cyberwatching.eu

The European watch on cybersecurity & privacy

Policy

Cybersecurity and Privacy ecosystem model report

A Taxonomy of Cybersecurity and Privacy to assess the coverage of developed landscape by EC and nationally funded projects

April 2018

Abstract

This deliverable acts as the first in a series of publications over the duration of the Cyberwatching.eu project detailing the process and methodology of quickly mapping and clustering European and national projects in a resilient cybersecurity framework.

Disclaimer

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Executive Summary

Ask a hundred people about cybersecurity, and you will get at least a hundred different opinions about what it actually means. Nonetheless, across all these different opinions one can identify a common theme or concern that are addressed.

One of the objectives of the Cyberwatching.eu project is to support projects in the cybersecurity domain in classifying and clustering themselves and others into meaningful groups of common topics and concerns to generate synergies and collaboration.

The process by which this is achieved involves a two-tier taxonomy of cybersecurity topics, against which European projects, both national and international, are first mapped against the first tier of domains of cybersecurity. Since many projects concern themselves with not only one domain, the three domains in the first tier are ranked accordance to the level of concern in the mapped project: High, medium, low, or not applicable: As a consequence, some projects are entirely out of scope, as the only concern themselves with *using* cybersecurity procedures or technology instead of *addressing* any of them as a concern of its own right.

This prioritised ranking allows the Cyberwatching.eu project to quickly and efficiently bring projects together and facilitate communication and synergies among them, so that the combined outputs will be larger than the mere sum of individual results.

This deliverable is the first in a series of reports addressing this objective of the Cyberwatching.eu project.

Section 1 provides the reader with an introduction into the larger topic and problem space and positions the Cyberwatching.eu project within the cybersecurity research landscape.

Section 2 introduces the reader to the mapping and clustering methodology used in this project.

Section 3 describes the Cyberwatching.eu cybersecurity research taxonomy that underpins the project's mapping and clustering efforts.

Section 4 positions the taxonomy in the wider research landscape, and compares it with other initiatives in this space, such as the NIST Critical Infrastructure Cybersecurity Framework, and the EC Survey Taxonomy. It also introduces a mapping between these three taxonomies.

Section 5 gives a complete account on the mapping and clustering methodology that is used in the Cybersecurity project in order to produce scientifically reproducible and resilient results.

In support to the previous section, Section 6 describes how the Cyberwatching.eu project identified and selected projects it admitted to the pool of mapped European cybersecurity projects.

The deliverable ends with section 7 detailing our next steps over the course of the project, and with section 8 providing conclusions on the results already achieved at this point.

Annexes A and B provide a complete list of all EU projects mapped so far, and the presentation given at the meeting with the EC JRC on comparing taxonomies, respectively.

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1 Introduction

Cybersecurity is a catch all description that is used in many spaces to describe a wide variety of different R&I activities, from the development of theoretical models for cryptography to the management of human computer interactions to ensure privacy is maintained. There are a very wide range of different definitions at the highest level available[1][2][3][4][5]. Alongside these multiple high-level definitions, a number of different frameworks have been developed. These though consider for the most part (NIST, ECSO etc.) how the different actions or activities to respond to a cybersecurity penetration or failure are managed. We feel that this is too deep a consideration and therefore it is still unclear how an R&I project that exists within the cybersecurity space may best reach out to other similarly targeted activities and know that they are going to have a realistic chance of alignment with key ongoing activities that make up the core of the two communicating activities. To give an indication of the scale of the activities in the cybersecurity space, the EC has allocated €600m to projects within this area, whilst the UK government on their own have supported activities worth £2bn. There are, as would be expected, a significant number of projects, both national and international. There is therefore the significant chance of overlap in activities, at best to allowed for shared learnings and at worst to support completely unnecessary duplication of activities.

Alongside the ability to more easily inform projects themselves about the possibilities of technical alignment with other relevant projects we also aim to support funding bodies themselves so they are able to understand the distribution of projects supported across the overall landscape and to identify imbalances which may mean over coverage of a certain area within the domain to the detriment of other parts. An overarching goal of Cyberwatching.eu is accelerating the development and deployment of cyber security and privacy research results and increasing Europe's ability to design and deliver innovative Internet services. In this timeframe, research and innovation projects have spearheaded the development of novel architectures and technologies, which can protect our European Digital Society against cybersecurity threats. Cyberwatching.eu will address these and similar challenges through its observation of national and pan-European R&I initiatives, standards, policy and regulation, and market needs.

We will first define a taxonomy of cybersecurity, to allow a single uniform understanding of the different sub areas of cybersecurity R&I to be established. This will be a two-layer design, firstly a top-level set of three domains and then a subset of 6 areas which are individually indivisible. Once these definitions are described we then rank the importance of initially each top-level domain and then each area for every project for which we have information. These rankings are then turned into numerical scores and a statistical analysis performed against them. The output being a quantitative analysis of the project based on

[1] https://www.enisa.europa.eu/publications/definition-of-cybersecurity
[2] https://en.oxforddictionaries.com/definition/cybersecurity
[3] http://niccs.us-cert.gov/glossary#cybersecurity
[4] http://www.itu.int/en/ITU-T/studygroups/com17/Pages/cybersecurity.aspx
[5] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/60961/uk-cyber-security-strategy-final.pdf

their relevance to the domains and areas. To validate the scoring, we will communicate with the projects discussing the scorings that have been given to them by the CW team and discuss specifically the results for their own projects that we have identified. As national projects have little or no reason to be early engagers/adopters the projects chosen for this will be those supported by the EC, where if necessary pressure from the funder to engage can be used. This statistical method of project alignment and analysis has been previously used within the Cloudwatch and Cloudwatch2 projects to successfully analyse the Cloud computing landscape using and then validating the NIST model of cloud computing[6].

[6] Caithness, N., Drescher, M. & Wallom, D. Can functional characteristics usefully define the cloud computing landscape and is the current reference model correct? J Cloud Comp (2017) 6: 10. https://doi.org/10.1186/s13677-017-0084-1

2 Mapping and Clustering in Cyberwatching.eu

Within the Cyberwatching.eu project the clustering of projects is a fundamental step in the value chain that the project provides overall. As can be seen in figure X the work of WP2 is the generator of information on projects at both a national and pan European scale that are available to work with the Cyberwatching.eu activity overall. The work package and hence activity feeds into both the Concertation activity, i.e. where we are aiming to bring together the community of projects in a manner which is beneficial to them and the EC so they better understand the landscape of cybersecurity and where they have placed projects within it.

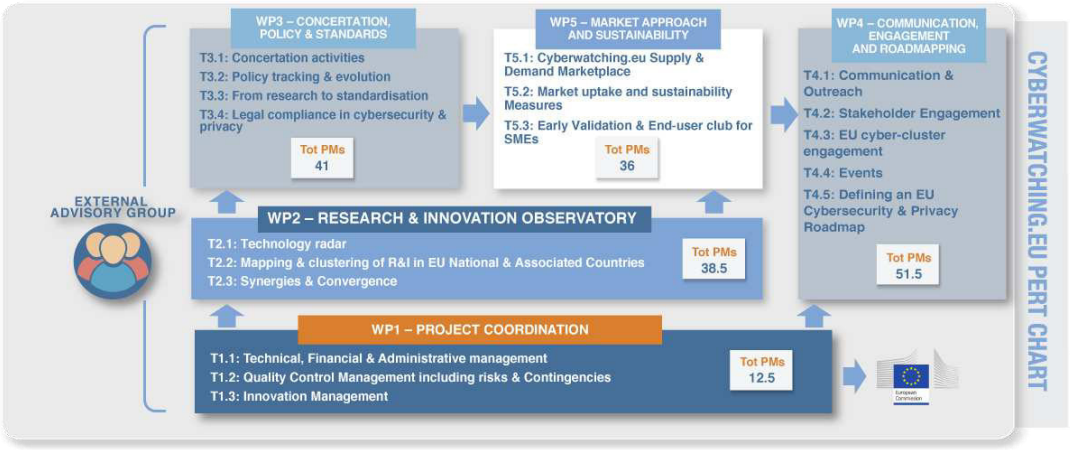


Figure 1 The interaction between workpackages within the Cyberwatching.eu project

The clustering is the first stage for two crucial activities within the Cyberwatching.eu project, as shown in figure 2. Here we describe the outputs which feed into the different stakeholder groups and the vehicles to ensure that those outputs are as relevant as possible.

Figure 2 Output from clustering feeding into Cyberwatching.eu activities and hence into outputs consumed by key stakeholders.

3 A cybersecurity taxonomy

The taxonomy as developed within Cyberwatching.eu is intended to allow the identification of different aspects of cybersecurity and from this the way that different projects and activities concentrate on different sub areas in their developments.

The two-layer design of the taxonomy is not a new concept; for example, the NIST Cybersecurity Framework definition[7] being a functional taxonomy focusing on improving the outcomes of cybersecurity implementations uses three levels of refinement: Function – Category – Subcategory. It is therefore primarily targeting and useful in the *operational* domain of cybersecurity. The overlap in topics between the NIST definition and he Cyberwatching.eu taxonomy is of complementary rather competitive nature: The difference lies in the intended outcome and result of these works. For instance, while both the NIST definition and the Cyberwatching.eu taxonomy both include the issue of intra- and inter-organisational attack propagation and containment, NIST looks at it from an organisational IT management perspective:

- Identify – e.g. “Is there a risk, and can we quantify it?”,
- Protect – e.g. “What protective technology do we use against it?”
- Detect – e.g. “What detection tools and processes are implemented?”
- Respond – e.g. “How do we mitigate, and communicate?”
- Recover – e.g. “What systems were affected, when and how to we improve them?”

In contrast, the Cyberwatching.eu taxonomy looks at it from the research and innovation perspective, looking to improve the body of knowledge as well as increase the variety and depth of the toolbox available to deploy and exploit: Staying in the example of attack propagation; the Cyberwatching.eu cluster “Human aspects of cybersecurity” includes human interaction with digital systems, system usability (or the lack thereof) or cultural diversity: All these aspects are important, and apply to different functional NIST categories: Interaction with digital systems may inform how attack propagation occurs within and across organisations (e.g. distributing malware-infected images or videos on current social media memes) as well as how one might protect infrastructure against it. But cultural differences of how digital systems are used (e.g. Anglo-Saxon usage patterns vs. east Asian media usage patterns) may inform how to respond to the same threat in different cultural contexts, or even how to communicate (use of language, authoritarian vs. non-authoritarian cultures) attack propagation across organisation and geographic regions.

The high-level definitions created are;

- ***Foundational technical methods & risk management for trustworthy systems in cybersecurity and privacy*** – The development of technologies that are directly associated with cybersecurity capabilities or features and methods by which the confidence in the technical capabilities of a system may be validated.
- ***Applications and user-oriented services to support cybersecurity and privacy*** – Specific capabilities or services which directly interact with system users and are developed with capabilities that are directly about how to improve the inherent capabilities and user experiences of cybersecurity and privacy in consumed services.

[7] https://www.nist.gov/sites/default/files/documents/cyberframework/cybersecurity-framework-021214.pdf

- **Policy, governance, ethics, trust, and usability, human aspects of cyber security & privacy** – Aspects of cyber security that are overwhelmingly driven by the human interaction, understanding and dependency on how secure systems are or have been designed to be.

Sitting below these top-level domains are, as discussed, further subdivisions which look at the main areas, which then cover what we would consider the whole landscape. Within the consortium the following subdivision is optimal;

- **Secure systems and technology**: How security can be built into technology from the design stage including cloud computing security, cryptography, trusted platforms, wireless security, mobile security and secure coding paradigms.
- **Verification and assurance**: Two disciplines that help establish how much confidence you can have in a system, both in terms of security and the privacy of all stakeholder groups who act with or in a system. Assurance focuses on managing risks related to the use, processing, storage, and transmission of information, whereas formal verification seeks to build a mathematical model of a digital system and then try to prove whether it is 'correct', often helping to find subtle flaws.
- **Operational risk, management and analytics**: Understanding the risk and harm resulting from cyberattacks, and how it propagates across and between organisations. Work focuses on creating situational awareness through aiming for a complete understanding of scenario and risk management; metrics and models for security postures; and analytics for predicting risk, prioritising responses and supporting security operations.
- **Identity, behaviour, ethics and Privacy**: Bringing diverse perspectives and interpretations to questions such as: Who are you online, how do you communicate, and what can (or should) you do? This also connects to the ongoing activities on Privacy launched through directives and regulations over the past year.
- **National and international security, privacy and governance**: looking at politics, international relations, defence, policy and governance issues: how do countries and communities interact with (and through) technology, and how might this change in different contexts?
- **Human aspects of cyber security**: Understanding the ways humans interact with (and through) digital systems – whether to understand and design for target users, or to understand how adversaries operate and can exploit the systems. This includes aspects like usability, trust, collaborative practices, social embeddedness, nationhood, cultural diversity, impact on economy, and the relationship between microsocial interactions and global structures.

This two-tier taxonomy allows for a number of meaningful arrangements. The most obvious arrangement is a hierarchical model, which is the default for this taxonomy (see Table 1).

Level 1: Category	Level 2: Cluster
Foundational technical methods & risk management for trustworthy systems in cybersecurity & privacy	Operational Risk and Analytics
	Verification and Assurance
Applications and user-oriented services to support cybersecurity and privacy	Secure Systems and Technology
	Identity, Behaviour, Ethics and Privacy
Policy, governance, ethics, trust, and usability, human aspects of cybersecurity & privacy	National and international security and governance
	Human Aspects of Cybersecurity

Table 1 - Hierarchical arrangement of taxonomy categories and clusters

A hierarchical arrangement allows for quick and efficient mapping of projects into categories, effectively facilitating projects to form groups of meaningful size and "gravity" to instigate conversations and discovering overlaps and synergies.

The implicit rule of hierarchical grouping does not allow "jumping" the cluster when further differentiating the projects into cluster: A change of category indicates one of two conditions:

- The initial categorisation was incorrect, or
- The hierarchical arrangement of the taxonomy is insufficient.

Both conditions can be detected early on as soon as differentiating projects into clusters will begin – they hence form built-in auto-correction features of the taxonomy.

The other suitable arrangement refers to an understanding of cybersecurity architecture as follows.

Figure 3 - Cybersecurity taxonomy as per cyber security architecture

The taxonomy's architectural arrangement illustrated in Figure 3 highlights the need of cross-cluster communication facilitation despite clustering along the hierarchy of the taxonomy: Despite being allocated to specific categories, *Verification and Assurance*, and *Human aspects of Cybersecurity* are cross-cutting issues in the cybersecurity landscape, and therefore need to be treated accordingly.

4 Comparisons with Other Taxonomies

It was decided that since there are a number of different taxonomies available that it would be relevant and useful to compare the Cyberwatching.eu taxonomy with two other leading activities in this area. Therefore, the NIST Critical Infrastructure Cybersecurity Framework (CICF) and the EC Cybersecurity Competency Survey Taxonomy were chosen for comparison. In each of these cases we have made both single and multi-dimensional comparisons. This was done as though a one-to-one mapping of terms, definitions and areas is desirable, it is highly likely that there will be multiple areas where there is alignment so a matrix of comparison in both cases had been produced.

4.1 NIST Critical Infrastructure Cybersecurity Framework (CICF)

The NIST CICF[8] defines five top level functions and within each of these up to 6 *categories*. Since the framework has a different overall target we have considered how the categories map to the Cyberwatching.eu categories and clusters. This first single allocation is given in Table 2 below in the NIST ordering format, with colour-coding to indicate which Cyberwatching.eu cluster each NIST category has been mapped to.

NIST CICF Function	NIST CICF Category
Identify	Asset Management
	Business Environment
	Governance
	Risk Assessment
	Risk Management Strategy
Protect	Access Control
	Awareness and Training
	Data Security
	Information Protection Processes and Procedures
	Maintenance
	Protective Technology
Detect	Anomalies and Events
	Security Continuous Monitoring
	Detection Processes
Respond	Response Planning
	Communications

[8] https://www.nist.gov/sites/default/files/documents////draft-cybersecurity-framework-v1.11.pdf

NIST CICF Function	NIST CICF Category
	Analysis
	Mitigation
	Improvements
Recover	Recovery Planning
	Improvements
	Communication

Table 2 - NIST CICF Functions and Categories; colour-coded by Cyberwatching.eu cluster mapping

The following table rearranges this mapping to order NIST categories to Cyberwatching.eu taxonomy clusters:

Cyberwatching.eu cluster	NIST CICF Category (Function)
Secure systems and technology	Data security (Protect)
	Maintenance (Protect)
	Protective Technology (Protect)
	Anomalies and Events (Detect)
	Security Continuous Monitoring (Detect)
Verification and Assurance	Risk Management Strategy (Identify)
	Detection Processes (Detect)
	Analysis (Respond)
Operational risk, management and analytics	Asset Management (Identify)
	Risk Assessment (Identify)
	Response Planning (Respond)
	Recovery Planning (Recover)
Identity, behaviour, ethics and Privacy	Access Control (Protect)
	Mitigation (Respond)
	Improvements (Recover)
National and international security and governance	Business Environment (Identify)
	Governance (Identify)
	Information Protection Processes and Procedures (Protect)
Human aspects of cyber security	Awareness and Training (Protect)

Cyberwatching.eu cluster	NIST CICF Category (Function)
	Communications (Respond)
	Communications (Recover)

Table 3 - Mapping NIST CICF categories to Cyberwatchng clusters

As can be seen, there are a number of instances within this one to one matchings that would be comfortable with another allocation to domain area. Therefore, we then consider the matrix matching between the two taxonomies.

As we assume that due to the differing goals of both the Cyberwatching.eu and NIST taxonomies there are likely to be multiple areas of overlap, we have created the following matrix comparison between the two.

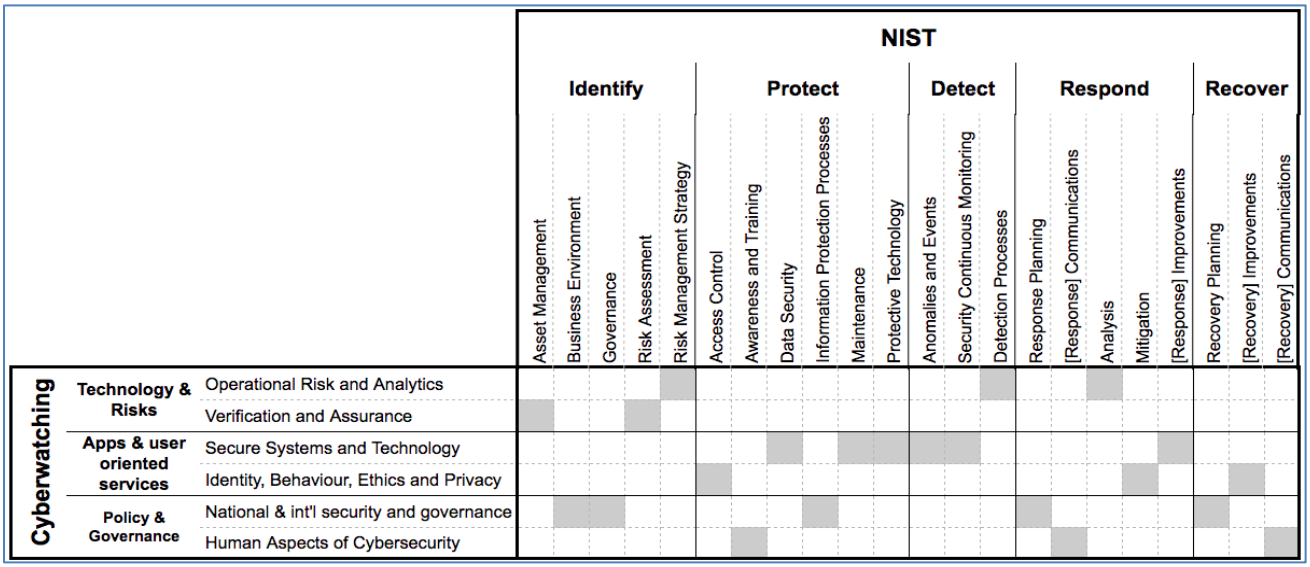


Figure 4 - Matrix mapping of Cyberwatching.eu taxonomy to NIST CICF

4.2 EC Survey Taxonomy

As part of efforts by the EC to understand the Cybersecurity landscape[9], the EC has commissioned a study through the EC JRC for which a specific taxonomy has been developed. We have compared terms as below, as these are top level domains in themselves we have ordered them as per the Cyberwatching.eu taxonomy for ease of understanding overlaps.

Cyberwatching.eu Clusters	EC Survey Categories
Secure systems and technology	Cryptology
	Network and Distributed Systems

[9] https://www.enisa.europa.eu/publications/enisa-threat-landscape-report-2017

Cyberwatching.eu Clusters	EC Survey Categories
	Software and Hardware Security Engineering
Verification and Assurance	Assurance, Audit and Certification
	Theoretical Foundations of Security Analysis and Design
Operational risk, management and analytics	Operational Incident Handling and Digital Forensics
	Security Measurements
Identity, behaviour, ethics and Privacy	Identity and Access Management (IAM)
	Technology and Legal Aspects
	Trust Management, Assurance, and Accountability
National and international security and governance	Data Security and Privacy
	Security Management and Governance
Human aspects of cyber security	Human Aspects
	Education and Training

Table 4 - Mapping the Cyberwatching.eu taxonomy to the EC survey categories

The following matrix visualization illustrates the mapping in a similar fashion to the mapping of the NIST CICF functions and categories:

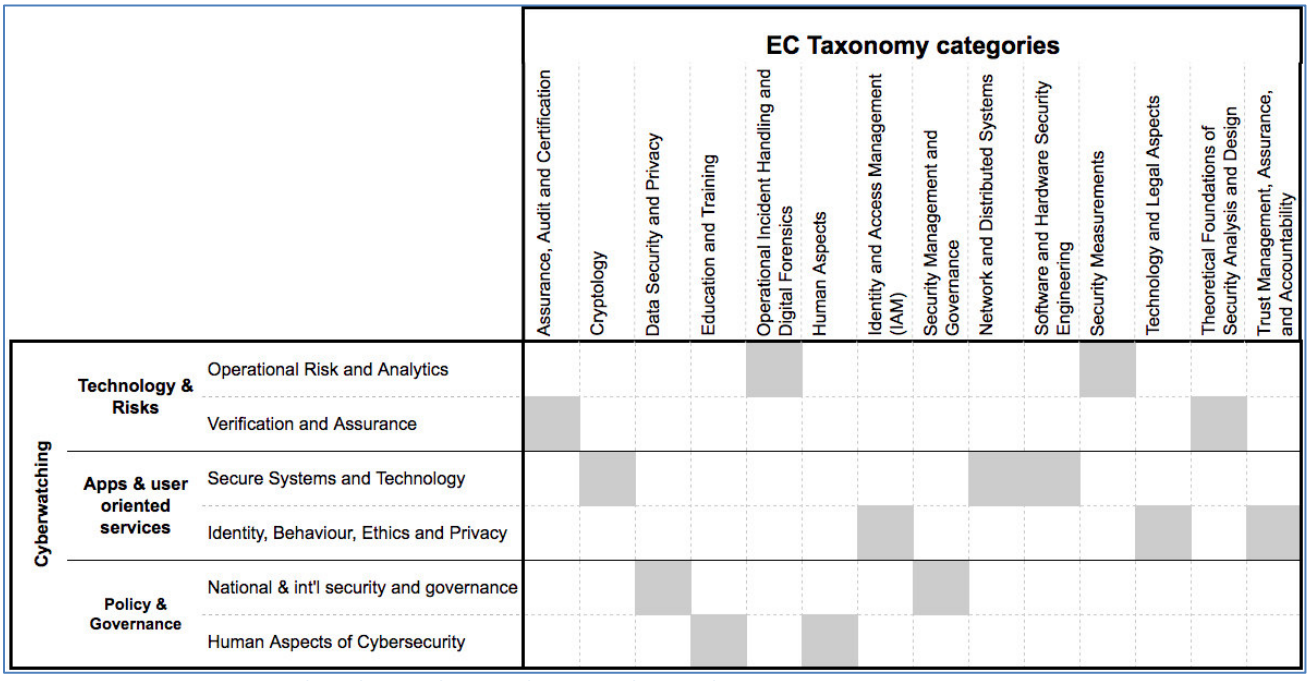


Figure 5 - Mapping the Cyberwatching.eu clusters to the EC cybersecurity taxonomy categories

In addition to the previously discussed work on matching taxonomy areas we have organised a meeting with representatives of Cyberwatching.eu, ECSO WG6 and the authors of the EC JRC taxonomy. The Cyberwatching.eu project officer was also present and asked to describe

the EC expectations from cyberwatching.eu & ECSO alignment on cybersecurity & privacy taxonomies.

Each group was asked to present their taxonomy, rationale for development and how they viewed alignment. The Cyberwatching.eu presentation given at the meeting is attached as Annex B and we were able to provide feedback to both other participating groups of how their and our work related, overlapped and was complimentary.

5 Clustering Methodology

Cyberwatching.eu will provide a platform for fostering project collaboration, through a two-stage clustering of projects thereby allowing cross pollination of both non-technical policy, experience and best practice findings as well as deeper technical specifics bringing experise from across the top-level cluster together to concentrate on specific issues coming together in smaller and more tightly focused groups. These will be taking an in-depth look at specific common topics, sharing updates with EC representatives and taking stock of progress. This also supports the promotion of research and innovation results and the meta layer grouping and lays the basis for further analysis of the ecosystem.

The first meta clustering is to bring together those projects whose overall externally described goals are aligned. This uses the high-level definitions previously discussed. The membership of these clusters will be defined by the high-level goals of projects as described by their public descriptions. This will allow a coming together of projects whose high levels goals may be more closely aligned rather than some attempts to create projects synergies that just attempt to bring together all projects that have been funded through a specific route or another.

Going beyond these top-level groupings we will then assess each of the projects within the communities to be supported to create a more quantifiably driven clustering around more technically focused capabilities or components within projects. This analysis of European cybersecurity and privacy projects will give a way also for the wider community and the EC to gain insight into where the projects are located within the cybersecurity and privacy landscape. The objective of this empirical analysis is to discover distinct smaller groups of projects that are consistent in their relationship to a set of defined general characteristics. These clusters of projects will form the basis for identifying:

- Future collaboration and sharing of experience on common technical priorities
- Re-use of project results by other current and future projects with components, technical ideas, methodologies or best practices identified by a repeatable statistical analysis rather than qualitative methodologies.
- Identify market positioning and potential exploitation opportunities with other projects

The higher-level identification of the criteria upon which the clustering is able to be done is based on a schema for the way that Cybersecurity and Privacy, methods, research and innovation may be classified in a number of different ways.

Cyberwatching.eu will start the analysis by collecting a dataset representing currently funded European projects and scored against the full set of identified defining characteristics on an interval scale. To support the data collection, an online tool will be delivered which analyses detailed knowledge of the cybersecurity landscape, and demonstrates how different projects form natural clusters based on their common relationship to a set of defining features.

The clustering procedure is based on the outcome of a classic Principal Components Analysis (PCA)[10]. We will visualise the landscape on a simultaneous biplot of the characteristic coefficients and component scores[11]. As a natural extension of the biplot we project scores from a reduced dimensionality PCA space onto the coefficient vectors and use those score for clustering. We will employ a classic Euclidian distance single linkage hierarchical clustering[12]. This statistical approach has been shown to be successful within the Cloud Computing space in CloudWatch and CloudWatch2 by identifying activities who otherwise would have ignored each other as prospects for technical experience or product sharing but who have a significant technical aligned which would have otherwise been missed.

Based on the analysis results, Cyberwatching.eu will home in on a maximum of 4 priority areas and actively engage with clustered projects in a series of activities which incentivises and encourages projects to contribute. These include:

- 4 Technology deep dive workshops to map existing solutions to priority areas and enable common approaches to similar challenges and facilitate re-use of research results
- White-papers focussing on challenges to be addressed by future Work Programmes
- Test and validate market readiness of solutions

[10] (a) Pearson, K. 1901. On Lines and Planes of Closest Fit to Systems of Points in Space. Philosophical Magazine, 2 (11): 559–572. (b) Hotelling, H. 1933. Analysis of a complex of statistical variables into principal components. Journal of Educational Psychology, 24, 417–441, and 498–520. (c) Jolliffe, I.T. 2002. Principal Component Analysis, 2nd edition, Springer-Verlag.

[11] (a) Gabriel, K.R. 1971. The biplot graphic display of matrices with application to principal component analysis. Biometrika, 58 (3): 453–467. (b) Gabriel, K.R. 1981. Biplot display of multivariate matrices for inspection of data and diagnois. In V. Barnett (Ed.) Intrepreting multivariate data. London, John Wiley & Sons. (c) Greenacre, M. 2010. Biplots in Practice. BBVA Foundation, Madrid, Spain.

[12] (a) Hastie, T., Tibshirani, R. and Friedman, J. 2009. Hierarchical clustering. In The Elements of Statistical Learning, 2nd edition, New York, Springer. pp. 520–528. (b) The Mathworks ® R2015a Documentation. Agglomerative hierarchical cluster tree.

6 Identification and mapping of relevant projects

The identification of relevant projects to include within the clustering exercise is key. As part of this a methodology was chosen whereby different consortium partners were asked to collect and contribute references and public contact details of cybersecurity projects.

First, all project partners were asked to summarise as to which EU member countries their cybersecurity professional network would extend. This information was captured in a confidential tabulation.

Next, all 28 Member states were allocated to Cyberwatching.eu project partners to garner *public* information about publicly funded cybersecurity projects in the member states. The allocation was done following two guidelines:

- The candidate country MUST be part of the respective partner's network, and
- The candidate country SHOULD be neighbouring, or as close as possible, to already allocated countries.

In parallel, the project's overall network power, ties to the Commission through the project's appointed EC project officer, and the use of the publicly available CORDIS system[13] a large number of past and present EC-funded cybersecutity projects were collected and added to the source material.

This source list is maintained as a living list, i.e. projects are added as and when they become known to us.

At the time of writing, this list includes:

- 147 EC funded projects
- 7 Italian projects
- 13 French projects
- 3 Albanian project sources (i.e. sources which collect project information)
- 3 Lithuanian project sources
- 2 Slovenian projects
- 7 German project sources
- 13 other cybersecurity initiatives

Our initial plan was confirmed by the expected results of data gathering: A vast majority of European projects, and in comparison, rather few national projects. Though this has in some ways been hindered by the lack of clear methods by which we are able to access lists, details or contact points for national projects. Our initial plan to map European projects first as a quick start of activities followed by more resource-intensive research of national projects (expected to be hindered by language barriers) was thus proved to be a good strategy, and put into motion. We are aiming to utilize contacts within Cyberwatching.eu who are part of ECSO as gateways to access countries for which we currently have no information. IT is therefore we consider not at this point suitable to add KPI around numbers of national projects per country that we are able to contact though when we have at least the contact

[13] https://cordis.europa.eu/projects/home_en.html

details of a competent national authority who may have national level information this may change.

6.1 Mapping EC projects to Cyberwatching.eu taxonomy categories

Initially we are using the three Level 1 categories as described in section 3:

- Foundational technical methods & risk management for trustworthy systems in cybersecurity and privacy
- Applications and user-oriented services to support cybersecurity and privacy
- Policy, governance, ethics, trust, and usability, human aspects of cyber security & privacy

Annex A lists all European projects that will be mapped in the first phase of the exercise.

Unlike in the Cloudwatch2 project, where projects were *scored* against the 13 NIST cloud computing characteristics, EC projects are being *ranked* against the Cyberwatching.eu taxonomy categories: The difference lies in the resulting score matrix: While scoring allows the same scoring value to be given for different characteristics (Cloudwatch2), ranking forces a decision as to which of the categories (Cyberwatching.eu) is most important, important, or least important for the given project. Translated into numerical scores, ranking will never see any two categories with the same score for any give project.

Also, Cyberwatching.eu allows for taxonomy categories to be *out of scope* and therefore not to be ranked for a given project. In fact, preliminary results indicate that there is indeed a small number of projects that cannot be ranked at all! In other words, they would not qualify as projects where cybersecurity would be a research of innovation topic.

In terms of statistical analysis, the process needs to cater for *definition holes* – equivalent to "no answer given" in surveys that allow answers to be skipped. In this context definition holes are a result of a taxonomy category being out of scope for a project.

While this may be counterintuitive at first, we expect the allowance of definition holes to result in significantly increased accuracy of the analysis of the initial mapping exercise as will be described in future deliverables.

7 Next steps

We will be presenting the preliminary analysis of the projects at the first Cyberwatching.eu Concertation meeting on the 26th April 2018. This will give the opportunity for the projects to provide input to both the definitions of the Level 1 categories but also see for themselves where they have currently been allocated. Following on from this we are aiming to start the scoring process for projects withi the level 2 taxonomy such that clustering will provide validations through bootstrapping of the overall project scoring and allocation mechanism.

8 Conclusion

Within this deliverable, we have described the taxonomy that the Cyberwatching.eu project have developed to enable an analysis to be completed of national and European cybersecurity projects. This will construct both a map of the ecosystem as a whole but also facilitate the clustering of projects that are aligned under specific thematic areas within the ecosystem. It is aimed that this will have a number of benefits including effective concertation for EC supported projects and ensuring more widely that best practice may be more easily shared as those projects coming together are actually structurally and thematically aligned.

The taxonomy developed has two levels, the Level 1 categories and the Level 2 clustering themes. An unusual item within the taxonomy is the fact that not all of the Level 2 clustering items are unique. It is clear for example that the two areas of verification and Assurance and Human aspects are cross cutting themes and the analysis undertaken of results will have to take this into account. We will of course also be able to verify that these really are cross cutting through the hierarchical clattering process.

To validate the taxonomy, we have attempted to match our terms with those in other models, in this case one each from NIST and the EC. It was clear following analysis that we have covered all areas within these though the allocation of sub terms to our level 2 terms could be done in a number of different ways depending on the opinion of the author that is doing the allocation.

Following the identification of projects, both national and international we have within the team completed a first pass analysis of the allocation of projects to the Level 1 categories. Following this we will then complete this for the Level 2 categories as well. We will through the EC projects in the area request that the projects verify our scores for a small number of projects so that we are able to confirm the methodology. Once this has been done a full analysis will be completed.

Overall we believe that our taxonomy describes the full breadth of what could be the cybersecurity landscape and hence with analysis will be a useful tool to enable projects to understand not only the whole landscape but also their place within is.

ANNEX A. EC PROJECTS MAPPED AGAINST THE TAXONOMY

Project	Call	Type	End	Project URL
AARC2	EINFRA-22-2016	RIA	Apr 2019	
ABC4Trust	ICT-2009.1.4	CP	Feb 2015	https://abc4trust.eu/
ADDPRIV	SEC-2010.6.5-2	CP	Mar 2014	http://www.addpriv.eu/
AEGIS	DS-05-2016	CSA	Apr 2019	http://aegis-project.org/
ANASTACIA	DS-01-2016	RIA	Dec 2019	http://www.anastacia-h2020.eu/
ARIES	FCT-09-2015	RIA	Feb 2019	http://aries-project.eu/
ARMOUR	ICT-12-2015	RIA	Jan 2018	http://www.armour-project.eu/
ASAP	ERC-AG-PE6	ERC-AG	Sep 2018	
ATENA	DS-03-2015	IA	Apr 2019	https://www.atena-h2020.eu
BEACON	ICT-07-2014	RIA	Jul 2017	http://www.beacon-project.eu/
BIOSEC	FP7-PEOPLE	MC-IOF	Feb 2012	
C3ISP	DS-04-2015	IA	Sep 2019	https://www.digitalcatapultcentre.org.uk/project/c3isp/
CANVAS	DS-07-2015	CSA	Aug 2019	https://canvas-project.eu/canvas/
certMILS	DS-01-2016	IA	Dec 2020	https://certmils.eu/
CHOReVOLUTION	ICT-09-2014	RIA	Dec 2017	http://www.chorevolution.eu/bin/view/Main/#
CIPSEC	DS-03-2015	IA	Apr 2019	http://www.cipsec.eu
CITADEL	DS-03-2015	IA	May 2019	http://www.citadel-project.org
CLARUS	ICT-07-2014	RIA	Dec 2017	http://clarussecure.eu/
CloudSocket	ICT-07-2014	RIA	Dec 2017	https://site.cloudsocket.eu/
CloudTeams	ICT-07-2014	IA	Feb 2017	https://www.cloudteams.eu/projects/
COCKPITCI	SEC-2011.2.5-1	CP-FP	Dec 2014	
COEMS	ICT-10-2016	RIA	Oct 2019	https://www.coems.eu/
COLA	ICT-06-2016	IA	Jun 2019	http://www.project-cola.eu/
COMPACT	DS-02-2016	IA	Oct 2019	
CONSENT	SSH-2009-3.2.1.	CP-FP	Apr 2013	http://consent.law.muni.cz/
CREDENTIAL	DS-02-2014	IA	Sep 2018	https://credential.eu/
CROSSMINER	ICT-10-2016	RIA	Dec 2019	https://www.crossminer.org/
CryptoCloud	ERC-AG-PE6	ERC-AG	May 2019	

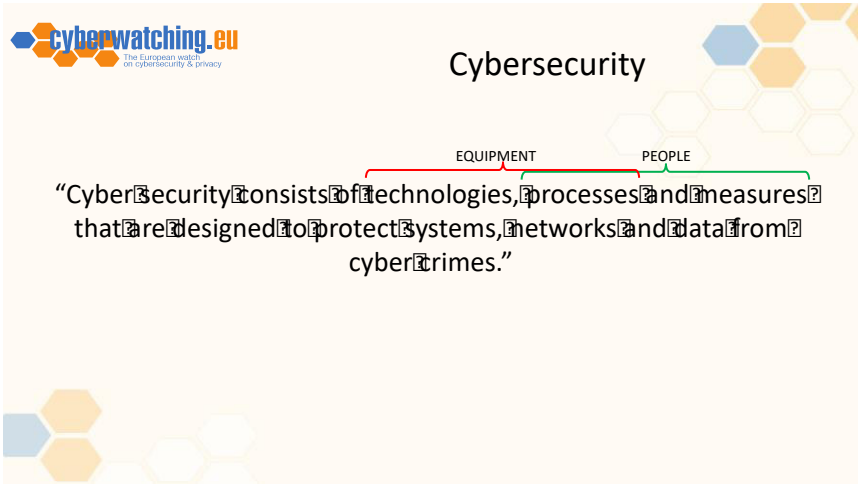
CS-AWARE	DS-02-2016	IA	Aug 2020	
CYBECO	DS-04-2016	RIA	Apr 2019	https://www.cybeco.eu/
CyberWiz	DRS-17-2014	SME-2	Aug 2017	https://www.cyberwiz.eu/
CYCLONE	ICT-07-2014	IA	Dec 2017	http://www.cyclone-project.eu/
CYRail	S2R-OC-IP2-	RIA	Sep 2018	
DAPPER	FP7-PEOPLE	MC-CIG	Mar 2018	
DECODE	ICT-12-2016	RIA	Nov 2019	https://www.decodeproject.eu
DEFENDER	CIP-01-2016-2017	IA	Apr 2020	
DISCOVERY	ICT-38-2015	CSA	Dec 2017	
DiSIEM	DS-04-2015	IA	Aug 2019	http://disiem-project.eu
DITAS	ICT-06-2016	RIA	Dec 2019	http://www.ditas-project.eu/
DOGANA	DS-06-2014	IA	Aug 2018	http://www.dogana-project.eu
DSSC	MSCA	MSCA	Apr 2022	
e-Sides	ICT-18-2016	CSA	Dec 2019	http://www.e-sides.eu/
ECRYPT-CSA	ICT-32-2014	CSA	Feb 2018	http://www.ecrypt.eu.org/csa/
ECRYPT-NET	MSCA-	MSCA	Feb 2019	http://www.ecrypt.eu.org/net/
ENCASE	MSCA-RISE	MSCA	Dec 2019	http://encase.socialcomputing.eu/
EU-SEC	DS-01-2016	IA	Dec 2019	http://www.sec-cert.eu/
EUNITY	DS-05-2016	CSA	May 2019	
FIDELITY	SEC-2011.3.4-1	CP-IP	Jan 2016	http://www.fidelity-project.eu/
FORTIKA	DS-02-2016	IA	May 2020	
FutureTrust	DS-05-2015	IA	May 2019	https://www.futuretrust.eu/home/
GenoPri	MSCA	MSCA	Apr 2018	
GHOST	DS-02-2016	IA	Apr 2020	http://www.ghost-project.eu
HEAT	ICT-32-2014	RIA	43100	https://heat-project.eu/
HECTOR	ICT-32-2014	RIA	Feb 2018	https://hector-project.eu/
HERMENEUT	DS-04-2016	RIA	Apr 2019	https://cyberconnector.eu/web/hermeneut
HIPS	ERC-CG	ERC-CG	Sep 2019	
IMPACT	ERC-2013-SyG	ERC	Jan 2021	http://www.impact-erc.eu/
KONFIDO	DS-03-2016	RIA	Oct 2019	http://www.konfido-project.eu/konfido/
LAST	ERC-SG-PE6	ERC-SG	Sep 2014	

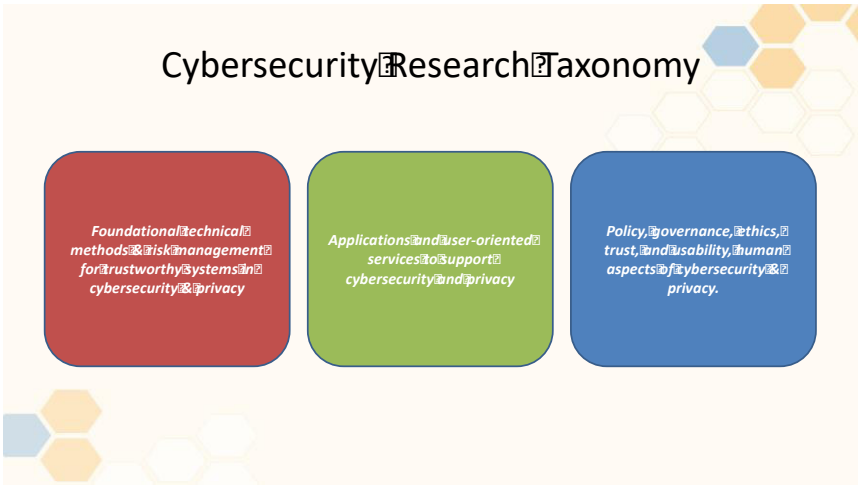
LIGHTest	DS-05-2015	IA	Aug 2019	http://lightest.eu
LV-Pri20	MSCA-IF-2014	MSCA	Jun 2017	
MAMI	ICT-12-2015	RIA	Jun 2018	https://mami-project.eu/
MAPPING	SiS.2013.1.2-1	CSA-SA	Feb 2018	https://mappingtheinternet.eu/
MAS2TERING	ICT-2013.6.1	CP	Aug 2017	http://www.mas2tering.eu/
MATTHEW	ICT-2013.1.5	CP	Oct 2016	https://matthew-project.eu/
MELODIC	ICT-06-2016	RIA	Nov 2019	
mF2C	ICT-06-2016	RIA	Dec 2019	http://www.mf2c-project.eu/
MH-MD	ICT-18-2016	RIA	Oct 2019	http://www.myhealthmydata.eu
MIKELANGELO	ICT-07-2014	RIA	Dec 2017	https://www.mikelangelo-project.eu/
MITIGATE	DS-06-2014	IA	Feb 2018	http://www.mitigateproject.eu
MUSA	ICT-07-2014	RIA	Dec 2017	http://www.musa-project.eu/
NECOMA	ICT-2013.10.1	CP	Mar 2016	http://www.necoma-project.eu/
NeCS	MSCA	MSCA	Aug 2019	http://www.necs-project.eu/
OCGN	MSCA	MSCA	Nov 2018	
OCTAVE	DS-02-2014	IA	Jul 2017	https://www.octave-project.eu/
OPENREQ	ICT-10-2016	RIA	Dec 2019	http://openreq.eu/
OPERANDO	DS-01-2014	IA	Apr 2018	http://www.operando.eu/
P5	SEC-2012.2.3-1	CP-FP	Oct 2016	http://www.p5-fp7.eu/
PaaSword	ICT-07-2014	RIA	Dec 2017	https://www.paasword.eu/
PACT	SEC-2011.6.5-2	CP-	Jan 2015	http://www.projectpact.eu/
PANORAMIX	DS-01-2014	IA	Aug 2018	https://panoramix-project.eu/
PARIS	SEC-2012.6.1-2	CP-FP	Feb 2016	http://www.paris-project.org/
PASS	PEOPLE-2007	MC	Nov 2012	
PATS	SiS-2008-1.2.2.1	CSA	Mar 2012	
PICOS	ICT-2007.1.4	CP	Jun 2011	http://www.picos-project.eu/
PQCRYPTO	ICT-32-2014	RIA	Feb 2018	https://pqcrypto.eu.org/
PRACTIS	SiS-2009-1.1.2.1	CP	Mar 2013	
PRECIOSA	ICT-2007.6.2	CP	Aug 2010	
PRESCIENT	SiS-2009-1.1.2.1	CP	Mar 2013	http://www.prescient-project.eu
PreserviX	ICT-37-2014-1	SME-1	Oct 2015	http://www.piql.com/

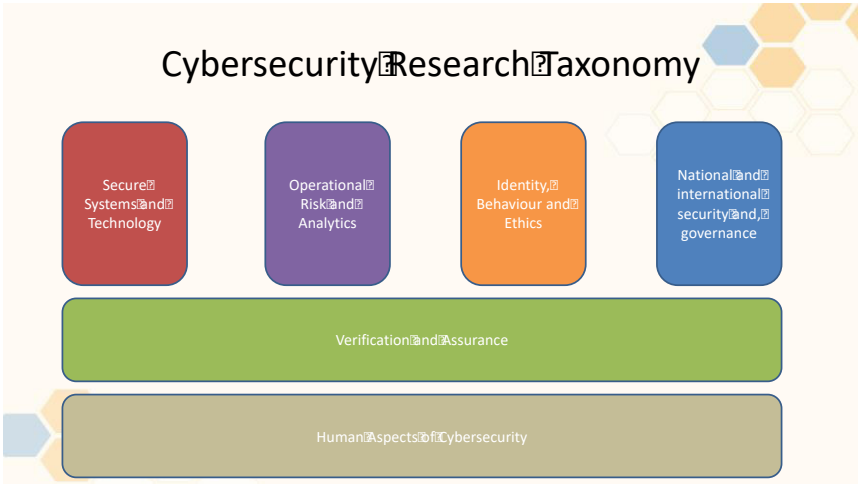
PrEstoCloud	ICT-06-2016	RIA	Dec 2019	http://www.prestocloud-project.eu/
PrimeLife	ICT-2007.1.4	CP	Jun 2011	http://primelife.ercim.eu/
PRIPARE	ICT-2013.1.5	CSA	Sep 2015	pripareproject.eu
PRISM	ICT-2007.1.4	CP	May 2010	http://www.fp7-prism.eu/
PRISM CODE	FP7-PEOPLE	MC-CIG	Oct 2016	
PRISMACLOUD	ICT-32-2014	RIA	Jul 2018	https://prismacloud.eu/
PRISMS	SEC-2011.6.5-2	CP-FP	Jul 2015	http://prismsproject.eu/
PRIVACY FLAG	DS-01-2014	IA	Apr 2018	http://privacyflag.eu/
Privacy.Us	MSCA	MSCA	Nov 2019	https://privacyus.eu/
PRIVACY4FORENSICS	FP7-PEOPLE	MC	Mar 2018	
ProBOS	SMEInst-13	SME-2	Sep 2018	
PROTECTIVE	DS-04-2015	IA	Aug 2019	https://protective-h2020.eu/
Ps2Share	ICT-35-2016	RIA	Dec 2017	http://p2share.eu
RAPID	ICT-07-2014	RIA	Dec 2017	http://www.rapid-project.eu/
REASSURE	DS-01-2016	RIA	Dec 2019	http://reassure.eu/
ReCRED	DS-02-2014	IA	Apr 2018	http://www.recred.eu/
REDSENTRY	H2020-SME1	SME-1	Dec 2017	
RESPECT	SEC-2011.6.1-5	CP-FP	May 2015	http://respectproject.eu/
REVEN-X1	ICT-37-2015-1	SME-1	Dec 2015	
SafeCloud	DS-01-2014	IA	Aug 2018	http://www.safecloud-project.eu/
SAFEcrypto	ICT-32-2014	RIA	Dec 2018	https://www.safecrypto.eu/
SAFERtec	DS-01-2016	RIA	Dec 2019	http://www.safertec-project.eu/
SAINT	DS-04-2016	RIA	Feb 2021	https://project-saint.eu/
SAURON	CIP-01-2016	IA	Apr 2019	https://sauronproject.eu/
SCISSOR	ICT-32-2014	RIA	Dec 2017	https://scissor-project.com/
SCOTT	ECSEL-2016	IA	Jun 2020	https://scottproject.eu/
SCR	SMEInst	SME-1	Dec 2016	
SecIoT	INNOSUP-0	CSA	Aug 2018	
SERECA	ICT-07-2014	RIA	Feb 2018	https://www.serecaproject.eu/
SHARCS	ICT-32-2014	RIA	Dec 2017	http://sharcs-project.eu/
SHiELD	DS-03-2016	RIA	31/12/2019	http://www.project-shield.eu/

SHIELD	DS-04-2015	IA	Feb 2019	https://www.shield-h2020.eu/
SISSDEN	DS-04-2015	IA	Apr 2019	https://sissden.eu
SMESEC	DS-02-2016	IA	May 2020	
SocialPrivacy	FP7-PEOPLE	MC-IOF	Aug 2015	
SODA	ICT-18-2016	RIA	Dec 2019	https://www.soda-project.eu/
SPECIAL	ICT-18-2016	RIA	Dec 2019	https://www.specialprivacy.eu/
SpeechXRays	DS-02-2014	IA	Apr 2018	http://www.speechxrays.eu/
SPOOC	ERC-CoG-2014	ERC-COG	Aug 2020	
STAMP	ICT-10-2016	RIA	Nov 2019	https://www.stamp-project.eu/
STOP-IT	CIP-01-2016-2017	IA	May 2021	https://stop-it-project.eu/
STORM	EE-13-2014	RIA	Aug 2018	
SUNFISH	ICT-07-2014	RIA	Dec 2017	http://www.sunfishproject.eu/
SUPERCLOUD	ICT-07-2014	RIA	Jan 2018	https://supercloud-project.eu/
SurPRISE	SEC-2011.6.5-2	CP-FP	Jan 2015	http://surprise-project.eu/
SysSec	ICT-2009.1.4	NoE	Nov 2014	http://www.syssec-project.eu/
TOREADOR	ICT-16-2015	RIA	Dec 2018	http://www.toreador-project.eu/
TREDISEC	ICT-32-2014	RIA	Mar 2018	http://www.tredisec.eu/
TRUESSEC.EU	DS-01-2016	CSA	Dec 2018	https://truessec.eu/
TYPES	DS-01-2014	IA	Oct 2017	http://www.types-project.eu/
U2PIA	SMEInst-13	SME-1	Mar 2017	
UNICORN	ICT-06-2016	IA	Dec 2019	http://unicorn-project.eu/
VESSEDIA	DS-01-2016	RIA	Dec 2019	https://vessedia.eu/
VIRT-EU	ICT-35-2016	RIA	Dec 2019	https://virteuproject.eu/
VisiOn	DS-01-2014		Jun 2017	http://www.visioneuproject.eu/
WISER	DS-06-2014	IA	Nov 2017	http://cyberwiser.eu/
WITDOM	ICT-32-2014	RIA	Dec 2017	http://www.witdom.eu/

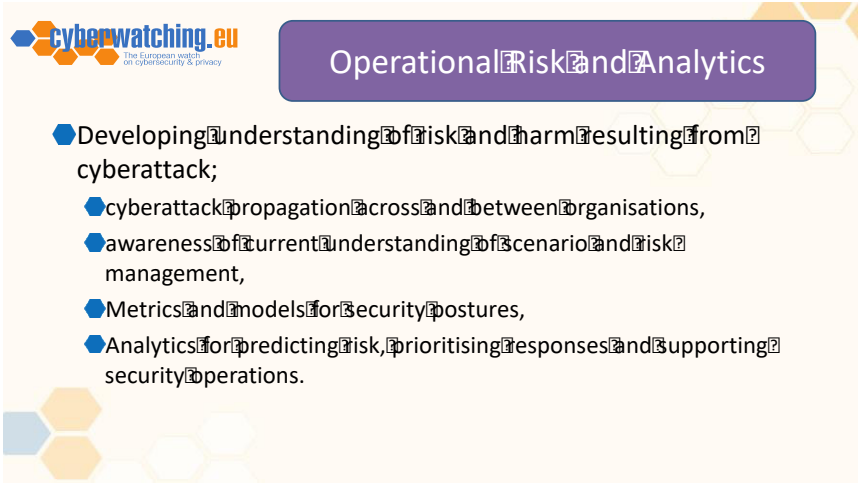
ANNEX B. PRESENTATION GIVEN TO JOINT MEETING ON TAXONOMY ALIGNMENT.




Cybersecurity Research Taxonomy
Foundational technical methods & risk management for trustworthy systems in cybersecurity & privacy
Applications and user-oriented services to support cybersecurity and privacy
Policy, governance, ethics, trust, and usability, human aspects of cybersecurity & privacy.


Cybersecurity Research Taxonomy
Secure Systems and Technology
Operational Risk and Analytics
Identity, Behaviour and Ethics
National and international security and governance
Verification and Assurance
Human Aspects of Cybersecurity


cyberwatching.eu
The European watch on cybersecurity & privacy
Secure Systems and Technology
Building Security & privacy into technology from the design stage and technologies that are designed to deliver security capabilities, examples include;
Cryptography,
Trusted platforms,
Wireless & mobile security,
Cloud Computing security,
Secure software development/coding paradigms.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The European watch on cybersecurity & privacy
Operational Risk and Analytics
Developing understanding of risk and harm resulting from cyberattack;
cyberattack propagation across and between organisations,
awareness of current understanding of scenario and risk management,
Metrics and models for security postures,
Analytics for predicting risk, prioritising responses and supporting security operations.


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The European watch on cybersecurity & privacy
Identity, Behaviour, Ethics and Privacy
Management of personal identity including different levels of assurance when used for online capabilities or services,
How to understand common norms when applied in the online or digital realm,
Diverse perspectives and interpretations to questions such as;
Who are you online with?
How do you communicate, and what can (or should) you do?
What expectations (personal and legally binding) are there? E.g. directives?
What expectations of privacy can there be and should there be?


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National and International Security and, governance
Development of Politics, International relations, defence, policy and governance issues
How do countries and communities interact with (and through) technology, and how might this change in different contexts?
How do national standards transcend borders or boundaries?
How should different threat persistence levels and domain cybersecurity understanding be shared?
At what point does something change from being a business problem to a national security problem?

Verification and Assurance

- Enabling the establishment of levels of confidence in a system in terms of security and privacy, primarily looking at other systems to either determine if they are secure or to assert they are;
  - Formal Verification seeks to build a mathematical model of a digital system and then try to prove whether it is 'correct', often helping to find subtle flaws,
  - Assurance focuses on managing risks related to the use, processing, storage, and transmission of information.

Human Aspects of Cybersecurity

- Understanding humans interaction with, and through, digital systems;
  - whether to understand and design for target users,
  - understand how adversaries operate and can exploit the systems.
- Includes aspects like usability, trust, collaborative practices, social embeddedness, nationhood, cultural diversity and the relationship between microsocial interactions and global structures.

Clustering mechanism from Model

- 4 technical development areas
- 2 Social or service based cross cutting areas
- Projects score themselves from 1 (least) to 5 (most) as to how important this area is to developments ongoing within the project.
- Projects will then be clustered using both Principle component analysis and Heirarical clustering on the resulting scores from projects that have engaged.
- Initially to create base dataset Cyberwatching members will score projects they are investigating using Service Offerings as basis.

Fitting to other models

- There are of course other models of CS available, both general and domain specific
- Then lets compare…

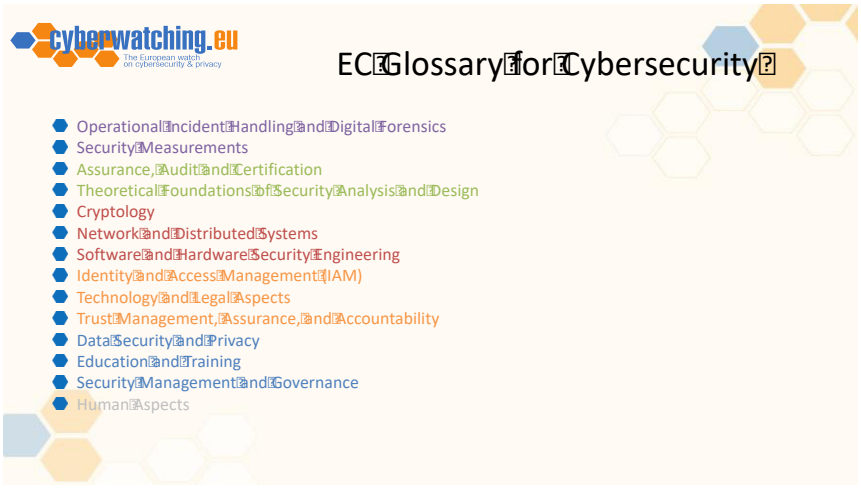
NIST Critical Infrastructure Cybersecurity Framework

- Identify
  - Asset Management
  - Business Environment
  - Governance
  - Risk Assessment
  - Risk Management Strategy
- Protect
  - Access Control
  - Awareness and Training
  - Data Security
  - Information Protection Processes and Procedures
  - Maintenance
  - Protective Technology
- Detect
  - Anomalies and Events
  - Security Continuous Monitoring
  - Detection Processes
- Respond
  - Response Planning
  - Communications
  - Analysis
  - Mitigation
  - Improvements
- Recover
  - Recovery Planning
  - Improvements
  - Communications

https://www.nist.gov/sites/default/files/documents/cyberframework/cybersecurity-framework-021214.pdf

EC Glossary for Cybersecurity

Domain	Description
Assurance, Audit and Certification	This domain refers to the methodologies, frameworks and tools that provide grounds for having confidence that a system or network is working or has been designed to operate at the desired security target or according to a defined security policy.
Cryptology	Cryptology groups together Cryptography and Cryptanalysis.
Data Security and Privacy	This domain includes security and privacy issues related to data in order to (a) reduce by design privacy and confidentiality risks without impairing data processing purposes or (b) by preventing misuse of data after it is accessed by authorized entities.
Education and Training	The learning process of acquiring knowledge, know-how, skills and/or competences necessary to protect network and information systems, their users, and affected persons from cyber threats.
Operational Incident Handling and Digital Forensics	This domain refers to the theories, techniques, tools and processes for the identification, collection, acquisition and preservation of digital evidence that can be of evidential value.
Human Aspects	This domain includes the interplay between ethics, relevant laws, regulations, policies, standards, psychology and the human being within the cybersecurity realm.
Identity and Access Management (IAM)	This domain covers security concerns related to the authentication, access control and authorization of individuals and smart objects when accessing resources.
Security Management and Governance	This domain refers to the governance activities, methodologies, processes and tools aimed at the management of cyber risks.
Network and Distributed Systems	This domain encompasses the scientific and technological competencies related to the interplay between cybersecurity networks and distributed systems.
Software and Hardware Security Engineering	This domain comprises security aspects in the software and hardware development lifecycle and supply chain such as risk and requirements analysis, architecture design, code implementation, code auditing, validation, verification, testing, deployment, runtime monitoring of operation and certification.
Security Measurements	Information security measures and indicators are used to facilitate decision making and improve performance and accountability through the collection, analysis and reporting of relevant performance-related data.
Technology and Legal Aspects	This domain refers to the legal and ethical aspects related to the misuse of technology, illicit distribution and/or reproduction of material covered by intellectual property rights and the enforcement of law related to cybercrimes and digital rights.
Theoretical Foundations of Security Analysis and Design	This domain refers to the use of formal analysis and verification techniques to provide theoretical proof of security properties either in software, hardware and algorithm design.
Trust Management, Assurance, and Accountability	This domain comprises trust issues related to digital and physical entities such as applications, services, components, or systems. Trust management approaches can be employed in order to provide assurance and accountability guarantees.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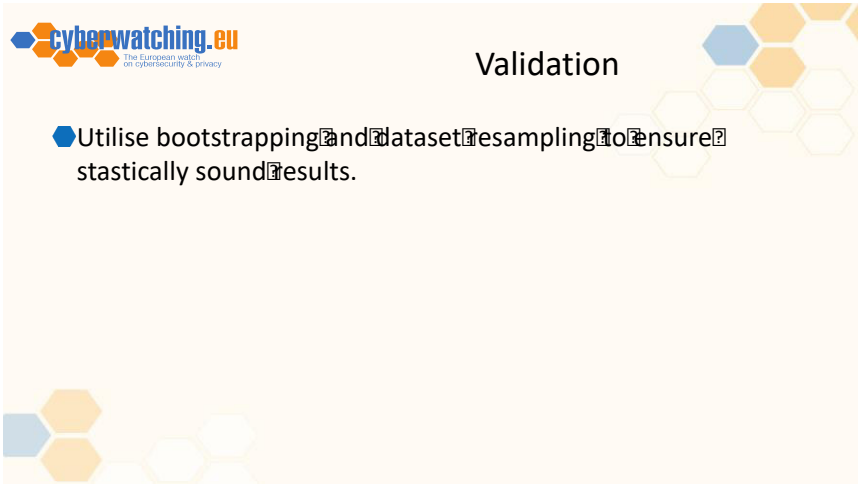
The European watch on cybersecurity & privacy
EC Glossary for Cybersecurity
Operational Incident Handling and Digital Forensics
Security Measurements
Assurance, Audit and Certification
Theoretical Foundations of Security Analysis and Design
Cryptology
Network and Distributed Systems
Software and Hardware Security Engineering
Identity and Access Management (IAM)
Technology and Legal Aspects
Trust Management, Assurance, and Accountability
Data Security and Privacy
Education and Training
Security Management and Governance
Human Aspects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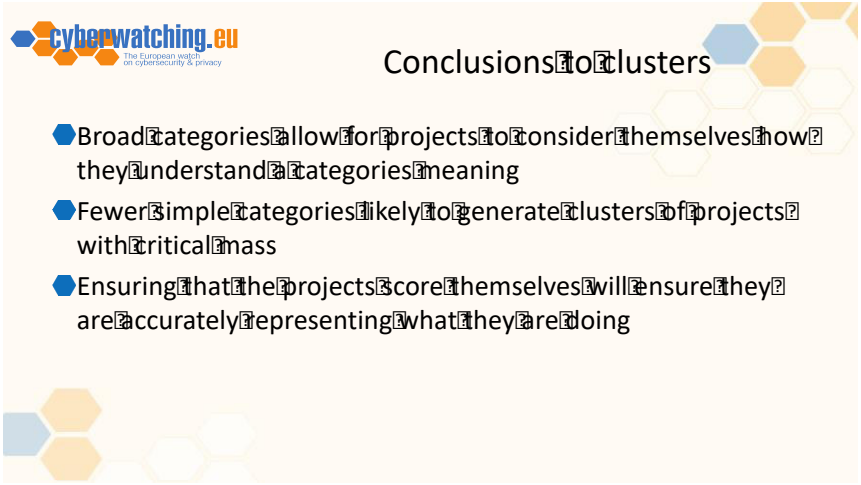
Validation
Utilise bootstrapping and dataset resampling to ensure
stastically sound results.


cyberwatching.eu
The European watch on cybersecurity & privacy
Conclusions to clusters
Broad categories allow for projects to consider themselves how
they understand a categories meaning
Fewer simple categories likely to generate clusters of projects
with critical mass
Ensuring that the projects score themselves will ensure they
are accurately representing what they are doing

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cyberwatching.eu has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 740129.