REINTERPRETING THE EXISTING

A Critical Review of Hardware and Software in Architecture Design Principles as a Strategy for Adapting Existing Built Stock to Evolving Needs

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Process

Transformation and change are essential qualities of architecture. “The true nature of buildings – that they can’t hold still” (Brand, 1994, p. 3). The adaptation of the built environment to meet new requirements is an ongoing process, one that cannot be complete as long as life within and around buildings evolves. “Buildings outlast civilizations, they evolve and they are changed, but their reuse emphasizes continuity” (Brooker & Stone, 2004, p. 9).

The challenge of designing for change has preoccupied architects for generations. A widely adopted strategy to address this is conceptualizing architecture as a composition of permanent and temporary components. Auguste Perret, for example, “believed in the longevity of buildings, where the structural frame would outlast all manner of short and medium-term furniture and fittings and drew his projects as if they were in a state of construction” (Adler, 2007, p. 3). Similarly, John Habraken’s Open Building concept proposed that “Supports”—the permanent elements—should endure, while the “Infill” could adapt to users’ evolving needs (Habraken, 1972). Herman Hertzberger described architecture as a combination of “more permanent, enduring—structural—layer on the one hand, and the openness to multiple interpretations” (Hertzberger, 2013, p. 22). These approaches underscore the importance of a building’s permanent elements in enabling ongoing transformation. “Architecture is what makes beautiful ruins.” summarized Auguste Perret.

Paradoxically, concepts of adaptable architecture are not often discussed within the context of existing buildings. In this regard, adaptation must be understood as an ongoing, iterative process rather than a single act. Current interventions should be strategic, creating opportunities for future modifications. As Habraken (2000, p. 18) states, “Ultimately, it is not forms but their transformations that reveal whether a configuration is alive or not.”

However, the configuration of many existing buildings often hinders the process of change, limiting their potential for functional reorganization. Regardless of their architectural, cultural, or historical qualities—or even the lack thereof—existing building stock represents a valuable material resource and requires efficient strategies for reuse and transformation. These strategies often involve partial demolition, with precise and strategic interventions helping to avoid large-scale deconstruction and enabling the efficient use of available material resources. Much like a sculptor who envisions a complete sculpture within a block of marble, an architect can identify an open structure within a building’s existing configuration, removing only the superfluous material.

To work with existing buildings, Kosmos Architects have proposed their own design strategy: Hardware and Software in Architecture. This approach facilitates continuous transformation with minimal material input, combining the robust load-bearing components of a building (Hardware) with easily modifiable interventions (Software). This article explores these principles, further delving into the temporal and spatial misalignment of building layers as a distinctive design opportunity.

The Building

Three identical prefabricated 15-story buildings were erected in 1971 in the South-West of Zürich as part of the Triemli City Hospital development designed by Architektengemeinschaft ASTZ – E. Schindler, R. Hässig, E. Müller, R. Joss, H. Rauber, R. Rohn, intended to provide accommodation for the hospital staff (Fig. 1). Most of the buildings in the hospital campus were constructed in the same decade. Together with the adjacent residential high-rise buildings of exposed concrete and the green hilly landscape they form an expressive modernist ensemble in the area. The surroundings, primarily characterized by residential buildings, are now undergoing active transformation. Namely, outdated houses are being replaced by new residential buildings organized according to contemporary housing standards. Location of the site in a High-rise area zone III (Hochhausgebietszone III), making it particularly attractive for new large-scale residential developments.

The three buildings, each measuring 16.6 by 30.1 meters in plan, rest atop a shared stylobate and house 750 private rooms, ranging from 13 m² to 17 m², for hospital employees. Each tower includes a ground-floor foyer and dining hall, while the upper floors are dedicated to living units, divided by load-bearing masonry walls. The minimally equipped rooms share centrally located toilet and shower facilities. A corridor surrounding the central utility core links all units to the wet zones and vertical circulation but lacks spaces for communication or socialization (Fig. 2)

The primary reasons for demolition included the high cost of renovation—estimated at about 80% of the cost of new construction—and the lack of a vision for how these structures could offer a competitive product in the housing market. However, 96% of the building is structurally strong and in good condition. (Devènes, Bastien-Masse, Küpfer, Fivet 2022). Given the environmental urgency, the architectural significance of prefabricated concrete structures an alternative to demolition was sought. This led to the organization of a competition to envision strategies for transformation of the building. The competition brief invited participants to propose solutions for "A place for people in a wide variety of living situations, for short or long periods of time."

For the team at KOSMOS Architects, this project offered an exciting opportunity to explore the potential of transforming prefabricated concrete buildings, which were not originally designed for adaptation, into structures capable of accommodating ongoing changes to meet diverse and evolving requirements over time.

Fig. 1. Ensemble of the three identical Triemli City Hospital employee housing buildings, 1981. Swiss Air Photo AG, Source: E-Pics.

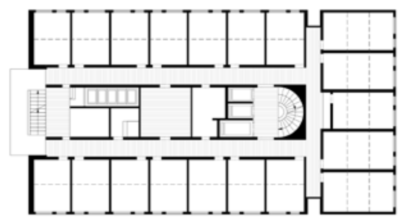

Fig. 2. Plan of a typical floor in the Triemli City Hospital employees' housing building, with private rooms divided by structural walls.

Challenge

When considering structures that can accommodate a variety of living situations for different durations, the discussion inevitably turns to the spatial adaptability of buildings over time. “Architects must mature from artist of space to artists of time.” (Brand 1994). This challenge prompts the exploration of architecture as a system that allows modification of its organization while preserving its main characteristics.

A building, by its nature, is an assembly of various material elements, each with different lifespans and varying frequencies of required adjustment. “A building is no longer a single object, but a combination of systems, each system with its own design process, production process and lifetime.” (Leupen, 2005 quoted in Schmidt, Austin 2016). This essential characteristic of a building was outlined by the concept of “Shearing Layers” introduced by Francis Duffy, and elaborated by Stewart Brand, who described a building as a combination of six layers: Site, Structure, Skin, Services, Space Plan, and Stuff. Later, this concept was expanded by Schmidt and Austin, who added three more layers—Surrounding, Space, and Social—aiming to define buildings at the intersection of urban, architectural, and social levels as they evolve over time.

Acknowledging the independence of the various elements that form architecture offers an opportunity to rethink some fundamental principles of architectural design. The attempt to align diverse building layers into a single, rigid configuration, which becomes challenging to maintain due to the temporal changes of these layers, can evolve into the development of a framework that supports a continuous process of change. “Frame withing change operates” (Moneo, 1978, 27). In this context, architecture is defined not by the walls themselves, but by the processes that occur between them. “The structure then becomes the rigid body within which architecture happens.” (Rinke 2023, 147).

The ability to adapt architecture is not merely a response to changing requirements but a means of empowering dwellers. It encourages them to actively assess their needs and reconfigure spatial and material resources, moving beyond the passive consumption of pre-designed combinations.

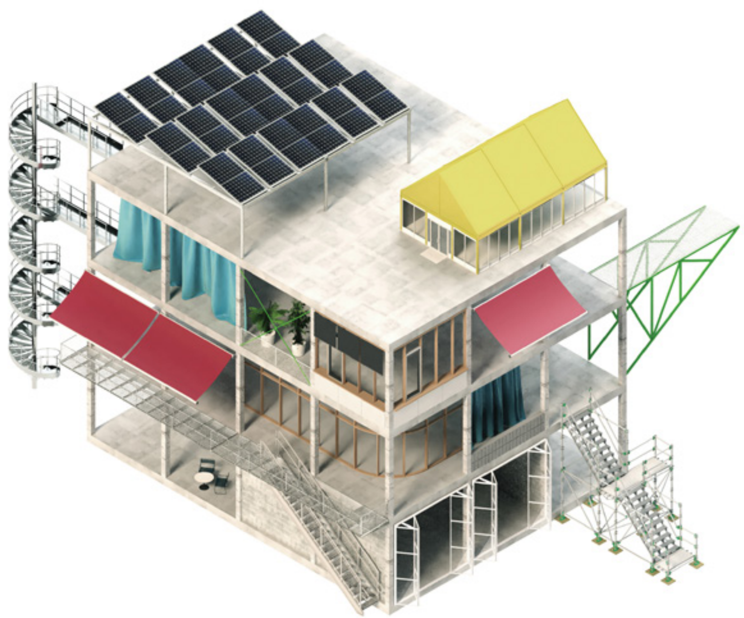

Fig. 3. Conceptual representation of Hardware and Software in architectural design principles, illustrating the distinction between a load-bearing structure (Hardware) and flexible architectural solutions (Software) that enable required functions and create necessary environmental conditions.

Hardware and Software in Architecture

Building on N.J. Habraken's Open Building concept of supports and infill, and inspired by the Structuralist division of building elements by their structural significance—what Hertzberger describes as "ephemeral and enduring" (2013, p. 20)—Kosmos Architects apply these principles in their work with existing structures. They view each act of transformation not only as a means to satisfy current needs but also as an opportunity to prepare the structure for future adaptations. Drawing inspiration from the digitalization of our living environment—where functionality can be transformed simply by installing a new app without altering the object itself—Kosmos Architects have coined their approach as Hardware and Software in Architecture. This strategy reimagines the building as a system in which enduring structural elements (Hardware) support fluid, easily adaptable layers (Software), enabling responsive and sustainable design (Fig. 3).

Hardware refers to the load-bearing system of an existing building, transformed into an open structure—a framework that defines a system of interconnected spaces. This framework facilitates functional changes, allowing for the division or merging of spaces and the introduction of varying climatic zones. It establishes the building's fundamental characteristics without rigidly prescribing internal processes, enabling flexible functional interpretation.

As Rinke (2023, p. 145) observes, "It can render structure a space of possibilities for various specific architectures, each offering qualities but always outlasting these architectural constellations." The building's Hardware remains open to accommodate diverse processes, while elements designed for specific uses are categorized as Software.

Software refers to a system of temporary and movable solutions that adapt the Hardware to meet specific functional requirements. These elements are designed to be easily modified or disassembled without compromising the load-bearing qualities of the Hardware. The independence of these two principal building components ensures that Software solutions remain flexible and responsive to the needs of particular uses and users. As Schmidt and Austin (2016, p. 31) note, "By making the user an active participant, this standard fundamentally readdresses the relationship and role between designer and user."

Not every load-bearing structure qualifies as architectural Hardware. Identifying and revealing the open structure of Hardware within an existing building is the first and most resource-intensive intervention, requiring what Wong (2017, p. 34) describes as "designing within pre-existing architectural principles." This process often entails selective demolition to unlock the structure's potential and open it to new interpretations. As Habraken (2000, p. 135) observes, "Each act of settlement relies on articulated form to stimulate further interpretation."
Elements of Software are designed for change and often have a temporary or movable nature. The deliberate decoupling

of a building's layers similarly enables natural adjustments to its function, spatial arrangement, and environmental conditions. This "delayering" allows for a broader range of configurations, adapting to varying functional demands, seasonal changes, or usage regimes on a weekly or even daily basis.

The disjunction of building layers simplifies adaptation, as adjustments to one parameter do not affect the others. This independence enables the reinterpretation of structural configurations for uses for which they were not originally designed, creating environments that preserve the fundamental parameters of the structural framework. As Habraken (2000) states, "Successful environments offer equilibrium… they are structured to ensure stability while allowing for continuous transformation" (p. 26). The diverse overlay of building systems—furniture, environmental envelope, and structure—generates a gradient of architectural conditions, expanding opportunities for various uses. This approach transcends the traditional dichotomies of indoor and outdoor, private and public, offering a spectrum of semi-conditions that blur the boundaries between heated and cold, covered and open, accessible and enclosed. This gradient facilitates a smooth transition from urban open spaces to private enclosures, activating social life and negotiating environmental conditions.

The continuous movement of these layers creates gaps between them, introducing exceptional spatial and climatic conditions. While these spontaneous misalignments may seem problematic, this porosity can also be explored as potential for organizing the built environment.

The Gap

Oxford dictionary defines Gap as a space where something is missing, indicating as well temporal gaps but also social gaps as a difference that separates people. Demolition introduces a gap in the existing spatial configuration, creating the potential for openness and emptiness that can be appropriated or preserved. Viewing the gap not as a separator but as a connector of architectural elements allows for the interpretation of its exceptional meanings on different architectural scales: a gap in the urban fabric can become a public space, a gap in the building structure can connect different rooms and functions, and a gap between building elements can be celebrated as an architectural detail.

The gap is an exception within the existing organization of the built structure, preserving potential for exceptional solutions. In industrially produced constructions based on standardized elements, the gap between these elements becomes a resource for individualization and contextualization of architecture, shaping the identity of the entire structure. An articulated system of gaps transforms a generic building into an open yet expressive structure, one that is open to diverse interventions while already possessing its own architectural qualities.

The gap between existing spatial configurations and required conditions prompts a reevaluation of functional demands and experimentation with available spatial, material, and technological resources. This discrepancy and contradiction between the old and the new define a vast field for architectural reflection. The limitations of the

context necessitate flexibility in new programs and unconventional interpretations of the required functions, which result in the development of new architectural typologies.
The gap in architecture reveals itself not only as a spatial configuration but also as a temporal condition, where each use and user are limited in time. "Use marks the beginning and end of each act of transformation" (Habraken 2000, 8). The transition from one regime of use to another presents an opportunity to re-envision a building's organization and the resources required for it. In Switzerland, a practice known as Zwischennutzung—or "interim use"—encourages such experimentation. Due to the temporary nature of this occupation, which often occurs in the months leading up to a building's demolition, significant material or financial investments in adapting the building are generally avoided. However, this often leads to innovative uses of both construction and non-construction materials. "A less precious material thus encourages occupants to use/change the space as needed, permitting the space plan to evolve" (Schmidt, Austin 2016, 93). For instance, storage boxes might be assembled to partition the space, and curtains can organize different climatic zones. Occupants often compromise on privacy, acoustic comfort, and climatic conditions to embrace and celebrate the unique spatial and functional opportunities presented by temporary use.
The duration of such events varies, ranging from several months to several years. Zwischennutzung can be seen as a prototype of Hardware and Software design principles, where the existing permanent structure is adapted to new uses through temporary interventions.

Fig. 4. Visualization of Hardware and Software design principles applied to three identical buildings, reconfigured for varying user rotation rates—Years, Months, and Days—using three architectural instruments: furniture, lightweight construction, and load-bearing structure.

Implementation

The three staff buildings of Triemli City Hospital share an identical structural organization, featuring a combination of in-situ concrete, precast concrete elements, and prefabricated load-bearing masonry walls. At the core of each building are the vertical circulation and wet zones, defined by in-situ concrete walls and surrounded by the central portion of the floor plate, which is also poured on-site. This combination of vertical and horizontal in-situ concrete structures forms the rigid structural spine of the building.

The exterior perimeter of the slabs, which vary in width from 4.6 to 5.7 meters from the façade to the in-situ portion of the slab, is assembled from prefabricated concrete elements. This part of the floor slab can be more easily reconfigured if needed. The precast floor panels rest on prefabricated masonry load-bearing walls, oriented perpendicular to the façade. These load-bearing walls, placed every 3.2 meters, define the enclosure of private living units along the façade. The combination of this dense load-bearing structure with a low ceiling height of 2.49 meters from floor to ceiling presents the biggest challenge for spatial alterations to the building.

The first step in adapting the building to meet new functional requirements involved transforming the existing structure into an Open Structure, which the architects refer to as architectural Hardware. Instead of viewing the rigid and repetitive spatial organization of the original plan as a constraint, it was embraced as an inherent potential of the building. The existing system of small compartments was reinterpreted as a modular system of spatial organization.

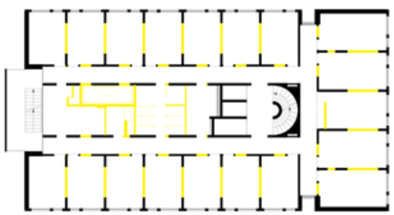

Fig. 5. Typical floor plan with yellow highlights marking the demolished building elements.

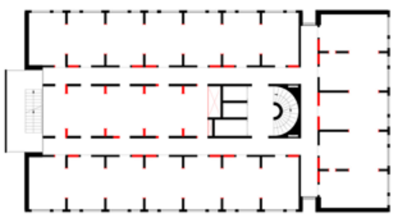

Fig. 6. Typical floor plan with red highlights indicating newly introduced elements of the structure.

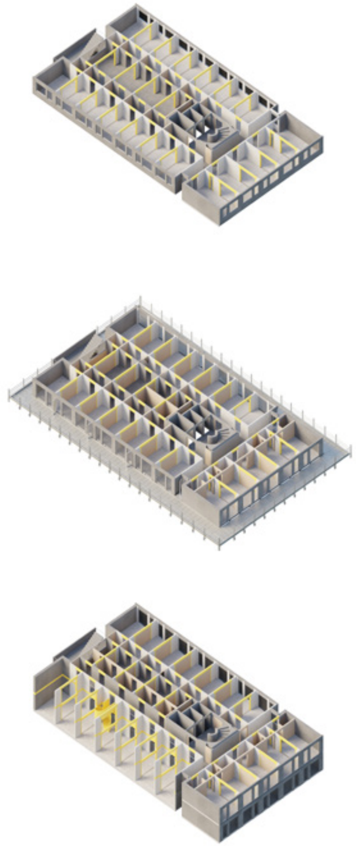

Fig. 7. Axonometric views of identical Hardware, adapted through Software.

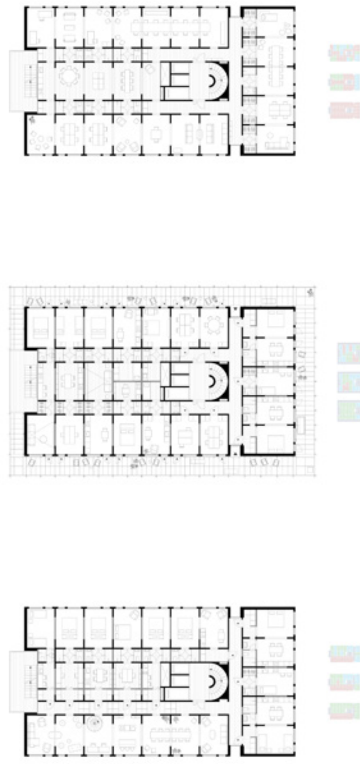

Fig. 8. Organization of space through furniture, light construction, and structural elements.

Partial demolition of the prefabricated masonry walls transformed isolated cells into a system of enfilades—an open spatial system (Fig. 5-6). This Open Structure, characterized by prominent arches, allowed for the organization of spatial clusters of diverse configurations and sizes by connecting and isolating different modules. The flexibility and responsiveness of the building to various uses over time were enabled by Software that allowed the opening and closing of gaps between the modules. (Fig. 7-8).

To maintain the rigidity of the building's load-bearing structure, all openings in the masonry walls have been reinforced with new beams and columns. The new bracing, featuring contrasting materials and colors, becomes an important architectural detail of the building. Systematically introduced throughout the structure, this bracing acts like a thread, tying together different spatial and functional areas. It reframes the existing architecture, "overlays this with new meaning" (Stone, 2023, 478) highlighting the qualities of the original generic structure transformed into the new open configuration, available for inhabitation by ephemeral means of architectural Software.

The new spatial configuration of the building encourages experimentation with functional typologies and various strategies of inhabitation, as well as reflection on the potential frequency of change. In this prototypical project, it was important to illustrate how different durations of use can influence the type of material means involved in facilitating functional needs and organizing these spaces. Three scenarios of occupation—Days, Months, and Years—using three identical buildings, initially transformed into identical Open Structures, illustrate the relationship between spatial organization, functionality, and the instruments for spatial adaptation.

The frequency of user change corresponds to specific functions: co-working spaces, student or seasonal housing, and rented apartments, where users rotate on a daily, monthly, or yearly basis. For each of these types, different material means have been provided to enable the adjustment and

personalization of the space: furniture, temporary structures, and the modification of precast building elements. (Fig. 9). This approach resulted in an open-plan system for the co-working space, organized by furniture; a divided plan of individual units for seasonal housing, with exterior amenities and circulation facilitated by temporary structures; and a shared system of rented apartments with double-height shared spaces and individual rooms, achieved through the modification of precast concrete elements.

The facades of the buildings reflect their internal organization and the material means involved in their spatial modifications. Pertaining to the Days scenario, the façade remains largely untouched, featuring only temporary elements, such as umbrellas, canopies, or curtains, indicate the building's new use from the outside. In the Months scenario temporary structures used to facilitate spatial organization envelope the entire building providing external amenities like terraces and circulation areas, creating a distinct architecture of the facade. Shared double-height

Fig. 9. Architectural elements—load-bearing structure, light-weight construction, and furniture—used to define spatial configurations, organize the environment, and enable functionality.

spaces exude on the façade of the Years scenario articulating a disassembly of the inner structure and contribute to the architectural expression of the building (Fig. 10).

The three temporal scenarios—Days, Months, and Years—applied to the three identical towers involve three types of material resources: furniture, temporary structures, and load-bearing structures. These scenarios illustrate a matrix of potential for adapting existing quotidian structures, transformed into architectural Hardware and reinterpreted for various types and durations of use through architectural Software. This project aims to establish principles for working with existing buildings that are oriented towards future changes, rather than treating the proposed design as the final configuration.

Fig. 10. Spatial organization for different user durations—Days, Months, and Years—utilizing various material means: furniture repositioning, modifications to light-weight construction, and transformations of precast concrete elements. The facade illustrates these three modes.

Simplification

"Achieving adaptation measures in buildings is challenging due to the nonstatic nature of buildings in the future" (Askar, Bragança, Gervásio 2021, p. 19). Predetermining possibilities for change limits design to specific transformation scenarios, potentially becoming an obstacle. As Schmidt and Austin (2016) note, "They'd be more adaptable if they weren't so designed" (p. 51), further emphasizing that "reinforcing simplicity is a good policy for adaptability" (p. 101). This highlights the need to keep the long-lasting components of a building simple and basic, enabling broad interpretations without predefining them.

When modifying existing structures for new uses, it is crucial to avoid overcomplicating them with additional structural interventions, ensuring future transformations can be achieved with simple adjustments and minimal material resources, aligning with sustainable principles. Designing the infill of load-bearing frameworks as temporary and movable elements allows for easy reconfiguration and reuse within the same or different structural frameworks. This approach keeps material resources of both the Hardware (structural framework) and Software (infill) accessible for future adaptations and reuse.

Efforts to capture the full complexity of architecture by adding more building layers often complicates both the design process and the understanding of interrelationships between layers. However, treating building layers as a design instrument benefits from a simplified approach to defining a building's structure and composition. For instance, Rinke (2023) reduces the number of adjustable layers to three: the load-bearing structure, the circulation, and the usable areas, arguing that these layers define the functional capacity for change. Within the context of this text, the author proposes understanding architecture as a synthesis of function within a specific climatic and spatial context—an architectural environment—framed by the load-bearing structure. This conceptualization highlights the performance of three essential building layers: use, environment, and structure. These categories can be represented by a single element, such as thick masonry walls with functional niches, or delayered into a system of layers that includes supports, elements defining spatial configurations and climatic characteristics, and functionality facilitated by fixed and loose furniture.

As Christopher Alexander suggested in his semilattice system for defining the complexity of urban environments through the intersection of various parameters: "As you can see at once, the different units do not coincide. Yet neither are they disjoint. They overlap" (Alexander, 1965, p. 18). Similarly, the categorization of a building can be conceptualized as an overlay of temporal and performative characteristics, discussed disjunctively, offering a nuanced framework for architectural analysis and design. These simple categories enable us to define complex systems while keeping their elements simple and easy to work with.

Conclusion

The concept of layered organization of the built environment effectively describes the diverse roles of building components in a building's configuration and reflects their varying rates of change. To enhance its efficiency as a design tool, the author suggests simplifying it by separating performative (use, environment, structure) and temporal (permanent, temporary, movable) characteristics, defining architecture as an overlay of two three-domain systems. This framework conceptualizes architecture as a composition of use, environment, and structure, realized through construction solutions categorized as permanent, temporary, or movable. This approach provides a and versatile tool for effective architectural design.

The gaps and discrepancies in the configuration of different building layers, caused by their varying rates of change, should not be viewed as problematic misalignments but as productive conditions that inspire unique spatial and material combinations. The contrast between the originally intended use of a structure and its new, often unpredictable future uses creates singular conditions—gaps, misalignments, and unexpected juxtapositions—that cannot be achieved through conventional, one-off design. These conditions offer opportunities for alternative ways of inhabiting and using space. The unconventional spatial configurations that emerge from these layered discrepancies—configurations that would never be intentionally designed—awaken users, encouraging them to reflect on and adapt to these unconventional architectural conditions.

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Figure References

Figure 1
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Figure 2
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Figures 3–10
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