Sustainable Future Flight Business Models: Motivations and Barriers

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Abstract. This paper investigates stakeholders' motivations and barriers within emerging Future Flight business models. Aviation is vital for developing economies, and the urgent need for a transition towards more sustainable practices is gaining prominence. Hence, understanding the factors shaping Future Flight technology's adoption is crucial. Drawing on ten interviews with pioneering Future Flight-related technologists, business leaders, social entrepreneurs, and policymakers, we employed the Technology-Organisation-Environment framework and Transaction Cost Economics theory to analyse critical factors influencing Future Flight business models. We show that participants are concerned about sustainable aviation fuel availability and Future Flight technologies' readiness. We emphasise the importance of technology maturity and commercial viability for successful Future Flight implementation. Smaller start-ups are poised to lead such development because of their nimbleness and sustainability focus. Concurrently, larger companies face challenges transitioning from traditional business models. We identified regulatory frameworks, social acceptance, and public demand as key drivers. Finally, we show how entrepreneurs desire standardised global regulations to support sustainable aviation practices. We offer insights into the complex dynamics of Future Flight adoption, highlighting companies' need to evaluate their cultural and human resource strategies while emphasising global regulatory standards' importance – as part of The CoFFEE Project's (www.coffeefutureflight.com) broader research programme.

Keywords: Urban Air Mobility (UAM), FlyDrive, Unmanned Aerial Systems (UAS)

1 Introduction

Aviation is increasingly critical in developing economies. Aviation enabled cities - including Denmark's Legoland (in otherwise secluded Billund) - to become 'experience' destinations [1] and is essential for some people in maintaining social relationships concerning spatially defused familial and friendship networks. However, aviation's high energy demands - and low-carbon technologies' limited development stage - raise important questions about environmental impacts.

FF developments have focused on the engineering challenges of building Advanced Air Mobility (AAM) – comprising Door-to-Door Regional Air Mobility (FlyDrive, aka. Flying cars travelling >50k) and Urban Air Mobility (UAM, aka. flying taxis/buses travelling <50k) - and Unmanned Aerial Systems (UAS, aka. drones) powered by electricity or hydrogen. Engineers assume businesses and social entrepreneurs will someday develop interconnected social networks and capabilities ('ecosystems') to make their mechanisms viable. Nevertheless, FF can only enhance society and strengthen the economy when individuals, groups of users and non-users, innovation ecosystem stakeholders, and local communities adopt these new technologies and aviation forms.

Understanding the emerging innovation ecosystems is critical as the UK Research and Innovation Agency's (UKRI) Vision and Roadmap for FF [2] proposes distributed service integration to be achieved by 2028. FF requires rethinking critical business theory, as current business models require reconsidering sustainable development and circular economy. Without understanding the emerging innovation ecosystem, complex stakeholder networks, and technology implementation process, FF will likely fail.

This paper aims to determine the motivations and barriers of aerospace industry technologists, business, social entrepreneurs, and supply chains within the evolving FF scenarios and how they influence the emergent FF business models. We achieve this aim by reporting on ten interviews with pioneering Future Flight-related technologists, business leaders, social entrepreneurs, and policymakers while employing the Technology-Organisation-Environment framework and Transaction Cost Economics theory.

1.1 Methodology

1.2 Setting and Sample

We recruited participants through professional networks, social media posts, and snowballing. Purposive sampling against key attributes (e.g., company size) determined participant selection, including AAM/UAS manufacturers, transport business users and suppliers, and social entrepreneurs who understand FF's social and economic impact. We also applied snowball sampling to identify cases of interest during the interview.

We interviewed 10 participants (M=6, F=4), including entrepreneurs (n=4), professional publics (n=3), technologists (n=2), and policymakers (n=1) with expertise and experience in economics, logistics, aviation engineering, and occupational psychology.

1.3 Data Collection

We developed an interview protocol to explore the technological, organisational, and environmental factors influencing FF business models. Technological factors describe FF's technology characteristics. Organisational factors include the company's scale and reach in the market. Environmental factors are those outside the organisation's control.

Questions elicited participants' opinions on the closest technologies they expect to be developed in the next five to ten years, the social, economic, and environmental impact of FF, and their intention to engage with the circular economy. Individual semi-structured interviews (c.60 minutes) were recorded, professionally transcribed, and imported into NVivo for analysis.

1.4 Data Analysis

Influenced by the Technology-Organisation-Environment (TOE) framework [3] and Transaction Cost Economics (TCE) theory [4], broad initial codes were set up to guide the coding process as the top layer codes in the catalogue. After familiarisation with the data, the first reading mapped out the contextual information about each participant and their organisation/company. The second reading was a data-driven coding process, cross-checking codes with contextual information to determine potential patterns. From the participants' responses, we determined the reasoning behind their predictions regarding trends, technologies, and potential impacts. This followed Wiltshire and Ronkainen's [5] inductive and abductive thinking.

2 Results

2.1 Technological factors

Fuel Availability

Most participants (7/10) knew that decarbonisation's scope surpasses superficial rhetoric. In particular, there was a high awareness of the importance of a 'green' production process and physical infrastructure to achieve 'net zero'. Some participants addressed the problem of batteries for their limited circular economy attributes to date (p11), distance limitation (p4, p9), and the reliability of hydrogen as a fuel (p7). Some participants were, however, optimistic about Sustainable Aviation Fuel's (SAF) development, considering it the *"most promising"* technological potential and expecting an *"acceleration of SAF"* (p3). Critically, large companies' motivation to invest in SAF and hydrogen shall influence their business models' evolution.

Readiness

The readiness of FF technologies may take longer to mature than the UKRI roadmap proposes. Many participants spoke about the reality of the timeline regarding AAM and UAS. It is plausible that an unhealthy equity investor culture leads to over-hyped timelines and unrealistic expectations. Participants confirmed the potential for advances with low-carbon fuels, navigation, and autonomy; however, their commercial viability, efficiency at scale, and usability will determine the readiness of FF technologies.

2.2 Organisational factors

Company Culture

In part - because the participants' motivations for creating a positive impact align with the company/organisation they are part of - many participants are sensitive to sustainability. Some participants intend to engage with a Circular Economy (CE) approach. However, CE is still a niche concept in the industry because of the technological limitation of recyclable composite materials (p4). One participant (p1) even criticised CE for not advocating for reduction as it risks increasing consumption.

Human Resources

It is plausible that companies in the FF industry are having difficulty recruiting appropriate talents. Eight of ten participants expressed concerns about the industry's talent and skills shortage. Two participants described a *"war of talent"* with other industrial sectors in need of artificial intelligence talent (p5), identifying a *"massive shortage of engineers"* (p11). This shortage also relates to public bodies charged with regulating FF links with the difficulty of offering competitive salaries to skilled workers (p11).

The data also suggest that staff expertise is vital in shaping a company's products/services (p9, p11). Many participants believe the shortage can be mitigated by identifying industry skill requirements (p5, p11) and developing new training protocols (p2, p4, p8). One participant suggested that a diversified workforce could benefit FF. For example, recruiting female engineers (p11). Younger workers' emphasis on desiring to contribute to sustainability could positively change a company's culture.

Inertia To Change

It is plausible that smaller start-up companies with new business models will change the FF industry. There is inertia for big companies to continue making a profit without changing business models. Some participants explained that *"big companies' business models are planned around planes designed 25 years ago"* (p4). Small to Medium sized Enterprises (SMEs) also are reluctant to change their business models *"because they are locked into the supply chain"* (p4).

In contrast, smaller start-ups honed their resources on niche products/services. They built a competitive advantage over multinational companies by obtaining patents and securing their supply chains (p7). Conversely, participants saw big companies more motivated to invest in SAF and retrofit their existing planes. However, smaller start-ups certify early in their development process to avoid later expenses.

2.3 Environmental factors

Regulations And Government

All participants stressed the crucial role of regulations. Many participants identified the delay and gaps in regulations to support the FF industry's development. The industry's growth created demands for certifying vehicles and operational safety clearances (p11). The companies sought for the regulators to establish *"a level playing field"* (p8) and address the disparity in global standards (p8). Considering big companies' inertia to change, governmental regulations supporting sustainable fuel development (i.e., tax on traditional fuel) will drive the industry significantly. Currently, the lack of regulatory changes resulted from the limited regulatory capacity and shortage of skills (p9, p11), which is believed to be the biggest challenge.

Social Norms

Many participants acknowledged the public as a critical FF stakeholder. Public acceptance of FF products/services will likely be shaped by social norms and the potential impact of social disparity. Some participants suggested the high likeness of the more affluent, smaller population benefiting from FF technologies. One participant (p9) indicated that the Fly Drive market would probably diffuse in society before the UAM market because the public already accepts flying outside of urban environments.

3 Discussion and Conclusion

This paper aims to determine the motivations and barriers of aerospace industry technologists, business, social entrepreneurs, and supply chains within the evolving FF scenarios and how they influence the emergent FF business models. In pursuing this aim, we identified seven key factors that will likely impact the emergent business models from the perspectives of technology, organisation, and environment. We determined that readiness and fuel availability are two critical barriers in the technological context. There is a low probability of aviation businesses transitioning to carbon-zero air mobility due to a lack of alternative fuels. The costs incurred from adopting new technologies when technology readiness and scalability are uncertain would lead to low or negative profitability for airlines [6]. However, escalating consumer demand for sustainable air travel, combined with governmental imposition of carbon taxes could drive investment from major industry players in the development of SAF.

Our findings suggest that start-ups will likely lead the FF industry's development, addressing the less attractive niches to established aviation businesses and focussing on those niches requiring moderate capital investment. In the organisational context, start-ups possess a company culture that drives the design of niche products and services intending to improve sustainability performance. Unlike multinational aviation businesses and SMEs with, to date, insufficient financial incentive to push for 'jet zero', start-ups actively engage with upcoming FF technologies to carve out niche markets.

In the environmental context, we identified concerns over changing regulations and policies. Niche innovation and transition to jet zero are highly dependent on the government providing financial incentives and policy stability. While research noticed the impact of the increasing popularity of private aeromobility on sustainability [7], our findings suggest that social disparity is a critical barrier to public acceptance. Moreover, entrepreneurs recognise public's influence and are optimistic about changing public acceptance, such as concerns of accessibility, privacy, and mental health (noise pollution). Shifting social norms will motivate the industry to invest in sustainable fuels and new business models. Like the public's preference for a central government FF regulation [8], entrepreneurs demand standardised global industry regulations and faster implementation to accommodate FF development.

Theoretically, the TOE framework can be mobilised to identify factors that support implementing a circular economy approach to businesses. We progress this theory by showing that environmental factors are critical to start-ups, SMEs, and multinational companies. In contrast, organisational and technical factors' importance varies depending on the organisation's scale of operation, market segment, and culture.

In conclusion, businesses aiming to establish themselves in the industry should evaluate their organisational culture and human resources. Companies should revise their strategic business models to offer a more significant sustainability commitment. Businesses should diversify their hiring to gain broader talent (gender, age), work ethos, and focus on sustainability. To foster confidence among businesses and investors in financing FF developments, it is imperative for government entities to ensure policy stability. Regulatory bodies must establish industry standards at a global level to accommodate the FF industry. Additionally, they need to address the skills shortages and increase their capacities to fulfil the industry's certification and safety clearance needs.

3.1 Limitations and Future Research

Our underpinning TOE framework is limited in capturing the complexity of the adoption and implementation process and the rapidly changing external environment for novel industries such as future aviation. To mitigate this limitation, the UKRI-funded umbrella project (CoFFEE Project: https://coffeefutureflight.com) shall continue to collect more interview data from a diversified body within the Future Flight Community. In particular, a more significant sample of policymakers and technologists. Doing so shall allow us to extend our findings' generalisability into policymakers' perspectives.

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