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NEW MEAIWI METHOD OF ERGONOMIC ASSESSMENT OF THE INTEROPERABILITY OF THE INTERFACE OF WEB PRESENTATIONS

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Abstract In the modern digital ecosystem, the technical capacity of systems to exchange data is traditionally referred to as interoperability. However, as regards human-computer interaction and human orientation (human-centric approach in Industry 5.0), such an approach disregards the role of the user as a functional part of the socio-technical system. This paper introduces a new approach to the solution of ergonomic interoperability of the interfaces of web presentations beyond technical parameters, considering more the metrics of the compatibility of the interface to the cognitive and physical abilities of the users. The proposed methodological framework breaks down interaction in four important domains: technical interoperability, semantic interoperability, accessibility for interoperability, and organizational interoperability. For the purpose of quantifying the maturity level of interfaces, an original assessment instrument was developed in a form of a questionnaire with a dual verification mechanism and aspects of technical and interactional. The practical application of the MEAIWI (Method of Ergonomic Assessment of Interoperability of Web Interfaces) has been illustrated as a case study in the Padbury Parish Council Web presentation. Results show that the proposed method is able to detect interaction discontinuities that might go unnoticed by traditional testing methods, thus making a holistic contribution to the insight of the quality of dialog between the human and the computer. The proposed framework allows quality evaluation of the interface to be consistent and repeatable, which provides a basis for future research and enhancement of web presentation design.

Keywords: Ergonomic interoperability of interfaces; Industry 5.0; human‑centric approach; web interface; assessment questionnaire; technical interoperability; semantic interoperability; accessibility for interoperability; organizational interoperability; human‑computer interaction (HCI).

1. INTRODUCTION

In the time of digital transformation, web presentations have turned from static information sources to the primary points of contact between organizations and users. Although technical infrastructure is a precondition for the operation of any digital service, its real value of usability is achieved solely by the user interface. In the most general sense, the user interface is defined as the set of all those components of an interactive system (software or hardware) that provide the information and controls with which the user needs to carry out each of the specific tasks with the help of the latter [1].

However, traditional approaches to development and evaluation of Web systems often concentrate on technical interoperability (data exchange between machines) at the cost of the fact that the user is an equal and functionally indispensable part of a system. If the interface is not adjusted to the cognitive and physical limitations of humans, the technical correctness loses its importance because then interaction becomes inefficient or impossible.

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The aim of this paper, globally, is to fill the gap between the technical functionality and the actual usability by proposing the concept of ergonomic interoperability and introducing a new, operationalized methodology for its evaluation using the example of web presentations.

2. ERGONOMIC INTEROPERABILITY OF INTERFACES

Ergonomic interoperability of an interface is defined here being the extent of the correspondence between the functional and communicational characteristics of the interface and the psychological (cognitive) and physical abilities of the user in a given context of use, so that the user can understand, process and use the presented information and perform the intended actions effectively and efficiently, with minimal cognitive and physical load, with few errors and while maintaining comfort, safety and satisfaction.

Ergonomic interoperability of interface is not just a technical attribute of software, it is a gauge of the quality of dialogue between man and computer. Based on the definition that, it represents the degree of alignment between functional and communicational characteristics of the interface and the psychological (cognitive) and physical abilities of the user in a given context of use, this concept can be understood as a bridge between the digital logic of the system and the biological and cognitive logic of the human. When this degree of alignment is high, the user does not have to "adapt to the machine"; instead, the particulars of the interface are organised in a way that naturally supports the way people perceive information, make decisions, and perform actions.

At the centre of the concept are two groups of characteristics of the interfaces. Functional characteristics are what the user can do, the way that actions are performed (e.g. search, navigation, data entry and submission, cancellation, error recovery). Communicational characteristics refer to the presentation of information and the guidance of the user through interaction (e.g. content structure, clear control label, consistent use of terminology, understandable messages, feedback, and system state). An interface possesses ergonomic interoperability if these characteristics are not shaped "around technology" but around the task and goal of the user, i.e. if the interactions support the completion of the task rather than becoming an obstacle [1].

Another important component of the definition is the context of use. The same interface may be interoperable enough in one situation, but insufficiently interoperable in another. The reason for this difference is that devices, environment, and user limitations have changed: screen size, keyboard/mouse/touch input or interruption of attention. Therefore, "interoperability" in this context is not understood as an abstract design property but as a property that is manifested in actual use: i.e. the user is able to understand, process and apply the information and then the intended actions can be performed without any further mental effort and without physical effort.

Finally, the definition defines the outcomes where ergonomic interoperability is recognized. The first layer of outcomes is performance-based: tasks are completed effectively (the goal is achieved) and efficiently (with reasonable expenditure of time, steps and effort), with few errors. The second layer is "humanizing": interaction occurs while the comfort, safety and satisfaction are maintained as there is no justification for speed or technical correctness if the interface leads to fatigue, frustration or risky errors. This logic is in line with the standard ergonomic understanding of usability quality, where the success of interaction is determined by concepts of effectiveness, efficiency and satisfaction in the context of use [2].

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3. INTERFACE FOR ERGONOMIC INTEROPERABILITY OF WEB PRESENTATIONS

The interface for ergonomic interoperability of a web presentation is here defined as the degree of alignment of parts of a website (visual, auditory, and interactive) which, in a given context of use, adapts the way information is displayed and interaction is managed to the psychological (cognitive) and physical abilities of the user, so that tasks are performed effectively and efficiently, with minimal effort and few errors, while maintaining user comfort, safety, and satisfaction.

In traditional IT discourse, interoperability is most commonly considered to refer to the ability of software and hardware systems to exchange data (M2M). In the framework of human-computer interaction, however, the information system is considered as a socio-technical system in which the user is an integral and functionally indispensable part. According to the definition, which belongs to a group of general definitions of software engineering, interoperability can be defined as the capacity of two or more systems or components to exchange information and to employ the information exchanged [3], where exchange and use are the determining conditions.

With regard to a web presentation:

- Technical interoperability refers to the exchange of data between the server side and client (browser), and also its proper display in the user interface.

- Ergonomic interoperability includes the second condition from the definition, namely allowing the user to actually use the exchanged information: to be able to perceive it, understand it, process it cognitively and use it in the task.

If the interface is not aligned with the cognitive and physical abilities of the user, information exchange may be technically achieved, but use may be limited or unsuccessful, and thus interoperability is incomplete in terms of the definition. For this reason, the term "ergonomic interoperability" exactly means the ability of the interface to guarantee the transition from technically available information to information that is functional to the user, considering the human and the digital system as components of the same information system with a close alignment.

To realize ergonomic interoperability in practice, it has to be taken as a multilayered structure. It is not exhausted only at the level of technical stability (technical interoperability), but requires, in addition: semantic alignment (that the meaning of symbols and terminology correspond to the mental model of the user), accessibility (the interface is adapted to various sensory and motor limitations, in line with the principles of inclusive design) and organizational alignment (the interface supports the real life and business processes of the user). Only by the integration of these levels does the interface no longer act as an impediment and become a transparent mediator of the socio-technical system.

3.1. Aim of Research

Despite the fact that in practice individual aspects are often checked (e.g. technical correctness, accessibility or general usability), there is still missing a unified and clearly operationalized methodology which assesses systematically the ergonomic interoperability of web interfaces as a whole, i.e. as a relation between the technical exchange of information and its actual, functional use by the user for a specific context of use. As a result, web presentations might fulfill the formal

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technical requirements but still cause errors, unnecessary efforts, unsafe actions or user dissatisfaction, especially in real situations (different devices, little time, variable environmental conditions). Therefore, the development of a methodology for ergonomic assessment of web interface interoperability is an important step forward, so that the quality of the interaction can be measured in a consistent and repeatable manner, and so that the evaluation results lead directly to concrete design improvements that reduce barriers and increase efficiency, safety, and user satisfaction.

4. DEVELOPMENT OF A METHODOLOGY FOR ERGONOMIC ASSESSMENT OF WEB PRESENTATION INTERFACE INTEROPERABILITY

For the purposes of operationalization of the concept established, an assessment methodology has been developed whose main instrument is a structured questionnaire, whose main aim is to translate into measurable indicators the theoretical requirements of ergonomic interoperability. The methodology is based on the decomposition of human-computer interaction in four key domains in technical interoperability, semantic interoperability, accessibility for interoperability and organizational interoperability, thus enabling a quantitative assessment of the degree of alignment between the functional and communicational characteristics of the interface and the abilities of the user in a given context of use.

4.1. Questionnaire for Ergonomic Assessment of Web Presentation Interface Interoperability

The purpose of this questionnaire is to quantify the degree of ergonomic interoperability of the interface of a web presentation, that is, the level of correspondence of the functional and communicational characteristics of the interface to the cognitive and physical qualities of a user. In this way, the effectiveness of the interface in facilitating the successful and efficient task completion in a given context of use is evaluated, which should have minimal load and preserve the comfort, safety and satisfaction for the user.

In general, the evaluation of each item in the questionnaire is based on a four-point scale 0 / 1 / 2 / NA and values assigned to each item are assigned according to the degree of implementation and functionality of the feature represented in the question. The scale is intended to differentiate fully met specification requirements from partially achieved ones, as well as cases (i) when the specified feature does not exist or does not function objectively, and (ii) when the item under consideration is not applicable because of the absence of an element or situation pertinent to the observation in the web presentation. This allows for quantitative comparison of results while at the same time ensuring transparency with required documentation of the evidence for each assigned score.

Scale: 0 / 1 / 2 / NA (not applicable in the specific case).

2 – Fully met (The feature described in the question is implemented and functional in normal conditions of use; there are no observed deficiencies.)

1 – Partially met (The feature is present, but is in some way only partially implemented, inconsistent or only works in certain cases/conditions.)

0 – Not fulfilled at all (The feature is not present and/or not functional, or it is implemented incorrectly so that it does not achieve its intended purpose; when there is reliable evidence of absence/non-functionality.)

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NA – Not applicable (The item does not apply to this web presentation because the relevant element/scenario does not exist, e.g., there is no form, there is no media, there is no external link, etc.).

Along with the numerical score, each item should also have evidence, in the form of a brief explanation directly justifying the value assigned. This evidence is the minimum documentation that must be provided if the result is to be checked and repeated under the same conditions of assessment.

Evidence: Brief explanation regarding the score.

A detailed account of the evaluation procedure is given in Chapter 4.2. The questionnaire is split into four sections: technical interoperability, semantic interoperability, accessibility for interoperability and organisational interoperability. Questions in the technical interoperability section measure the ability of the interface to adapt to various technical environments. Questions in the semantic interoperability section assess whether consistency, comprehensibility, and coherence are built into the interface. Questions in the accessibility for interoperability section are meant to test the interoperability of the interface with assistive technologies and usability for all users. Questions in the organizational interoperability section are designed to assess the ability of the interface to be integrated into business processes and interactions with partners.

MEAIWI QUESTIONNAIRE

1. Technical interoperability

T1 – Does the web presentation display correctly and remain functional across all major browsers (Chrome, Firefox, Edge, Safari)?

0 1 2 NA

Evidence:

T2 – Is the web presentation design fully responsive (mobile interoperability), i.e., does the content scale properly on smartphones and tablets?

0 1 2 NA

Evidence:

T3 – Does the page load and become functional (scrolling and clicking possible) within 5 seconds after clicking the link, or does the user have to wait significantly longer on a standard internet connection?

0 1 2 NA

Evidence:

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T4 – Are all interactive components (buttons, links, input forms) accessible via keyboard (ergonomic interoperability for users without a mouse)?

0 1 2 NA

Evidence:

T5 – During interaction, do unexpected interruptions, display freezes, or browser security warnings (e.g., invalid certificate) occur?

0 1 2 NA

Evidence:

2. Semantic interoperability

S1 – Are terminology and labels (e.g., on buttons) used consistently across all pages?

0 1 2 NA

Evidence:

S2 – Do visual elements (icons) have clear and universally understandable meaning within the site context?

0 1 2 NA

Evidence:

S3 – Is the navigation structure (menu) logical, predictable, and consistent throughout the site?

0 1 2 NA

Evidence:

S4 – Are error or status messages clear, precise, and do they offer a solution to the user?

0 1 2 NA

Evidence:

S5 – Are key data (contact, address) consistent with data on other platforms (e.g., Google Maps)?

0 1 2 NA

Evidence:

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3. Accessibility for interoperability

A1 – For all informational images (diagrams, charts, product photos), is a textual description or legend visibly positioned immediately next to the image?

0 1 2 NA

Evidence:

A2 – Do gray texts or colored texts on a colored background visually stand out clearly without eye strain when reading?

0 1 2 NA

Evidence:

A3 – Is it possible to enlarge the text on the page (e.g., using the Zoom function in the browser) to at least 200% without the text overlapping or extending beyond the screen (horizontal scrolling)?

0 1 2 NA

Evidence:

A4 – Using the print option in the browser (Print Preview), does the page display with a clear and hierarchical list of headings (without large blocks of unformatted text)?

0 1 2 NA

Evidence:

A5 – When clicking directly on the textual description of a field (whether displayed outside the field as a separate element or inside the field as part of the input content), does the cursor automatically position itself in the corresponding input field?

0 1 2 NA

Evidence:

4. Organizational interoperability

O1 – Does the interface enable easy and efficient transactions (e.g., sending inquiries, making purchases, logging into the portal)?

0 1 2 NA

Evidence:

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O2 – After submitting a key request (e.g., login, order status check), does the visual display change immediately (e.g., a new page appears, or an icon/text “Loading…”)?

0 1 2 NA

Evidence:

O3 – Do “calls to action” clearly guide the user toward the desired business goal?

0 1 2 NA

Evidence:

O4 – Does the interface provide unambiguous feedback on the success or failure of an action (e.g., “Thank you, your message has been sent”)?

0 1 2 NA

Evidence:

O5 – In the browser tab title and page URL, is the topic clearly and unambiguously visible?

0 1 2 NA

Evidence:

4.2. Structure of the Proof Mechanism: Technical and Interaction Validation

To achieve the greatest objectivity of the evaluation, avoiding evaluator bias, completion of the MEAIWI questionnaire does not only rely on subjective judgment, but requires a strict verification of all the answers. This verification process is dual in nature and is undertaken by two complementary sets of activities defined as follows:

1. Technical aspects for verification and

2. Interaction aspects for verification.

In this way, it is possible to take into account each of the questions identified in the questionnaire from two perspectives: the perspective of the system architecture (code) and the perspective of the user experience (usage).

1. Technical aspects for verification

The first level of verification consists of Technical aspects for verification, which are focused on the "under-the-hood" analysis of the interface. This set of activities involved reading the source code (HTML, CSS, JS) directly and using a set of diagnostic tools (Developer Tools, Browser consoles, automated validators and so on).

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The purpose of the technical aspects of verification is to establish that technical prerequisites to interoperability (those not visible to the naked eye) are met. For instance, technical verification will check whether there is alternative text in the code for an image, whether interactive elements are semantically correctly defined, or if there are hidden errors that prevent the loading of resources. Answers to these questions can be delivered by IT experts, ergonomists with technical knowledge, or can be divided to some extent using software tools.

2. Interaction aspects for verification (experience validation)

The second level of verification is Interaction aspects for verification that requires the evaluator (ergonomist or trained user) to interact with the system in real-time. These aspects simulate the real user scenarios to empirically verify the behaviour of the interface.

The focus is on perceptual and cognitive aspects of use: whether the wait for loading was frustrating, whether the way to navigate through the menu makes sense, and whether feedback after an action (e.g. submission of a form) is clear and unambiguous. Unlike the technical verification, this method involves human evaluation of the context, comfort and understandability of the information displayed.

Unified application

Although some simpler questions can be confirmed by applying only one method, the most complex ergonomic evaluation is achieved through the unified application of both mentioned aspects. For example, to confirm the accessibility aspect (e.g., question A5), it is not enough to visually verify that a text description of the field exists (Interaction verification); it is also necessary to technically confirm that in the code this description is linked to the field through the appropriate attributes (label for/id), and then interactionally verify that clicking on the text actually moves the cursor into the field.

Only when the conditions of both aspects are met—that the system is technically correctly constructed (based on the implementation of technical verification questions) and that it functions effectively in practice for the user (based on the implementation of interaction verification questions) - can it be considered that the requirement of ergonomic interoperability is fully satisfied (score 2).

Synthesis of findings from independent evaluators

The methodology stipulates that the evaluation can be carried out by two independent evaluators (auditors) using the same questionnaire, with each evaluator applying a specific set of verification questions:

- Technical auditor - evaluates items by applying technical aspects (questions) for verification.

- Interaction auditor - evaluates items by applying interaction aspects (questions) for verification.

Both auditors assign scores of 0, 1, 2 or NA independently for each question in the questionnaire, based on evidence from their respective domains. The final score for each item is formed by comparing the scores of both auditors and applying the principle of the minimum score $E_{final} = \min(E_{technical}, E_{interaction})$. This principle is applied because ergonomic interoperability requires that

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conditions are met simultaneously at the technical and interaction level. A detailed presentation of the decision matrix for forming the final score with an interpretation of all possible combinations of auditor findings is given in Table 1. When assigning a score, only aspects that are applicable to the observed website are considered, while aspects that are not applicable (because of the absence of corresponding elements or scenarios) are not considered in the decision-making process.

Table 1. Matrix of synthesis of findings of the technical and interaction auditor and the principle of forming the final score.

Technical auditor's assessment	Interaction auditor's assessment	Final score	Interpretation
2	2	2	*Fully satisfied.* The system is technically correct and functionally efficient for the user.
2	1	1	*Partially satisfied.* Technical conditions are met, but there are problems in interaction (e.g., an unclear icon even though the code is correct).
1	2	1	*Partially satisfied.* The user manages to complete the task, but there are technical shortcomings that compromise stability or standardization.
1	1	1	*Partially satisfied.* Shortcomings have been observed in both aspects.
0	(any score)	0	*Not satisfied.* A critical technical shortcoming prevents the function.
(any score)	0	0	*Not satisfied.* The function is unusable for the user, regardless of the technical implementation.

4.3. Quantification of Ergonomic Interoperability Levels and Decision Thresholds

After the evaluation and synthesis of findings by independent auditors, qualitative assessments are converted into one quantitative indicator - the Ergonomic Interoperability Index for a website. This process allows ranking of the web presentation objectively and comparing it with standardized performance criteria.

Calculation method

The first step in quantification is to determine the number of applicable questions (M). To make sure that the assessment is correct and reflects the actual context of use, questions judged as "NA" (not applicable) are completely excluded from the calculation - for example, questions about e-commerce are not counted for websites that do not have this functionality. This way the web presentation does not have to be penalised for not having functionalities that are not relevant for the purpose the web presentation is serving.

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The highest attainable system score is based on two times the number of applicable questions (2 x M) because the highest rating on an individual item is 2. The final result is found by dividing all the obtained points by the maximum score possible, then expressed as a percentage, following the formula:

$$Score\ (\%) = \frac{\sum Points}{2\ x\ M}\ x\ 100$$

Interpretation of results and decision thresholds

Based on the obtained percentage value, the level of ergonomic interoperability of the interface is classified into one of four maturity categories, which define the necessity of corrective measures:

• *Satisfactory level (≥85%)*. The interface is of high ergonomic interoperability standards. The system is robust, user friendly and technically correct. Any shortcomings are minor and do not impact the execution of the task; only minor corrections are needed.

• *Level requiring minor improvements (70–84%).* The interface is generally functional but sporadically, there are deficits in consistency, accessibility, or technical optimization that can possibly impede the interaction of certain groups of users.

• *Level requiring significant revisions (50–69%).* There are systemic problems in human-computer interaction. Users encounter barriers which require increased cognitive effort or cause errors. A detailed plan of revision and implementation of corrections is needed.

• *Critical level (<50%)*. The interface fails to satisfy the basic conditions of ergonomic interoperability. The number of technical and interaction barriers is such that partial fixes are not cost effective; a complete redesign of key parts of the interface is recommended before deployment.

The rationale of the applied evaluation scale is that it's correlated with standard psychometric usability scales and the principles of engineering reliability. These thresholds represent the nonlinearity of the user experience: a few errors can have a huge impact on user satisfaction, and user experience can only be perfect with an inordinate effort.

5. EXAMPLE OF ASSESSMENT OF WEB PRESENTATION INTERFACE INTEROPERABILITY

For practical verification of the defined methodological framework, a comprehensive assessment of the interoperability of the user interface of the official Padbury Parish Council web presentation, available at: https://padburyparishcouncil.com/, was carried out. The study covered the analysis of four key domains: technical interoperability, semantic interoperability, accessibility for interoperability, and organizational interoperability. The evaluation results are systematized in the Table 2 below, which for each defined criterion (question from the questionnaire) comparatively presents the technical finding (based on source code analysis, system parameters, and standards) and the interaction finding (based on empirical verification of user experience and functionality), thus providing a holistic insight into the degree of compliance of the analyzed system with interoperability principles.

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Table 2. Results of the assessment of the interoperability of the Padbury Parish Council web presentation interface using the MEAIWI method.

ID of question	Technical finding	Assessment of the technical finding	Interaction finding	Assessment of the interaction finding	Final assessment
T1	The <!DOCTYPE html> declaration (Standards Mode) is present in the source code. The page uses standard HTML5 elements and common web mechanisms (with no observed use of deprecated or browser-specific extensions), so there are no technical indicators that the site cannot be properly displayed and functional in the main browsers (Chrome/Firefox/Edge/Safari).	2	Based on the use of several browsers (Chrome, Firefox, Edge, Safari), it was observed that the web presentation loads and displays consistently. No visual deviations, layout "breaks," or malfunction of key interface parts (menus, buttons) were detected when switching browsers, thereby practically confirming functionality on all the mentioned platforms.	2	2
T2	In View Source/DevTools it was confirmed that the <meta name="viewport" content="width=device-width, initial-scale=1"> is present in the <head>, and the CSS contains @media (media queries) rules that change the layout/dimensions of elements at defined breakpoints, thereby establishing the technical basis for responsive adaptation on mobile devices.	2	By manually changing the browser window size to mobile phone dimensions, it was observed that the entire layout of elements successfully transforms. The main menu switches to a functional "Hamburger" format, the text automatically wraps without overlapping or spilling outside the frame, and images scale proportionally. Navigation and reading remained fluid without the need for horizontal scrolling.	2	2
T3	By analyzing network performance in DevTools, it was confirmed that the server response time (TTFB) and the time to interactivity are within the limit of 5 seconds. Although the scripts in the header do not have defer attributes, the page uses small overall resources (low page weight), which enables fast parsing and rendering of the DOM structure.	2	During testing on a standard internet connection, after clicking on the link, the page became fully functional and ready for interaction (scrolling, navigation) in a very short time (estimated at about 2 to 3 seconds). The waiting was imperceptible and did not cause frustration, thereby practically meeting the criterion of fast response (under 5 seconds).	2	2
T4	Key controls are implemented as standard HTML elements (e.g., main menu links, "Search" button), which provide default keyboard focusability (Tab/Enter). However, the Accessibility Statement explicitly states the limitation: "you cannot skip to the main content when using a screen reader," thereby confirming the technical deficiency of a mechanism for	1	By attempting navigation exclusively with the Tab key, it was determined that focus can move through interactive elements and that there are no keyboard "traps." However, in practice no available option for directly skipping navigation was observed, which required a large number of key presses before reaching the main	1	1

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ID of question	Technical finding	Assessment of the technical finding	Interaction finding	Assessment of the interaction finding	Final assessment
	skipping repetitive content blocks.		content on each page and reduced usage efficiency.		
T5	Inspection of security protocols verified the presence of a valid SSL certificate (HTTPS protocol), with the browser's address bar not displaying warnings about an insecure connection ("Not Secure"). In the developer tools console (DevTools Console), no blocking scripts, infinite loops, or mixed content errors were recorded that could technically cause a malfunction or freeze of the interface.	2	During regular interaction (opening pages from the menu, scrolling, and clicking on internal links), no freezing of the display or unexpected interruptions of the interface were observed. The browser's address bar shows a secure HTTPS connection (without certificate warnings or "Not Secure" status). No security warnings were detected when opening pages, nor loading interruptions that would prevent usage.	2	2
S1	View Source confirms that the language of the document is explicitly defined in the root element as <html lang="en-GB">. The terminology in the main navigation is consistent across the observed pages (menu items are identical / use the same labels).	2	Review of the homepage and internal pages (e.g., "Home," "Agendas," "Contact Us") shows that the labels in the main navigation and key interface elements are consistent and repeated in the same form, without variations in terminology for identical functions. No situations were observed where the same action or page is designated by different names in different places.	2	2
S2	Analysis of the navigation menu code detected an interactive element (icon) that does not contain visible text nor a programmatically defined equivalent (missing aria-label or hidden text). Because of this, the meaning of the control is not unambiguously machine-readable and relies on the visual recognizability of the symbol.	1	A visual inspection identified accessibility-related icons (the universal symbol and screen reader). Since these are conventional and recognizable symbols, their meaning was intuitive and clear at first glance, and they did not cause any doubt regarding their function during use.	2	1
S3	Comparative analysis of the source code of the homepage and internal pages confirmed that the HTML structure of the main menu is consistent (same navigation block, same hierarchy of / elements, and same classes on the checked URLs), which ensures a uniform navigation structure.	2	During the search for key information (such as contact details or minutes) through the main menu, it was observed that the path to the target is direct and logical. Navigation remained stable and unchanged when moving from the homepage to internal pages, thereby enabling easy orientation	2	2

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ID of question	Technical finding	Assessment of the technical finding	Interaction finding	Assessment of the interaction finding	Final assessment
			and predictability of the location of desired content.		
S4	Analysis of the form's response after submitting invalid data identified an active mechanism for input validation and feedback generation. The system processes the values entered into the form fields and, in the case of an incorrect format (e.g., email address), displays a status container with a textual error description ("Invalid email address") and a visual warning block, thereby confirming the existence of validation logic on the client and/or server side.	2	By simulating the entry of invalid data, the system detected an error, but the message ("Invalid email address") was displayed on a green background that usually suggests success, while a blank red box appeared below without content. This visual signaling is contradictory and confusing, with no message in the red box offering concrete instructions for correcting the format.	1	1
S5	Analysis of the "Contact Us" page structure identified the following data: the name of the contact person, telephone number, and email address are explicitly displayed in textual form. However, the HTML content does not define an element that would represent the institution's physical address (e.g., <address> or an equivalent text block). The integrated map module renders a general view of the Padbury settlement, but without an associated location identifier (Point of Interest marker or link to the exact Google Maps location). Additional verification in Google Maps search under the name "Padbury Parish Council" did not return a result indicating a precise location. Due to the absence of verifiable address data, technical consistency of key information with external platforms can be confirmed only for the "contact" component, while the "address" component remains unvalidated.	1	During verification of the "Contact Us" page, the user can easily find contact details (phone and email) and use them to establish communication. However, within the site content it is not possible to find a clear physical address of the institution, nor can the displayed map unambiguously indicate the exact location of "Padbury Parish Council" (the map shows the wider Padbury area without an explicit marker/label for the institution). Additionally, the attempt to confirm the location on an external platform was unsuccessful, since a Google Maps search for "Padbury Parish Council" does not return a relevant result. Therefore, the user cannot practically verify the location/address through other platforms, so interoperability of key data in the "address/location" domain remains unachieved, although contact interoperability is functional.	1	1
A1	Analysis of the "Latest Parish News" section revealed inconsistency in the use of textual descriptions alongside	1	During review of the "Latest Parish News" section, the user easily understands the content of the news cards,	1	1

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ID of question	Technical finding	Assessment of the technical finding	Interaction finding	Assessment of the interaction finding	Final assessment
	informative visual elements. In the news blocks, a "Card UI" pattern is applied where the image and accompanying text (title, description) are grouped in the same logical container, providing immediate context for interpreting the content. However, in the integrated map module displaying the marked area, there is no visible textual legend or heading outside the map frame that would explicitly define the displayed geospatial data, so interpretation relies primarily on the visual representation.		since the images are directly accompanied by a title and short description that clearly explain their context. In contrast, when interacting with the map below the news, the user does not receive explicit information about what the map actually shows (e.g., whether it represents administrative boundaries, the institution's location, or general geographic context). Due to the absence of a visible textual legend or explanation alongside the map, the user is forced to assume the meaning of the display, which reduces clarity and confidence in interpreting the information.		
A2	Colorimetric evaluation of style definitions (CSS Computed Styles) determined that the combinations of text and background colors meet readability standards. Analysis of the relative luminance ratio between the primary textual content (dark gray/black font) and container backgrounds (white #FFFFFF and light gray) shows a contrast ratio above the minimum threshold of 4.5:1 in accordance with WCAG 2.1 AA requirements, thereby ensuring clear visual distinction without degradation of readability.	2	While reading content across different parts of the page (introductory text, news cards), it was confirmed that the visual contrast between text and background is optimal. Textual elements, including those in gray shades on lighter backgrounds, are clearly legible without the need for eye strain or zooming, thereby enabling easy perception of information in the standard display mode.	2	2
A3	In the "Accessibility Statement," no shortcomings are listed regarding display scaling (Zoom) or content reflow at up to 200% enlargement. Although issues with text spacing (line-height/spacing) are recorded in the 'Non-compliance' section, the zoom functionality itself is not indicated as faulty. This is consistent with finding T2, since 200% zoom technically triggers the same CSS mechanisms (@media queries) as the mobile view.	2	When testing display enlargement at 200%, the page successfully retained structural integrity. The content (news with images) did not collapse into a single vertical column but maintained a two‑column organization, with image and text dimensions proportionally adjusted. The text remained legible without overlapping, and navigation through the content was possible without the need for horizontal scrolling.	2	2

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A4	Analysis of the style definitions intended for the print media type (@media print) confirmed the implementation of rules that preserve the semantic hierarchy of the document when rendered for printing. HTML heading elements (<h1>–<h6>) retain stylistic priority and visual distinction compared to the body text, while interactive containers (navigation, menu) are programmatically excluded from display (display: none). This generates a linearized DOM output optimized for pagination, without the presence of unformatted content blocks.	2	By activating the Print Preview option in the browser, it was confirmed that the visual display of the page is automatically transformed into a paper-adapted format. Navigation menus and superfluous graphic elements are removed, while the textual content retains a clear logical structure and a readable hierarchy of headings, without the appearance of unformatted blocks or overlapping text.	2	2
A5	Analysis of the source code of the "Contact Us" form revealed the absence of explicit <label> elements associated with the input fields. Semantic identification of inputs is achieved solely through placeholder attributes within <input> and <textarea> elements. This implementation causes the textual description of the field's purpose to disappear from the DOM once the field gains focus or contains an entered value, resulting in the loss of persistent field identification during interaction.	2	Testing confirmed that by clicking directly on the textual field name (e.g., "Full Name"), the cursor is immediately positioned inside the input box. Although the text is located within the field itself, the system correctly interprets the user's action and automatically activates writing mode, eliminating the need for precise targeting of the empty space around the text.	2	2
Ol	Analysis of the site's functional units identified the contact form as the only implemented point for two-way data exchange (transaction). The technical realization of this process is optimized for speed: the form uses a "flat" structure without pagination, does not require prior authentication (login/registration) or session processing, and the number of fields is reduced to the absolute minimum (three), thereby eliminating technical friction during request submission.	2	Evaluation of the inquiry submission process confirmed that the transaction is maximally simplified. Due to the absence of complex procedures such as account registration or multi-step identity verification, the visitor is able to initiate communication immediately. The interface's focus exclusively on this single interactive action, combined with the minimal number of fields to complete, makes the process fast and intuitive, without	2	2

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			risk of task abandonment caused by fatigue or confusion.		
O2	Analysis of the form submission mechanism established that the application uses a synchronous communication model resulting in a full page reload/redirect. After executing the HTTP POST request, the server returns a response that immediately initiates navigation to a new URL (confirmation page), thereby replacing the entire DOM tree of the form with new content. This implementation technically ensures that the visual state of the interface is unambiguously synchronized with the completion of the transaction.	2	Immediately after activating the data submission command, an instant change on the screen was observed. The system did not display temporary loading indicators on the existing form but instead automatically switched to an entirely new page. This sudden and clear visual transition provides the user with unambiguous feedback that the submission process has been successfully completed and the request accepted.	2	2
O3	Analysis of the archive access interface identified a combined model of guiding the user toward the goal. The parameter-based filtering system (dropdown controls for "Year," "Month," and "Meeting type") technically narrows the set of displayed records, while the primary call to action is implemented through standardized "View detail" buttons within each result. This structure clearly separates the selection phase from the action phase and programmatically directs the user to the detailed view of the chosen meeting, without ambiguity during interaction.	2	During use of the meetings page, the user easily recognizes the next step in interaction. After filtering the list by year, month, or meeting type, each displayed record contains a clearly visible "View detail" button that unambiguously signals the action to continue. Clicking the button leads directly to the page with details of the selected meeting, without additional steps or confusion, confirming that the calls to action intuitively and efficiently guide the user toward the intended goal.	2	2
O4	The inquiry submission flow is structured through clearly marked actions ("Submit"/"Send your query") and mandatory confirmation of the privacy policy, which technically supports the existence of feedback in case of failure/success of submission (transaction status). In addition, the "Accessibility Statement" provides a procedural channel	2	After the form was submitted, a clear and prominent textual message appeared on the screen confirming the success of the action. Instead of subtle or temporary notifications that could easily go unnoticed, the display of a separate confirmation page unambiguously informed the user that the process was completed and the message sent, thereby eliminating any	2	2

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ID of question	Technical finding	Assessment of the technical finding	Interaction finding	Assessment of the interaction finding	Final assessment
	for reporting issues if the feedback is not clear.		uncertainty regarding the outcome.		
O5	Analysis of the HTML document's <head> section and the URL structure confirmed the application of semantic naming principles. The <title> tag is properly filled with descriptive text that combines the specific page name and the organization's name (pattern: Page Name – Site Name), while the URL follows a "Clean URL" (RESTful) architecture with readable slugs, avoiding cryptic parameters or session ID numbers.	2	A visual inspection of the browser tab and the address bar confirmed that the information is clear and contextually relevant. The tab title precisely identifies the open page, making it easy to navigate even when multiple tabs are open simultaneously. The URL is logical and readable, clearly indicating to the user which part of the site they are on by allowing keyword recognition directly within the link.	2	2
					Σ = 35

5.1. Results Analysis

By applying the defined formula for calculating the level of ergonomic interoperability, based on the aggregate data from Table 2, the following parameters were obtained:

• The total number of analyzed items (questions): 20
• Maximum possible score (2 × M): 40 points
• Achieved total score: 35 points

The percentage value of compliance is calculated as follows:

$$Score\ (\%) = \frac{35}{2\ x\ 20}\ x\ 100 = 87{,}5\ \%$$

According to the defined scale, the result of 87.5% places the Padbury Parish Council web interface in the category: satisfactory level (≥ 85%).

This means that in this case, the interface corresponds to high standards of ergonomic interoperability. The system is robust, user-friendly and technically sound. Any shortcomings are minor and do not have an impact on the execution of the tasks, which means that only minor corrections are required.

5.2. Discussion of Results

Although the overall result is high, a detailed domain analysis indicates specific points of discontinuity in human–computer interaction which, although they do not block functionality, reduce the overall user experience.

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Technical interoperability (score: 9/10)

The website demonstrates exceptional technical stability. The use of standard HTML5 elements, optimization for mobile devices (Responsive Design), and fast loading (Low Page Weight) form the basis of the high score. The only identified shortcoming (T4) concerns the absence of a mechanism to skip navigation ("Skip to content"). This may not be of significance to the average user, but it is a big impediment to efficiency among users who would only use the keyboard or the screen readers and then they have to engage in boring repetitive actions.

Semantic interoperability (score: 7/10)

This is the lowest rated domain. Although the basic terminology is clear, some problems were noticed in communicating meaning in certain contexts:

- Icons (S2). The lack of the use of textual labels of aria-label causes that certain controls can only be interpreted through the sense of sight.
- Validation (S4). The most serious UX flaw is the display of an error message on a green background (which means success in semantic terms). This contradictory visual signalling extends the cognitive processing of the user.
- Location (S5). The absence of structured information about the physical location or an accurate indicator on the map makes it impossible to link it with external navigation services.

Accessibility for interoperability (score: 9/10)

The site generally complies with WCAG guidelines, particularly regarding contrast, text scaling, and print adaptation. The only score reduction (A1) is related to map interpretation, where the absence of a legend or textual alternative leaves the user without precise context about what the graphic representation conveys.

Organizational interoperability (score: 10/10)

This domain had the highest level of performance. Business processes on the site (contact form, document search) are simplified to the essence. The "flat" architecture without superfluous steps, clear calls for action, and unambiguous feedback on the status of the request creates a frictionless interface that is an example of good practice for information portals in the public administration sector.

5.3. Suggestions for Improvement (Corrective Measures)

Since the site has been classified in the category requiring minor corrections, the following targeted interventions are recommended, in order to bring the result closer to full compliance:

1. Implementing "Skip Links" solves the problem found in question T4. Add a hidden link at the beginning of the <body> tag that becomes visible on focus (Tab) and allows a direct jump to the main content (<main>).

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2. Correcting visual validation solves the problem found in question S4. CSS styles for error messages should be changed to have a red background or border, and clear instructions on how to correct the input format.

3. The problems of questions S2 and A1 are solved by adding semantic markers. All icons should be provided with aria-label attributes with the description of their function. The map should be presented with a title or legend on the geographical scope that it is showing.

4. Explicit location data solves the problem found in question S5. The "Contact Us" page should contain the textual address of the institution (if there is an office) or a clear note about operating procedures, in order to eliminate user uncertainty.

6. CONCLUSION

The basic scientific and practical contribution of this study is the definition and operationalization of ergonomic interoperability of interfaces that have not been systematically addressed in the literature before. While traditional approaches to evaluating web systems are fragmented - considering technical performance, accessibility or usability separately - the presented methodology is the first in the world to integrate these aspects into a single framework, treating the interface as a critical meeting point between the biological logic of the user and the digital logic of the machine.

The important innovation of the MEAIWI method is the double verification mechanism. By introducing parallel streams of assessment - technical (analysis of code structure and parameters of the system) and interactional (the analysis of experience and cognitive factors) - the methodology avoids shortcomings of standard tests. It shows that the technical correctness of code (e.g. the existence of an alt tag) does not always ensure ergonomic functionality (e.g. the comprehensibility of the content of that tag for the user), thus redefining the very notion of quality of digital service.

For the first time, this work provides a quantitative instrument (the ergonomic interoperability index of the interface) that allows quantifiable ranking of the maturity of interfaces of web presentations. In doing this, the abstract requirements of human-centered design, proclaimed through the vision of Industry 5.0, are put into concrete, engineering-measurable indicators. The MEAIWI method does not consider the user as an external element that has to be adapted to technology, but rather as a component of the socio-technical system whose cognitive and physical features are the starting point for the definition of ergonomic interoperability.

The results of the conducted analysis revealed that the web presentation of Padbury Parish Council is an example of a system with optimal, simple, and efficient presentation. The reason behind the high level of interoperability is a minimalist design that stays away from complex functions, which minimizes the possibility of errors. With the implementation of the proposed minor corrections, the website would have met the even strictest criteria for ergonomics both with regard to technical and its interactional validity.

It needs to be emphasised that the proposed methodological framework is not limited to simply evaluating websites. It forms the basis for the ergonomic interoperability standardization of the digital environment. Its universality allows its application on various types of digital interfaces from

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e-government portals to web presentations of complex industrial systems, in order to ensure that technology acts for humans in a way that is not only efficient, but also cognitively adapted and safe.

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