

CREATING CO-LOCATION CONCEPTS UNDER CONSIDERATION OF HYBRID APPROACHES IN CONSTRUCTION PROJECTS

Leonie Szyperski¹, Maximilian R.-D. Budau², Gernot Hickethier³, and Shervin Haghsheno⁴

ABSTRACT

During the COVID-19 pandemic, across industries many project teams started working from home instead of their (co-located project) office, thus relying on virtual teamwork. This shift prompted the use of hybrid or virtual co-locations, whose purpose is to improve communication and collaboration in the project team. However, there is limited research on the effectiveness of these hybrid and virtual co-locations. A co-location can be implemented in both traditional and partnering delivery models, however, this research focuses on co-locations within partnering projects. To address this gap, interviews were conducted with co-location participants in Germany, Switzerland, and the US to gather a wide range of experiences, as well as supplement and validate the literature review. From this information, a co-location requirements catalog was created, and five concepts of co-location setups were identified and developed with varying degrees of hybridity. The research showed that trust and communication are crucial for collaboration, which is one goal of installing a co-location. Therefore, the implementation of a hybrid or virtual co-location must take this goal into account. In-person events play a key role in building and maintaining trust. As technology continues to advance, research on hybrid and virtual teamwork is becoming increasingly relevant.

KEYWORDS

Co-location, big room/obeya, collaboration, hybrid co-location, integrated project delivery (IPD)

INTRODUCTION

The COVID-19 pandemic sent many workers into home-office and virtual teamwork, including workers from the construction industry. The pandemic has resulted in the implementation of virtual and hybrid co-locations. The co-location is a procedure teams using collaborative project delivery models, such as IPD, implement (Lahdenperä, 2012). A co-location aims to foster communication, trust, and collaboration and can be implemented in traditional or partnering construction projects. However, there is a need to further understand co-locations, including hybrid and virtual variants, and their implications to have clear vocabulary for implementation and further research. This research seeks to address this gap in knowledge by investigating

¹ Project Manager, Yukon Projects, Karlsruhe, Germany, leonie.szyperski@yukon.pm, orcid.org/0000-0003-4751-4490

² Research Assistant, Civil and Environmental Engineering Department, Karlsruhe Institute of Technology, Karlsruhe, Germany, maximilian.budau@kit.edu, orcid.org/0000-0002-2572-1176

³ Project Manager, Yukon Projects, Karlsruhe, Germany, gernot.hickethier@yukon.pm, orcid.org/0000-0002-0380-3787

⁴ Professor, Civil and Environmental Engineering Department, Director, Karlsruhe Institute of Technology, Karlsruhe, Germany, shervin.haghsheno@kit.edu, orcid.org/0000-0002-0602-6370

traditional co-locations, as well as hybrid and virtual derivatives, with a focus on the construction industry. The motivation for this research stems from the significant changes in work practices caused by the COVID-19 pandemic and the need to adapt to new modes of teamwork.

Figure 1 shows the structure of this paper. Each blue box represents a chapter, and the hexagons depict key points covered within the chapters. The introduction contains a brief overview of the paper. The results of the literature review covering the existing definitions of the co-location, goals, purpose, requirements, and concepts of a co-location. The method chapter explains the procedure of the literature review, as well as the gaps found, leading to the need for interviews. The following two chapters discuss the results of this paper: the five co-location concepts and the co-location as a method. Based on the interview results, the five identified co-location concepts found in the literature review were supplemented and explained in further detail. Additionally, in this research, we define the co-location as a method to encompass all five concepts. Finally, the closing remarks and conclusions wrap up and summarize the contents of this paper.

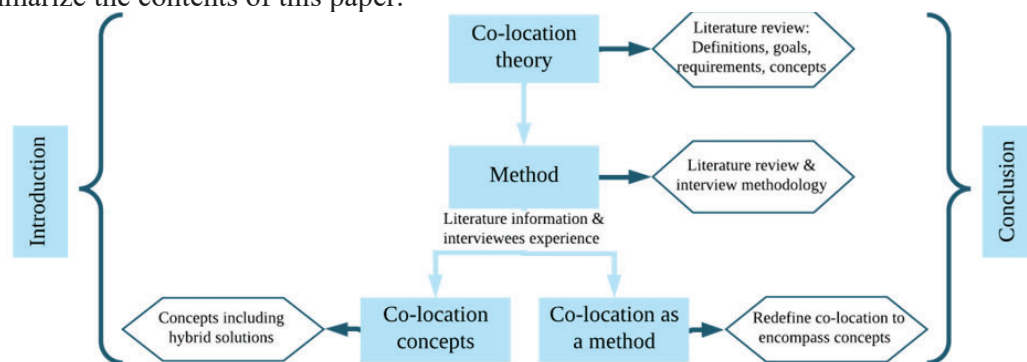


Figure 1: A Visualization of The Structure of This Paper.

CO-LOCATION THEORY

DEFINING CO-LOCATION

Often literature uses co-location, big room, and Obeya room interchangeably. However, they have different meanings and need clear differentiation.

A co-location in the construction industry refers to the practice of key members of a project working together in a shared space, usually a construction project office, to facilitate communication, teamwork, and productivity (Allison et al., 2018). This shared physical space, is designed to bring the team together to foster collaboration, create a group identity, and reach the goals of the project (Allison et al., 2018; Ashcraft, 1996; Fischer et al., 2017; Lazarte, 2020). Allison et al. (2018) mention it can be a physical or a virtual space. The co-location is not a universal requirement for all IPD projects, but research has found it to be an important factor in successful IPD projects (Haghsheno et al., 2022; Rodrigues & Lindhard, 2021). Although Hosseini et al. (2018) found the co-location to be the fourth most important partnering element in their research, only 6 of 43 projects observed implemented a co-location in Norway. Haghsheno et al. (2022) found three out of 13 international papers examined to believe a co-location is a must-have, and a further two mention the co-location as an optional element.

Obeya is an environment designed to facilitate the free flow of information and communication among team members and stakeholders, not a physical room (Dalton, 2019). It often includes visual management tools like charts, schedules, and trend lines to display the current status of a project (Liker & Morgan, 2006). Visual information management (VIM) is a tool used in Obeya to create transparency and transport relevant information to team members and display their work (Björnfort et al., 2012; Dalton, 2019). Obeya is derived from the Japanese

word for "big room" and was originally used in the Toyota production system (Liker & Morgan, 2006).

The big room is a physical space where team members can come together to discuss and work on a project. The big room is designated as the design and coordination office of the project (Temel et al., 2019). Its purpose is to facilitate communication, collaboration, and innovation (Staun, 2020; Temel et al., 2019). The concept of the big room, however, is not clearly defined in the construction industry (Alhava et al., 2015). Obeya is a similar concept, but it specifically refers to an environment that supports the free flow of information and communication, not coordination. The big room is a part of the co-location and can contain visualizations inspired by the Obeya concept.

THE GOALS AND PURPOSE OF A CO-LOCATION

The co-location has a positive effect on integration and collaboration, which helps projects run more smoothly (Adamtey, 2019; Galvin et al., 2021; Mesa et al., 2019). The co-location aims to create a space that promotes collaboration and addresses challenges such as a large group of interdisciplinary people and the need for fast decision-making and information exchange (Allison et al., 2018). Figure 2 illustrates how the co-location facilitates collaboration, with the following paragraph containing the explanations of the connections.

The co-location enables fast decision-making and problem-solving through the exchange of ideas and discussions in the co-location (Allison et al., 2018; Bygballe et al., 2015; Galvin et al., 2021; Gomez et al., 2018). Effective communication and information exchange, aided by the physical proximity and presence of key partners in the co-location, is a factor in building relationships, trust, and collaboration (Adamtey, 2019; Ashcraft, 1996; Rahim et al., 2015; Thompson & Ozbek, 2012). Being present in the co-location allows for relationships to develop and for partners to gain an understanding of each other, leading to an increase of trust over time (Galvin et al., 2021; Olson & Olson, 2010). Trust is a prerequisite of teamwork, crucial for IPD projects, and needs to be consciously built from the start (Majava et al., 2019; NASFA et al., 2010). Performance indicators such as the percent plan complete (PPC) trend line can be tracked in the co-location to increase the team's reliability and commitment to project goals (Andary et al., 2020).

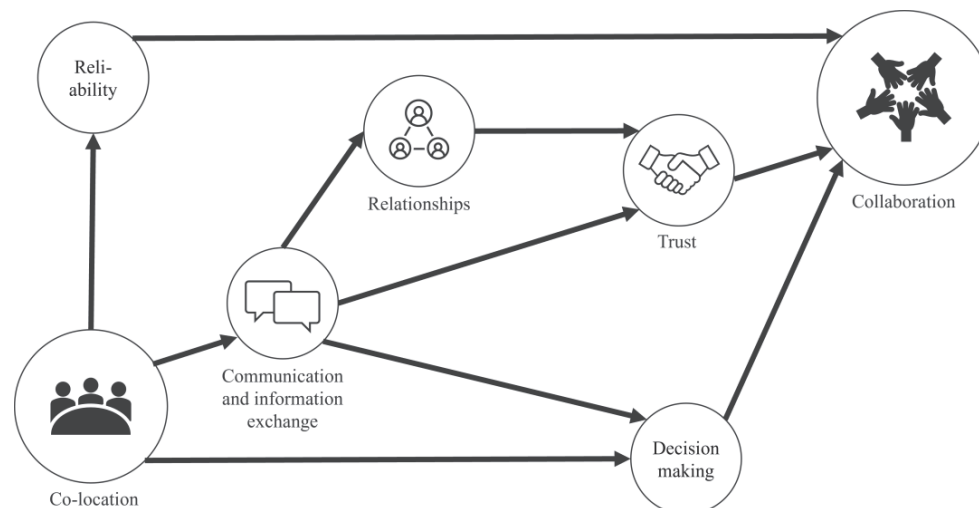


Figure 2: How the Co-location Leads to Better Collaboration within an IPD Team.

CO-LOCATION REQUIREMENTS CATALOG

Allison et al. (2018) outline a large list of considerations, attributes, and characteristics of a co-location. Knowing the requirements helps to fulfil the potential of a co-location. A co-location

requirement can be a hard factor, like a conference room or a coffee machine, as well as a soft factor such as teamwork. The list created by Allison et al. (2018) is validated and supplemented during the literature review and interviews. Table contains the complete list and can be found in the appendix. The goal of this list is to aid those who want to set up a new co-location, so they can use this as a checklist throughout the creation of the co-location.

Not all requirements need to be considered at the same time, the categories are listed chronologically when which requirements need to be considered. The categories *Team/culture* and *Project organization* can begin in parallel to the remaining categories.

THE FIVE CO-LOCATION CONCEPTS

There are five overarching co-location concepts identified in the literature, sorted here by the amount of physical presence:

Full-time co-location: completely in-person, 4-5 days a week at the co-location. Allow for the telecommuter (Fischer et al., 2017).

Part-time co-location: 1-3 days a week at the co-location (Allison et al., 2018).

Pulsed co-location: every other week or one week per month in the co-location. Focus on releasing work when in the co-location (Fischer et al., 2017).

Part-virtual: an almost completely virtual co-location except for workshops which are done in-person (Hosseini et al., 2018).

Virtual co-location: a virtual co-location with options for virtual or augmented reality (Fischer et al., 2017; Wolfartsberger et al., 2020).

A concept that can be combined with the above, is the *rotating co-location*. This is when the co-location is at one of the partner's offices and rotates between the various offices depending on the phase and needs of the partners (Fischer et al., 2017). The co-located *telecommuter* is when partners are allowed to work on other projects while present in the co-location (Fischer et al., 2017). For all concepts, except full-time, office hours need to be set. Establishing a clear schedule of when partners need to be present is imperative for a part-time and hybrid co-location to function (Fischer et al., 2017).

METHOD

The literature review covers the definition of co-location (A), existing co-location concepts (B), as well as the requirements and goals of a co-location (C). By using a Boolean search, numerous combinations of keywords were entered into various academic websites, such as sciencedirect.com and emerald.com. An example of a Boolean search being: (requirements OR characteristics OR value OR advantages) AND (co-location OR big room) AND (lean OR lean construction OR IPD). From the literature found, the sources that each author cited were also combed through for additional articles and potential sources. Publications include English and German articles. Literature was sorted into three categories listed above (A, B, C), and only included when within the context of the construction industry.

During the literature review, it became clear there are significant gaps in the available information regarding the co-location. To begin, co-location has several competing definitions and does not encompass the five co-location concepts, which we identified. Additional gaps found included points summarized here into six categories: (1) hybrid communication, (2) teamwork regarding hybrid co-locations, (3) co-location requirements, (4) digital solutions and alternatives, (5) reasons for a hybrid co-location, and (6) information on the degree of hybridity (DOH) within a co-location concept. Further gaps found that will not be covered further in this paper are as follows:

Key performance indicators (KPIs) in a hybrid co-location

Pedagogic view and psychological analysis of teamwork in hybrid co-location
 Minimum project size for a physical co-location
 Creating a co-location on a budget as well as co-location cost suggestions
 Social networks analysis (SNA) of the project team for co-location decisions
 Project quarterback rating (PQR) for assessing hybrid co-location performance
 Analysis of space needed in co-location based on people and budget size
 Effectiveness of concepts concerning collaboration, productivity, and planning using case studies

To address the gaps found in the literature review as well as supplement and validate the information found, a survey and subsequent qualitative interviews were conducted with co-location participants in Germany, Switzerland, and the US. Detailed interviewee responses to the six categories will not be covered in this paper. The goal of the interviews was to explore different perspectives and understand how participants tackled the challenges of the COVID-19 pandemic regarding the co-location. The interviews were semi-structured, explanatory interviews and structured into three blocks: introduction, main questions, and conclusion (Bogner & Menz, 2009; Gansen et al., 2011; Meuser & Nagel, 2009). This allows for the structure to keep the dialogue goal-orientated, but enough freedom to ask additional or clarifying questions.

A total of 41 people were contacted based on their experience with co-locations in the various project phases, 26 of whom agreed to participate in an interview in the months of February, March, and April of 2022. The participants included designers, builders, project owners, users, and coaches. Table 1 lists the project identity, position, and country of each interviewee. The German and Swiss interviewees represent seven IPD projects. Therefore, the results cannot be generalized to address traditional project delivery methods. The US interviewees were not based on a specific project, but rather on their general experience. Most of the interview partners were in the project management team (PMT), and some were in the senior management team (SMT) of their project. PMT and SMT definitions as well as corresponding names e.g. core team and alliance team will not be addressed in this paper. To ensure anonymity, the names, and companies of the participants, and their IPD projects, are not disclosed. The interviews were transcribed and analyzed using the qualitative content analysis method from Mayring (1991).

Table 1: An Overview of the Interview Partners.

Project	Builder	Lean Coach	Owner	Owner's representative	Designer	User's representative	Country
P1		1	1		2	2	DE
P2	2	1	2				DE
P3		2				1	DE
P4		2					DE
P5	1	1		1	1		CH
P6	2	2					DE
P7	1	1					DE
-	1	3	1				DE, USA

CO-LOCATION CONCEPTS

OVERVIEW OF THE FIVE CONCEPTS

With the information and experience of the interview partners gathered during the interviews, the five concepts found in the literature review were elaborated on and described in further detail. An overview of these five concepts can be found in Table 2. Due to limited space the results of the interviews will not be outlined, but rather the further development based off the interview results.

A co-location is hybrid when one or more team members are not physically present, and the rest is physically present. The DOH peaks when there are several participants in the co-location but also several working remotely on the none-core days. A co-location becomes virtual when all members are joining in virtually. The concepts have varying degrees of hybridity, beginning with a full-time face-to-face (F2F) co-location with close to zero hybrid components. Then the hybridity is increased and peaks at concept 3, the pulsed co-location. In concepts 4 and 5, hybrid components are replaced by virtual components. Components are processes that happen within the co-location, such as meetings and workshops, as well as requirements listed in the requirements catalog.

Table 2: An Overview of the Co-location Concepts with Varying Degrees of Hybridity.

Concepts	Concept 1 Full-time	Concept 2 Part-time	Concept 3 Pulsed	Concept 4 Part-virtual	Concept 5 Virtual
Picto-grams					
Physical presence in days a week [d/w]	4-5 d/w	1-3 d/w	Every other week or one week per month	Select processes in person, everything else is virtual	0 d/w Completely virtual
Options	Tele-commuter		Possibility for a rotating co-location	Virtual or augmented reality	Virtual or augmented reality
DOH	Low	High	Medium	Low	Low

The goal of a hybrid or virtual co-location is to maintain at least the same level of collaboration as a traditional F2F co-location. This section covers the created concepts proposed to reach this goal.

The process of choosing a concept depends on different project framework conditions such as the size of the project both in costs and complexity, as well as the phase of the project. Due to the diversity of project conditions in the construction industry, there is no one size fits all solution for choosing a concept. The decision on which co-location concept depends on the project framework, such as budget, complexity, duration, and the current project phase. It also depends on the chosen team and if they are compatible with a high DOH.

CONCEPT 1: FULL-TIME CO-LOCATION

This concept encompasses the traditional F2F co-location. This is where all project partners come to the co-location in-person, 4-5 days a week. This concept has a low DOH. The *telecommuter*, as described above, is when project partners can work on other projects while at the co-location. Note that it is not recommended to force partners to come five days a week as this goes against the new normal. If five days a week are needed, create a shift system where the first half of the team is there Monday-Thursday and the second half Tuesday-Friday. To

implement this concept, the full standard co-location requirements catalog is required. Table in the appendix contains the catalog, including both requirements found in the literature review as well as during the interviews. The full-time co-location is suggested mainly during the construction phase for large and complex projects. During the construction phase, the co-location should be as close to the construction site as possible, in the earlier phases it can be located closer to the team's offices.

CONCEPT 2: PART-TIME CO-LOCATION

The second concept is a part-time co-location averaging 1-3 core days a week in-person and the rest in a hybrid or virtual setup. Team members are allowed to work in the co-location on the non-core days if this is what they prefer, but they are not required to be present. This concept is by far the favored concept based on the interviews. This concept is the sweet spot between F2F and virtual. It allows for the benefits of a physical co-location while still giving the flexibility of a concept with a higher DOH. Here a physical co-location is necessary that follows the same requirements and steps as in Concept 1. Additionally, to the full-time requirements, the part-time co-location needs hybrid components. For this concept, it is recommended to do LPS in person but have a digital copy so that on the days away from the co-location participants can still access this information, especially when only using the co-location 1 or 2 days a week. The team should either use software that allows interactive work in the big room or have the physical post-its copied into a digital version after each LPS meeting, which could be as simple as uploading photos. This depends on the team and whether they chose to invest in software and how affine they are with technology. VIM should be present in the co-location; however, the project should have an additional dashboard online as well to quickly access the current project status. Most meetings, including SMT, PMT, and PIT meetings are all in-person at the co-location. Organizational and simpler topics can be held in a hybrid or virtual format. Meeting rooms need to be equipped with appropriate hardware such as microphones, screens, and cameras to be able to hold hybrid meetings.

CONCEPT 3: PULSED CO-LOCATION

The third concept is the pulsing co-location. This means that a team is either at the co-location every other week or one week per month. The week where presence is mandatory are the so-called core days for this co-location. Depending on the team it may only be 3 days a week, once a month. It is possible to have a rotating co-location, which, as described above, is when the co-location rotates between the partner's offices and does not have a separate location. If there is a separate co-location and not a rotating co-location, each team member can choose for themselves whether to be present on the non-mandatory weeks. Due to the low amounts of mandatory presence, other processes increase in importance and must compensate for the time missing in the physical co-location. It is important to have a cohesive virtual dashboard to maintain VIM even when not present in the co-location, this can be a virtual whiteboard software or integrated with the BIM model. LPS meetings are done in a virtual format. Note that due to the large number of participants in a LPS meeting, it is suggested to be completely virtual to avoid miscommunication. The importance of LPS meetings increases with the DOH as it allows for the whole team to come together and communicate what is currently being worked on. This concept has the highest DOH, meaning most of the co-location aspects are in a hybrid format.

CONCEPT 4: PART-VIRTUAL CO-LOCATION

The part-virtual concept is ideal for smaller projects or project phases that require less collaboration. The team should meet in person for select processes that enable the team to still build trust and relationships that in turn allow for open communication and collaboration. In-person events, like team building events and the kick-off, are even more vital for this concept

as they are the few times the team comes together. Team building events need to be reoccurring to maintain the level of collaboration. These events can either be done at the partner's offices, or in event rooms rented for those specific occasions. All other processes are done virtually. This includes SMT and PMT meetings, as well as LPS meetings. Facilitation and leadership skills are of higher importance here to ensure the team is still collaborating and getting along. The team needs to have clear communication and meeting rules, as well as more discipline than using a traditional co-location. This co-location form is almost completely virtual, and therefore, the DOH sinks.

CONCEPT 5: VIRTUAL CO-LOCATION

The last concept is the completely virtual co-location. This has no in-person or hybrid aspects. The virtual co-location is currently not recommended. Due to the missing in-person interactions, it is difficult to build trust, communication, and therefore, collaboration. This concept should only be implemented if the team is a small tight-knit group that has experience working together. Due to chance communication missing entirely, other communication channels as well as VIM need to carry more weight. Set importance on video calls with the camera and microphone on, rather than chat platforms. This maximizes the number of communication styles in use. Options for virtual or augmented reality can help further increase the number of communication styles being transmitted. A virtual dashboard that is clean, structured, and contains all important project status information in one accessible place is vital. Software needs to be intuitive and available to all team members. Ideally, a communication platform is used that encompasses everyday communication, the project dashboard, the LPS, the BIM model, the master schedule, and other relevant information.

CO-LOCATION AS A METHOD

Due to the terms co-location, big room, and Obeya room being used interchangeably, as well as the definitions not encompassing hybrid or virtual co-locations, we expand the definition of the co-location. To create clarity, we define co-location as follows:

The co-location is a method of transforming a space to bring a team together and foster collaboration through coordination, visualization, and transparency. It is the space where interdisciplinary teams come together to collaborate, communicate, and work as an integrated team side-by-side. This includes all hierarchies, e.g., in IPD projects the project implementation teams (PITs), PMT, and SMT. The co-location uses visualizations to inspire the team, using the principles of the Obeya room throughout the space. The co-location does not have to be a permanent physical space in the case of a hybrid or virtual co-location.

By defining the co-location as a method, rather than a physical space, hybrid and virtual co-locations can be considered. For smaller projects, the physical co-location may just be a big room including the workstations of the team. Larger projects will encompass the big room as well as meeting rooms, a coffee corner, and an open co-working space.

CONCLUSIONS

Creating a high-performing team of interdisciplinary, cross-functional people in a complex construction project needs trust and open communication. The co-location is a tool that improves collaboration and communication in construction projects. A co-location includes various components such as VIM and LPS, as well as elements like acoustics and the Internet. Due to the COVID-19 pandemic and the parallel transformation of technology, it has become the new normal for companies to offer employees more flexibility to work from home (Raghavan et al., 2021). A hybrid approach to co-location has become increasingly important, combining in-person and remote work. A co-location must have the fitting components and be used effectively to be successful. Based on the literature review, supplemented, and validated

through the interviews, a comprehensive requirements catalog was created and can be used as a checklist for future co-locations.

We defined co-location as a method to transform a space to bring an interdisciplinary team together and foster collaboration through coordination, visualization, and transparency. The co-location does not have to be a permanent physical space in the case of a hybrid or virtual co-location. Depending on the size of the project, a co-location can be as small as the big room or large enough to include the big room as well as smaller meeting rooms, a coffee nook, and an open co-working area. The co-location actively uses visualizations to inspire and guide the team, using concepts of the Obeya room throughout the space.

Five co-location concepts were identified in the literature review and developed further with clear definitions, three of which are hybrid. By defining each concept clearly, future discussion over the concepts will have fitting vocabulary. The second concept, being the most recommended in the interviews, is a part-time co-location where participants are present 1-3 days a week depending on project size and preference. These concepts should be seen as suggestions and need further examination to understand their impact on collaboration, teamwork, and the project. They are based on 26 interviews and a literature review. The interviews were held mainly with co-location participants in Germany, findings here cannot be generalized for international purposes.

In conclusion, interviews showed hybrid co-location concepts can be successful, however, none recommended the long-term implementation of a virtual co-location. Interviews showed that in-person events need to be at the beginning and throughout the project to build and maintain trust. As the DOH increases, communication channels such as chance communication decreases. Interviewees argue other communication channels such as LPS need to compensate for the missing communication.

The co-location concepts need to be further analyzed and tested in practice to ensure their accuracy. Each project is different, and no co-location is the same. Further differentiation needs to be taken based on the project's size, both in volume as well as in the number of project participants. Additional sources of information could be included in the future, such as case studies and large-scale surveys to gain more practical data. Further international interviews should be held to ensure the accuracy of these findings and to remove cultural biases.

A process and research of a topic are never complete. As lean methods would say, one needs to constantly plan, do check, and act (PDCA). This paper covers one iteration of co-location concepts that are built on prior research and practical implementations. We recommend that in the next iteration, these concepts be, implemented, checked, and further improved.

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APPENDIX

Table 3: A complete catalog of co-location requirements and characteristics, as found in the literature review and the interviews. Italics: new findings, not mentioned in the literature.

Categories	Requirements	Literature source	Unique mentions
Team/culture	Team compatibility/cultural fit	AIA California Council, 2007	4
	<i>Collaboration mindset</i>		2
Project organization	Clear and fair MPC	Pishdad-Bozorgi, 2017	
	Project charter	Allison et al., 2018	
Region	Proximity to team offices	Allison et al., 2018	
	Proximity to site	Allison et al., 2018	1
Attributes	Bright	Allison et al., 2018	2
	Flexible	Allison et al., 2018	1
	Comfortable	Allison et al., 2018	
	Accessible and safe	Allison et al., 2018	
	<i>Colorful</i>		1
	<i>Quality</i>		1
	<i>Open design</i>		5
Environment	Natural light/lighting	Allison et al., 2018	3
	Ventilation	Allison et al., 2018	1
	Temperature	Allison et al., 2018	1
	Acoustics	Allison et al., 2018	5
	Weather protection	Allison et al., 2018	1
Rooms	Kitchen access	Allison et al., 2018	9
	Break-out rooms	Allison et al., 2018	13
	Big room	Allison et al., 2018	8
	Shape and size of space	Allison et al., 2018	2
	Washrooms, room for coats/boots	Allison et al., 2018	
	<i>Recreational area</i>		3
Functionality	Wall space	Allison et al., 2018	5
	Partition walls	Allison et al., 2018	3
	Furniture/furnishing/layout	Allison et al., 2018	4
	Storage	Allison et al., 2018	
Technology	Audio/video	Allison et al., 2018	3
	Internet	Allison et al., 2018	6
	Projectors	Allison et al., 2018	2
	Computers	Allison et al., 2018	6
	Software	Allison et al., 2018	
	<i>Modern IT</i>		5
Co-location organization	Rules of engagement	Allison et al., 2018	1
	Seating arrangement	Thompson & Ozbek, 2012	2
	Celebrate success	Allison et al., 2018	1
	Shared learning/workshops	Ashcraft, 1996	1
	Clear purpose/goals	Pishdad-Bozorgi, 2017	2
	Psychological safety	Ebrahimi & Dowlatabadi, 2019	2
	Coffee/tea/snacks	Allison et al., 2018	
	Visual information management	Ashcraft, 1996	9
	<i>Regular PMT project updates</i>		1
	<i>Sense of added value</i>		2
	<i>Respect among partners</i>		1
	<i>Workshop material</i>		1
	<i>Clean/organized</i>		1