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Themes for an Airport Hub in the transition towards a Multimodal Transport Hub – an embedded researcher's perspective

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Future mobility systems will likely incorporate more multimodal journeys. These multimodal journeys integrate multiple modes of transport, and their higher future prevalence highlights the importance of paying attention to the modality transfers within journeys. To carefully facilitate these transfers, we advocate the creation of passenger-oriented Multimodal Transport Hubs (MTHs), which integrate both infrastructure and services of multiple travel modalities to ensure high-quality transfers between the different modes of transport. This study is part of a research project investigating how Airport Hubs can transform into MTHs and aims to learn in practice how the case study FlyHub deals with new travel modalities and how FlyHub integrates these into its ecosystem. Through the presence of an embedded researcher in the case study context, performing the explorative pre-step of the Action Research approach, the study builds an understanding of the context and the rationale for possible succeeding cycles of action and research. Accordingly, we identified five themes that either stimulate or thwart the transition of FlyHub into an MTH. The five themes are 1) recognition of the importance of innovation and long-term outlook, 2) limited exploration possibilities, 3) the MTH concept being (too) abstract, 4) multi-system transition going slow, and 5) changes and transitions being a struggle for power.

Keywords: *mobility; multimodal; airport; transition*

1 Introduction

The current mobility system is undergoing substantial changes driven by two critical trends: the growing demand for sustainable solutions and digitisation. The former involves the rise of eco-friendly mobility options, like biofuels and electric, hydrogen, and solar technologies. At the same time, the latter is propelled by Information and Communication Technologies (ICT), aiming to make passenger travel faster, cheaper, safer, and more efficient (Ceder, 2021). As a result, we see the emergence of cross-modality and cross-operator mobility services (X-mobs), which allow passengers to plan, book and pay for their journey across different mobility operators and travel modalities (Veeneman et al.,



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2020). An example of an X-mob service is Mobility-as-a-Service (MaaS), which offers a personalised subscription to passengers to use a range of travel modalities (Canale et al., 2019).

If these trends persist, future mobility systems will likely incorporate more multimodal journeys, which "capture and integrate the advantages of various modes of transportation" (Huang & Mu, 2018, p.256). The rise of multimodal travel highlights the importance of paying attention to the transfers between travel modalities, as those are the critical points where disruptions may occur (Monzón et al., 2016). Travellers transfer between modalities in so-called transit hubs, such as Airport Hubs, Rail Hubs, or Public Transit Hubs (Toet et al., 2022). These locations are nodes where different transport subsystems, each linked to a means of transport, meet. In this study, we follow the definition of transit hubs given by Li and Xu (2019) as "the gathering point of various travel modalities".

To facilitate optimal transfers within multimodal journeys, we advocate the creation of passenger-oriented Multimodal Transport Hubs (MTHs). At these highly developed transit hubs, the services of several travel modalities come together (Anderson et al., 2017) and are offered bundled to passengers. Integrating transaction, reservation, information and planning services of different transport modes (Veeneman et al., 2020) is an example of combined services that facilitate a high-quality transfer for passengers at an MTH. In addition, for a well-functioning MTH, its infrastructure is also an essential asset. These facilities are required to operate the travel modalities (such as rail tracks, highways, and runways) and connecting elements such as buildings and moving walkways (Canale et al., 2019; Li & Loo, 2016). An advanced application of MTHs, where infrastructure and services are aligned to integrate multiple modes of transport fully, is very limited in practice.

The creation of passenger-oriented MTHs is encouraged by the EU Commission, which stated that "...airports, ports, railway, metro and bus stations, should increasingly be linked and transformed into multimodal connection platforms for passengers" (European Commission, 2011, p.6). Airport Hubs have the potential to transform into MTHs, as these bring together the infrastructure of multiple travel modalities and already provide high-end integration for air travel. Our work focuses on Airport Hubs instead of smaller and regional airports, as the Hubs cater to airlines/alliances using the Hub-and-spoke model. Airlines that operate according to this model collect passengers through long and medium-distance flights at airports (spokes) and transfer them at their hub into (ultra-long distance) second-leg flights (Zgodavová et al., 2018). According to previous research (Toet et al., 2022), ultra-long distances typically range from 5000 to 10.000 km, long from 200 to 5000 km, and medium from 50 to 200 km. In addition to these ultra-long-range flights, of which the passengers want to journey onwards, Airport Hubs often feature several short (with a range of up to 50 km), medium and long-range travel modalities. Thus, in terms of the presence of travel modalities and infrastructure, Airport Hubs have the potential to become MTHs.

However, most current Airport Hubs focus on integrated services within air travel rather than between different travel modes. To become MTHs, Airport Hubs must facilitate seamless transfers between diverse travel modes and become part of a passenger-centric mobility system. Therefore, Airport Hubs should accommodate high-quality multimodal transfers by integrating infrastructure and services from various transport operators. Figure 1 illustrates how an Airport Hub physically connects the infrastructure of several mobility systems and how an MTH also integrates services. Prior research (Toet et al., 2022) proposes adopting Chesbrough's model (2017) to access, harness, and absorb new modalities into their business to become MTHs.

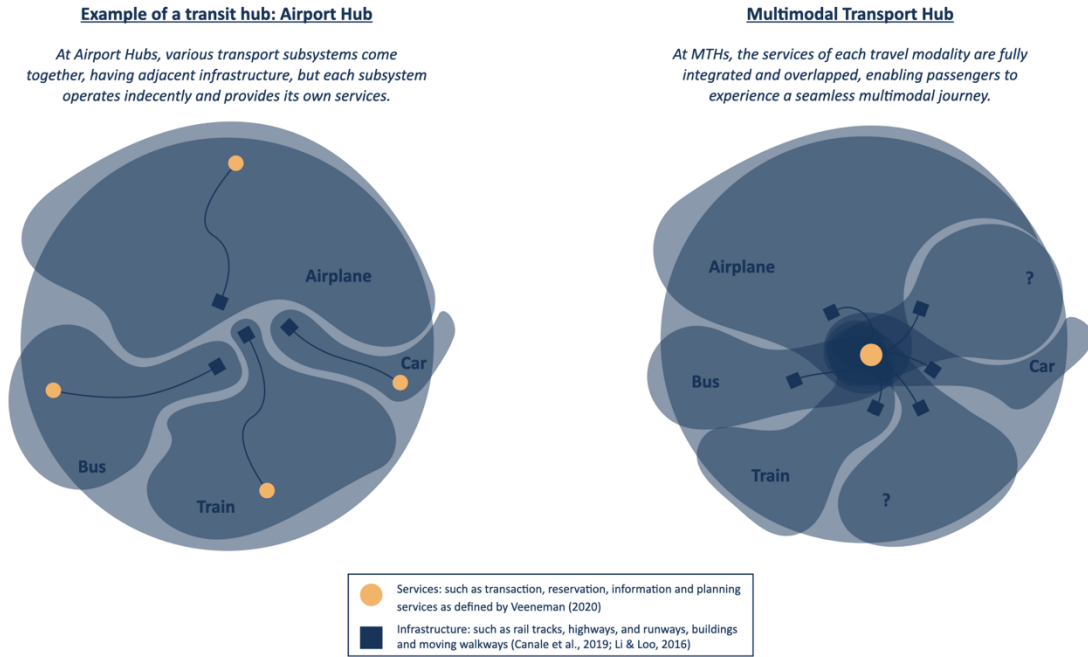


Figure 1. An abstract visual of Airport Hubs and MTHs.

This study is part of a project sponsored by FlyHub and ClickNL, which was established to investigate how Airport Hubs can transform (themselves) into MTHs. This paper investigates themes that arise when an Airport Hub explores new travel modalities, serving as a starting point for subsequent studies. It documents the themes one of the authors identified during her immersion in the FlyHub case study from September 2021 to February 2023. The central research question is: What themes arise when an Airport Hub aims to innovate with new travel modalities in order to transform into an MTH?

2 Method

The embedded researcher applied an Action Research (AR) approach to investigate how Airport Hubs deal with the (potential) introduction of new travel modalities. The AR approach is about "research in action, rather than research about action" (Coughlan, 2002, p.222), meaning that researchers actively participate in practice, with the underlying notion being that "the best way to understand something is to try to change it" (Greenwood & Levin, 2007, p.18). AR is considered a suitable method for gaining insider knowledge of an organisation since it stimulates researchers to become part of the object of study (Bartunek & Louis, 1996).

The AR approach builds on the spiral process explained by Coughlan (2002). This process is visualised in Figure 2 and presents the AR cycle as consisting of three parts: a pre-step, the six main steps of the action research cycle, and the meta-step to monitor. This paper documents themes arisen in the pre-step to the AR cycle, in which the embedded researcher built up an understanding of the context and the rationale for possible succeeding cycles of action and research. The researcher's experiences included collaborations of FlyHub with Hyperloop, Urban Air Mobility (UAM), Electric Flying Consortiums, and Air-Rail connections.

The remainder of this chapter discusses data collection and analysis, why a case context description was added, and the background and position of the embedded researcher.

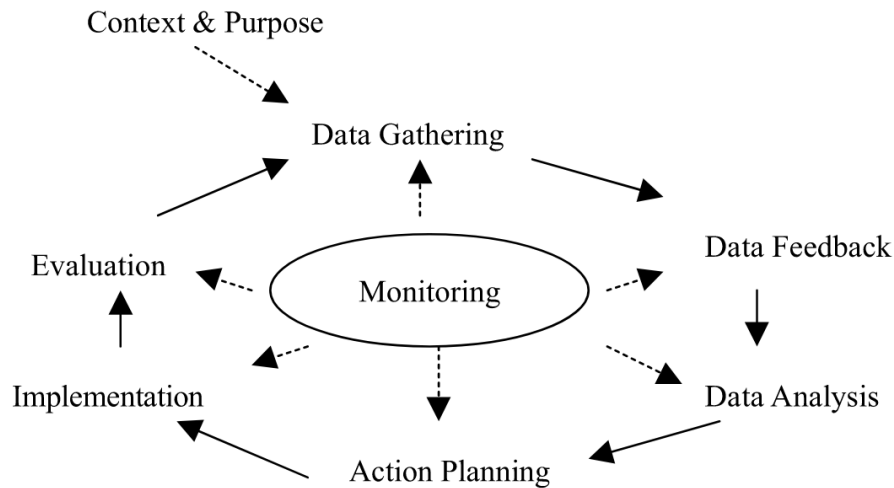


Figure 2. The AR cycle. Source: Coughlan (2002)

2.1 Data collection

A typical way to gather data in an AR process is "through active involvement in the day-to-day organisational processes relating to the AR project" (Coughlan, 2002, p.231). The data were collected between September 2021 and February 2023. The data sources comprised interviews with innovation managers, executives and project members, observations of meetings and day-to-day work, informal and formal documents, and e-mails and chat exchanges with (internal) stakeholders.

Informants included project teams and innovation managers that managed the innovation team's portfolio, but data was also gathered by initiating and actively participating in project teams. The data initially emerged from the smaller context of the innovation team and later also originated from the broader department and project teams associated with multimodality practices.

The observations and interviews were captured through journal keeping, allowing the researcher to capture thoughts, ideas, impressions, and decisions (Coughlan, 2002; Herr & Anderson, 2005). (Coughlan, 2002; Herr & Anderson, 2005).

2.2 Data analysis

The data analysis approach consisted of four steps, also visualised with examples in Table 1.

1. Anonymisation: Personal information, such as name, e-mail address and company, were anonymised. The company was given the pseudonym 'FlyHub', and all the data was stored in a software package for qualitative data analysis (Atlas.ti).
2. Meaning units: Due to the extensive raw data set, we have selected the meaningful parts of the content to perform an insightful analysis, referred to as meaning units. (Giorgi & Giorgi, 2003; Graneheim & Lundman, 2004).
3. Coding: The next step was to shorten the length of the meaning units without affecting their content (Lindgren et al., 2020). This being an explorative study, we coded the (condensed) meaning units with an open coding strategy, in which categories and themes emerge from the

raw data, with the researcher being open to all possible directions (Khandkar, 2009; Wicks, 2017). The coding process was iterative, adding, merging and deleting codes until the codes were stable (Miles & Huberman, 1994).

4. Identifying themes: The next step was to identify factors, mechanisms or subthemes that either stimulated or thwarted the introduction of new modalities or the transition of FlyHub into an MTH and cluster these according to themes. On the report of Graneheim & Lundman (2004, p.107), a theme is "a thread of an underlying meaning through, condensed meaning units, codes or categories, on an interpretive level".

Table 1. An illustration of the data analysis process, starting with the raw data (far left column) and subsequently applying codes (second column) to elucidate the emergence of sub-themes (third column) and themes (far right column).

Meaning unit	Code	Subtheme	Theme
"We're not stopping UAM because it is coming. If we decide to market UAM, we can influence how we can use it best."	Influence innovations	Stakeholders want to retain power	Stakeholders operate from their own goals
"[airlines] will remain part of the scene"	Attractiveness of aviation	Airport focus on aviation	
"Innovation at FlyHub is slightly different [than at start-ups] because the culture of failure is difficult. Projects are very complicated, and many stakeholders are involved"	Big consequences of failure	Testing is difficult at big airports	Big airports have limited exploration possibilities
"easier to start at regional airports. Fewer regulations, airlines etc."	Less strict regional airport regulation	Collaborations with regional airports for innovation	

2.3 The importance of the context

Greenwood and Levin (2007) point out that one should be careful in generalising the knowledge gained in AR projects. Insights from AR studies, including this research, are context-bound. Theory formation in AR projects entails moving from specific cases to broader generalisations (Eden & Huxham, 1996), making it crucial to actively interpret and conceptualise practical experiences in similar contexts. To assess the transferability of knowledge, it is essential to identify both the similarities and differences between the new context and the original context where the knowledge originated (Greenwood & Levin, 2007; Shenton, 2004). Hence a "thick description" of the case should communicate the contextual factors (Lincoln & Guba, 1985, p.214). We describe this study's case context below.

2.3.1 Transfer infrastructure and services

This research focuses on FlyHub, a major European Airport Hub that facilitates a global Hub-and-Spoke network of destinations. FlyHub has the infrastructure and services to offer integrated services for

high-quality transfers between air modalities. FlyHub's infrastructure also features an integrated railway station with access to the (inter)national (highspeed) rail network and which is a transfer station for national trains. FlyHub provides infrastructure and, to a lesser extent, services for transfers between rail modalities. The same applies to bus modalities at FlyHub, since its infrastructure is in place, but the (transfer) services provided could be more extensive. Thus, apart from physical proximity and a few (pilot) projects, transfers between different travel modalities are not facilitated with integrated services as defined by Veeneman et al. (2020).

In addition to ultra-long and long-distance modalities, FlyHub is served by a range of short and medium-range travel modalities: it is accessible via private transport (car, taxi, motorcycles and bicycles) and public transport (train and bus). Furthermore, FlyHub is spatially constrained as its geographical location is close to the central urban area it serves.

2.3.2 Organisational context

This research was initially part of the portfolio of FlyHub's innovation team, embedded in the strategy and planning business unit. During the research period, FlyHub and aviation were (still) recovering from the Covid-19 pandemic. As a result, a significant reorganisation had just altered the staffing of business units, departments and teams at the start of this study. As COVID-19 faded, FlyHub, like other major Airport Hubs, struggled to accommodate the rapidly growing passenger numbers due to severe staff shortages and significant operational issues. Following a switch at the top leadership of FlyHub, the innovation team shifted within the research period to short-term innovations that directly contribute to the operational recovery.

2.4 The embedded researcher

In qualitative research, like AR, the researcher's background and position influence the content, approach, and interpretation of the research (Giorgi & Giorgi, 2003; Greenwood & Levin, 2007; Malterud, 2001). Hence, transparency about the motives, beliefs, background, and prior knowledge of the (embedded) researcher is recommended (Malterud, 2001; Shenton, 2004). The embedded researcher joined FlyHub in September 2021 with limited prior knowledge of the company's complexity. She was familiar with FlyHub, had travelled through it several times, and conducted a prior study at an airline operating from FlyHub.

The researcher's worldview aligns with pragmatism, acknowledging the subjective perception of the objective world (Cornish & Gillespie, 2009; Morgan, 2007). AR aligns with this perspective, recognising that "reality is interconnected, dynamic, and multivariate and always more complex than the theories and methods that we have at our disposal." (Greenwood & Levin, 2007, p.54).

The embedded researcher initially approached multimodality practices from an outsider's perspective but later transitioned towards being an insider, as is common in AR projects (Herr & Anderson, 2005). This shift was facilitated by available interim roles within the organisation. However, despite becoming embedded, the researcher maintained some distance from internal stakeholders, as required in AR, to observe their actions critically (Greenwood & Levin, 2007).

3 Results

The study found five distinct themes concerning issues either stimulated or thwarted 1) the identification, selection, and integration of new travel modalities and 2) the transition of FlyHub into

an MTH. These themes can be seen as an expression of the latent content of the data (Graneheim & Lundman, 2004). In this chapter, we elucidate these themes, exploring their underlying meanings with support from relevant data evidence.

3.1 Theme: recognition of the importance of innovation and long-term outlook

We identified five indicators that innovation was considered necessary and important by FlyHub during the research period. The recognition of innovation was widely supported within FlyHub and encouraged embracing complex long-term issues, such as new travel modality adoption. This innovative attitude, way of working, and long-term outlook can also be positive for transforming an Airport Hub into an MTH.

First, FlyHub has a long history of innovation and proudly advocates its roots as a pioneer in aviation that go back over 100 years. During the research period, the innovation team was part of the strategy and planning department, whose director reported directly to the CEO of FlyHub. Also, it was noticed by the researcher that FlyHub had "innovation managers" scattered throughout each department (e.g. Asset Management, Operations, IT and Data, Security, and Commercial). Hence, innovation was caught as a core value manifested in organisational roles throughout the organisation.

Second, FlyHub's board of directors, including the CEO, directly monitored the innovation team's portfolio. Once every few months, the directors met to decide on investments, experiments, and focus points, guided by the innovation team. One of the innovation managers argued that "It's better to have the directors meet for short periods more frequently than to try to be "efficient" by having a 12-hour marathon once a year. An annual meeting may be efficient for the directors but could represent a high cost of delay for the projects waiting for approval or funding of next steps" (12/2021). The embedded researcher observed that during innovation decision-making processes, the CEO was active, prepared well, and made decisions quickly.

The extensive portfolio of the innovation team seems further evidence of the recognised value of innovation. An innovation executive explained that the innovation team focused on six distinct themes (09/2021), and the portfolio owed its size to, among other things, the improvement drive of the innovation team. This ambition to have an impact was well cited by an innovation executive (10/2021): "The answer to every critical question is always: I don't know, but based on my mission, I will make sure it will work."

Fourth, the long-term focus of the innovation projects indicates the recognition of the importance of innovation. Even though FlyHub focused on all innovation horizons throughout all business units, the innovation team specifically worked towards long-term innovations (innovation executive, 09/2021). An innovation manager highlighted their focus on future complex problems, even those yet to appear. Thereby, FlyHub recognised lengthy innovation timelines for major transformations, like infrastructure and modalities development. FlyHub's innovation team tackled these projects through exploration and problem-mapping. Hence, learning a hypothesis was most important for the innovation team, as indicated by an innovation executive (05/2022). Consequently, once a project was ready for implementation, it was handed over to the business owners within FlyHub. The innovation hub's explorative core is evident in the frequently asked question: "What is the hypothesis from the point of view of viability, desirability & feasibility?" (innovation executive, 05/2022)

As a final point, FlyHub's emphasis on complex long-term problems and its extensive innovation portfolio argued for focused long-term innovation processes. The embedded researcher observed FlyHub's innovation team constantly identifying and scoping focus areas and goals. Next, the innovation team developed a distinctive approach, including creating an inspiring long-term vision. An innovation executive explained (09/2021) that creating a vision helped to enthuse internal and external stakeholders to work together towards this goal. This suggests that FlyHub's innovation team had the knowledge, motivation, and skills to involve internal and external stakeholders to transform into an MTH.

3.2 Theme: limited exploration possibilities

This theme reveals how FlyHub's exploration towards becoming an MTH is restricted by the numerous constraints faced by Airport Hubs due to complex processes and involved parties. A possible approach is to first pilot and implement travel modalities at regional airports through strategic partnerships.

The embedded researcher witnessed stringent security measures at FlyHub during the research period. First, an innovation manager illustrated this by referring to the low number of performed experiments "due to FlyHub's ecosystem" (2022). Second, the embedded researcher observed that the government drew up strict requirements for the certification of new aircraft, which made it challenging to carry out demo flights with new aircraft, such as hydrogen, electric and UAM. The embedded researcher experienced this consequence as demo flights with electric aircraft were cancelled twice due to certification problems (retrieved from chat, 06/2022). Nevertheless, an innovation executive underlined the prospects of future experiments at FlyHub: "[the] government can indeed create pilot space as we did with drones on airside in 2020" (06/2022).

Moreover, an innovation manager stressed the significant consequences of failure for FlyHub (2022): "Innovation at FlyHub is slightly different [than at start-ups] because the culture of failure is difficult. Projects are very complicated, and many stakeholders are involved". Being a major Airport Hub, when things go wrong, they go wrong fast, especially when the ongoing aviation operation is involved. Therefore, FlyHub's secure environment prevents serious consequences but hinders modality experimentation.

Besides, the embedded researcher noticed strict rules curbing Airport Hubs' monopolistic position, which complicated the exploratory phase of new travel modalities. These rules mandated predetermined operation rates for years. Based on this, the tariffs for new modalities were predetermined by the established rates, and consequently, considerably low rates could not be set for new modalities. Additionally, rate agreements between airports were prohibited due to the "European cartel prohibition," which prohibited contact between other companies (legal staff, 05/2022). Thus, when FlyHub wanted to test and promote new travel modalities, this was limited by strict legislation.

Next, a strategy employee cited that the "Biggest disadvantage of UAM & Hyperloop is laws and regulation" (06/2022). This means that the laws and regulations at that time only approved existing travel modalities and therefore caused implementation hurdles for new modalities at FlyHub.

Finally, FlyHub itself also proved reluctant to experiment with new travel modalities, as these required severe investments in infrastructure and costs. To illustrate, a strategy employee called the potential investment in the hyperloop instead of a pilot "a start" (05/2022), as commitment beyond the

experiment phase would be required by FlyHub. Besides, mobility innovations included long development times, inhibiting transition progress: "You have to order an extra wagon for luggage now, then you will have it in, say, eight years" (strategy employee, 07/2022). Hence, FlyHub was disinclined to build entirely new infrastructure, knowing development would take years when they were uncertain about the added value of the travel modality.

Despite all these counteracting factors on introducing new modalities and collaborating with other parties, practitioners mentioned how FlyHub created strategic partnerships with regional airports to stimulate innovating with modalities. Regional airports were attractive partners for FlyHub, as these had fewer and less strict rules because of fewer flight movements. Consequently, introducing new modalities was "easier to start at regional airports," (innovation executive, 04/2022) as experiments had more freedom.

3.3 Theme: the MTH concept being (too) abstract

The third theme addresses that the MTH concept was too abstract during the research period, as there was no set structure for dealing with new modalities, and the added value of an MTH for FlyHub was hard to grasp. This made it difficult for FlyHub to focus on transitioning to an MTH.

First, the MTH focus of the innovation team was mainly on exploring new travel modalities, as the MTH concept implied at that time that multiple modalities should be integrated at one location. As such, the innovation team identified, monitored, assessed, experimented with, and implemented new modalities, although these activities gradually overlapped without a predetermined structure. An innovation manager (04/2022) mentioned that "identifying and selecting new forms of mobility is a tough task", suggesting there was no straightforward approach to deal with new modalities. However, it was observed that new modalities were assessed on feasibility, desirability, and viability. But no explicit assessment criteria were set for these principles, reflecting the conceptual nature of modalities' added value for FlyHub during the study.

Second, multiple FlyHub employees acknowledged that the MTH transition entails more than introducing new travel modalities. For instance, an innovation executive (04/2022) highlighted the potential of new travel modalities to create promising revenue streams and business models: "New business models for FlyHub? Can UAM cause that, for example?". Furthermore, the question surfaced whether the MTH concept should and could be spread over multiple airports, captured by an innovation manager: "Can FlyHub create mini hubs and integrate them into one large hub?" (09/2021). The diverse interpretation of the MTH concept highlights its significant potential value within FlyHub. However, it also demonstrates the challenge of fully understanding it and reaching a shared perspective.

The abstract essence of the MTH concept is evident, among other things, in its limited focus within the innovation team. Consequently, the person in charge of the MTH focus was replaced five times in 16 months. This may have contributed to no substantial progress on MTH projects during the research period, as reflected by this statement of an innovation executive (11/2022): "I have informed X that I currently have no resourcing on the multimodal hub and therefore, I will not be able to scope and frame an exploration for a while".

Also, no inspiring long-term vision existed to engage internal and external stakeholders, despite the innovation team's belief in the importance of such a vision for radical innovation projects.

Consequently, the embedded researcher had to actively promote MTH activities and projects to attract participants within FlyHub. This was experienced whilst organising an MTH symposium supported by the innovation executive, who cited (06/2022): "I was looking at the response rate and invitee list and I think it is worth the try to create a bit more PR for the event internally to prevent a low show/no show".

What further limited long-term, highly innovative projects, such as MTH, was FlyHub's tremendous operational problems endured during the research period, as referred to in the method section. Consequently, the innovation team had to shift its focus to short-term developments: "Part of the pivot we are going through is having a clear focus and priorities as a team" (innovation executive, 11/2022). Therefore, the innovation team disengaged from the MTH concept as its added value was too abstract to matter today.

3.4 Theme: multi-system transition going slow

This theme represents that the transition of Airport Hubs into MTHs requires multiple stakeholders to collaborate in a multi-system transition. Unfortunately, this transition goes very slowly due to the many stakeholders involved.

The embedded researcher observed three indicators of FlyHub's strong connection with internal and external stakeholders during the research period. First, FlyHub was perceived as a large organisation with an internal power structure and many employees. Second, FlyHub's own ecosystem encompassed various parties essential for its operation, such as air traffic control, airlines, handlers, and security. Third, FlyHub was part of a larger external ecosystem linked to all modalities, political, and business structures in its surrounding environment. This made FlyHub an integrator in a larger ecosystem. A strategy employee captured this complex multi-system environment as: "FlyHub is definitely an ecosystem: it has its own ecosystem and is [also] part of an ecosystem" (06/2022).

Thus, during the research period, FlyHub relied on other stakeholders in the broader ecosystem to facilitate the significant organisational shift towards becoming an MTH, providing integrated infrastructure and services for multimodal journeys. A strategy employee confirmed players' reliance on the network with integrated luggage solutions at FlyHub: "Without (firm) commitments from the carriers and the network manager, investing in an integrated baggage solution is not yet meaningful". This was also the case with electric and hydrogen aircraft since charging equipment had to be at the desired destination (innovation executive, 04/2022). Therefore, we stress that FlyHub's transition towards an MTH demands synchronised actions and investments from many stakeholders.

The embedded researcher observed that in FlyHub, MTHs were often explored and co-created in extensive collaborations involving many stakeholders, such as other airports and airlines. Furthermore, there were collaborations with parties outside of FlyHub's core focus, such as rail operators, Hyperloop start-ups and UAM operators: "We will investigate together how we could design (partial) solutions and scenarios that support the needs of our intermodal customers" (an MTH consortium member, 10/2022).

Unfortunately, such collaborations also brought challenges and questions. One of the questions was how to organise such extensive alliances since collaborating with many stakeholders proved difficult, as stakeholders each had their interests (strategy employee, 06/2022). Besides, the embedded researcher observed that clear communication within collaborations was often lacking. Moreover,

there were difficulties coping with the investments involved, as the transition towards an MTH is about the system's interest as a whole, meaning not one party is responsible. The embedded researcher noticed the utilisation of subsidies to manage the high transition costs: "Complex projects often go beyond airports, you often need subsidies for that" (innovation manager, 11/2021).

Additionally, substantial operational disparities between modalities posed challenges in integrating two travel modalities. For instance, a strategy employee working on air-rail integration noted trains and planes as "water and oil" (11/2022). Pricing differences further complicated the integration of their ticketing services. Moreover, MTH's international focus required cooperation with stakeholders from other countries, which was even more complicated according to a strategy employee (11/2021): "Within countries works well, no difficult collaborations and such."

3.5 Theme: changes and transitions being a struggle for power

This theme reveals how stakeholders' evolving power positions during the transition impede change. The embedded researcher observed resistance to change as parties sought to retain power. In addition, FlyHub's influential position significantly impacted the success of other parties.

During the research period, aviation developments took the lead and directed actions through the airport terminals towards landside developments. This was addressed by a strategy employee (12/2021): "Landside is often a bit of a waiting game for airside. Don't think about it until you know what's coming your way". Consequently, FlyHub mainly focused on aviation during the research period, which caused aviation as FlyHub's means to maintain its power.

Next, FlyHub also aimed to exert power on new modalities to incorporate them into existing (power) structures: "We're not stopping UAM because it is coming. If we decide to market UAM, we can influence how we can use it best" (innovation executive, 08/2022). More, FlyHub's employees frequently highlighted the many advantages of aviation over other means of transport, such as "super-efficient" (innovation manager, 09/2021), "flexible" (strategy employee, 06/2022), and "universal" (strategy employee, 07/2022). These advantages made shifting their focus outside the aviation industry less attractive.

FlyHub responsibilities as an Airport Hub, where aviation activity steered airport development, indicate aviation's inherent power. Following this, airlines, as operators of this primary modality, were perceived as FlyHub's critical stakeholders: "[airlines] will remain part of the scene" (strategy employee, 06/2022). Focusing FlyHub's business on aviation and airlines was an instrument of maintaining its current power as an Airport Hub.

Next to FlyHub's focus on aviation during the research period, the hub-and-spoke model was also considered an essential property of FlyHub. As a result, new modalities were assessed based on the fit with the operational and business model of the hub, which principle is to transfer passengers between flights. Therefore, FlyHub only attempted to add modalities into its business to serve the hub-and-spoke model. This would allow FlyHub to maintain its current position, which meant facilitating transfers and bringing different transport operators together at FlyHub's location.

But also new modality operators invested in FlyHub's transition to attain a power position. The embedded researcher observed a common way to secure businesses when collaborating, namely through non-disclosure agreements (NDA). NDA's are a form in which parties agree to treat sensitive

business information confidentially, as explained by an innovation executive (05/2022): "Then a partner is willing to share much information." This information on businesses and operators was crucial for FlyHub to assess the extent to which investments or spatial reservations needed to be made. Besides, the embedded researcher noticed a transport operator investing in UAM aircraft development and infrastructure to ensure availability when the transport operator requires it.

Finally, FlyHub had a particular position of power that could influence the success of other parties: "If we don't work with X, X may become less interesting. It also gives [third parties] PR if we work with them" (innovation manager, 07/2022). Accordingly, FlyHub regularly received requests to sign 'letters of intent', indicating interest in future collaborations. A start-up said about the 'letter of intent': "something that would help us enormously in the next phase of our company: raising capital." Thus, next to controlling their power, the embedded researcher observed that major players like FlyHub could impact the success of new, smaller stakeholders.

4 Discussion

Our research focussed on studying in and from practice the corresponding research question: What themes arise when an Airport Hub aims to innovate with new travel modalities in order to transform into an MTH? We identified five themes as 'threads of underlying meaning' following Graneheim & Lundman (2004, p.107). Below, we discuss the five themes from three different angles.

During the research period, the MTH concept aligned well with FlyHub's focus on handling complex future innovations. FlyHub emphasised innovation, which was widely supported across business units and endorsed by the CEO. However, the MTH concept remained abstract, and the dedicated innovation team eventually redirected its focus. The abstraction can be attributed to the multifaceted nature of the MTH transition. It involves dealing with new travel modalities whose added value is unknown (at the time) and simultaneously requires a multi-system transition involving many players. The embracement of new travel modalities through accessing, harnessing, and absorbing, as advocated by Toet et al. (2022), seemed to have fewer rigid boundaries with slightly different activities in practice. The activities identified through our study included identifying, monitoring, assessing, experimenting with, and implementing new modalities. However, FlyHub had no set structure for managing these activities. Besides, FlyHub's transition towards an MTH faced challenges due to limited exploration possibilities in its stringent environment, leading the organisation to promote exploration at small airports. Moreover, the embedded researcher observed the first steps of the multi-system transition towards an MTH, which was found to have a slow pace due to numerous stakeholders seeking to maintain their positions of power. Furthermore, the results suggest that accessing new modalities and innovations, known in this study as 'identifying' and 'monitoring' activities, requires less attention due to the slow development of multi-systems and the power position of FlyHub.

We emphasise that the insights from this research derive from the observations made by the embedded researcher within the context of FlyHub. To ensure transparency and traceability in the data collection and analysis process, we have thoroughly substantiated the results by clearly illustrating how they emerged from the data. Examples of sources are text messages and e-mail phrases. In addition, we have presented the prior knowledge and background of the embedded researcher. We recognise its potential influence on data collection and analysis, which is considered essential in qualitative research (Malterud, 2001). During the research period, the researcher's role

evolved from outsider to partial insider (Greenwood & Levin, 2007; Herr & Anderson, 2005). This shift created challenges in objectifying insights due to the establishment of bonds of trust through the AR approach. However, it also facilitated the acquisition of deeper insights. On top of that, it is vital to acknowledge that the researcher was an intervention agent, known within FlyHub as the "Multimodal researcher" or "PhD candidate." Consequently, the researcher's presence in FlyHub impacted the initiation of multimodal projects.

This research indicates that AR is suitable for establishing profound, long-term engagement with the research context. This contrasts with fast-paced methods driven by limited budgets, often used by design researchers. The cyclic nature of AR, encompassing multiple iterations (Coughlan, 2002), seems well-suited and beneficial for the design research community, particularly when dealing with complex contexts. Nevertheless, as underscored in the method section, it is important to apply findings to other contexts apart from the one they emerged from for theory building. Consequently, the researchers strongly advocate for future investigations in diverse settings, such as other Airport Hubs beyond FlyHub, regional airports, or Rail Hubs. This approach should contribute to a deeper understanding of similar complex transitions, encompassing mobility systems centred around passenger journeys.

The findings have significant implications for researchers and practitioners. The following steps in this AR project involve gaining a deeper understanding of seamless multimodal passenger journeys at Airport Hubs. The knowledge acquired will be implemented in interventions that should enable multimodal travel at Airport Hubs as part of the transition to MTHs, followed by evaluations in the context. The embedded researcher will continue using AR to study and integrate (new) services of modalities within Airport Hubs.

Moreover, this case study has shed light on compelling research areas that warrant attention in future studies. Primarily, future research should focus on developing theoretical knowledge for Transport Hubs to deal with and implement new travel modalities effectively. Based on this study we see a possibility for exploring Chesbrough's open innovation approach (2017) to harness and absorb new travel modalities. Second, further investigation is needed to understand how Transport Hubs navigate various stakeholders' diverse perspectives and needs during the transition to MTHs. Gaining a deep understanding of how they should manage competing demands can benefit future decision-making and strategy development. Lastly, studying the added value of MTHs and the potential of Airport Hubs within the evolving ecosystem is crucial. Since the concept of MTHs is still abstract, applying systemic design practices to co-create with stakeholders from different disciplines offers research opportunities to shape an effective and sustainable vision of Airport Hubs as MTHs.

Our discussion on the themes yielded valuable and pertinent insights from our research, advocating for the pursuit of further steps in the AR process.

5 Conclusion

This research revealed five themes that emerged when FlyHub aimed to innovate with new travel modalities in order to transform into an MTH. These themes are:

1. recognition of the importance of innovation and long-term outlook,
2. limited exploration possibilities,
3. the MTH concept being (too) abstract,

4. multi-system transition going slow, and
5. changes and transitions being a struggle for power.

These themes suggest that transforming FlyHub into an MTH is beyond the scope of FlyHub alone. It requires a full ecosystem transition, layered in multi-levels and -systems, where parties must work together to embrace new modalities within the system, including at FlyHub.

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