Energy**	**Control**	**User**
Supply chain compromise	X	X	X	X	X	X	X
Disinformation campaigns		X		X			X
Loss of privacy			X				X
Human error	X	X	X		X	X	X
Targeted attacks (led by smart devices)	X	X	X	X	X	X	X
Lack of analysis and control	X	X			X	X	
Advanced hybrid threats	X	X	X	X	X	X	X
AI Abuse	X	X	X	X	X	X	X

Source: ENISA, "*Identifying Emerging Cyber Security Threats and Challenges for 2030*", 2023, https://www.enisa.europa.eu/publications/enisa-foresight-cybersecurity-threats-for-2030

Final remarks

Threat trends	A	I	C	A	Energy	Control	User
Traditional	4	4	4	2	4	5	5
Current	3	5	4	4	5	6	6
Future	6	7	6	5	6	6	7

- We have seen "how" the number of threats in power systems trends to grow, providing a clear overview of:
  - **Traditional** (but persistent) threat trends
  - **Current** trends
  - **Possible** and future trends
- For all of them, we have also explored their impact, and particularly on:
  - **Energy** and its respective infrastructures
  - **Control** including its components and networks
  - **User or organisation**
- In most of cases, "control" may be the most attractive target for attackers
  - Why? Because through control, attackers may lead subsequent attacks against the energy and its resources

SIGNIFICANCE

References and sources

1. ENISA, "Smart Grid Threat Landscape and Good Practice Guide", December 2013
   URL: https://www.enisa.europa.eu/publications/smart-grid-threat-landscape-and-good-practice-guide
2. H. T. Reda, A. Anwar, A, N. Mahmood, Z. Tari, "A Taxonomy of Cyber Defence Strategies Against False Data Attacks in Smart Grids", ACM Computing Surveys, 55(14s), 1-37, 2023
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6. ENISA, "Identifying Emerging Cyber Security Threats and Challenges for 2030", 2023
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7. DeepL Translator for Proofreading.
   URL: https://www.deepl.com/translator

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Thank you

If you have any questions, please do not hesitate to contact:

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  ruben.rdp@uma.es