Technology readiness for cities: the near-future case of autonomous passenger drones

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Abstract: Autonomous Aerial Vehicles (drones) are a transformative technology at the cusp of being adopted for real world passenger transport in cities (Moore, *et al*., 2018). Passenger drone research remains focused on the advancement (Gao, *et al*., 2018), opportunities (Zhang, *et al*., 2018) and technology readiness (Torens, Dauer & Adolf, 2018) of drone features and systems. The technology-focused planning literature dominantly focuses on Smart City frameworks for enhancing technology integration into urban planning (Caragliu, Del Bo & Nijkamp, 2011), with an emerging focus on the implementation of specific technology strategies (Bayat & Kawalek, 2018; Yigitcanlar *et al.*, 2018). However, the literature stops short of interrogating the technology readiness of cities that will inevitably attempt to implement specific technologies (i.e. autonomous passenger drones) into their urban fabrics. That is, cities will be pressured to allow (or race to adopt) fleets of drone taxis to ease pressure on already stressed and near capacity ground transport networks; but where will drone operations be seen as safe, practical, desirable, or at least tolerable, additions to the urban rhythm and hum? How compatible are existing urban development patterns and policies to a future that includes aerial passenger drones landing in neighbourhoods and buzzing across their skies? This paper summarises the currently known opportunities for aerial passenger drone technologies for improving urban system performance and proposes an inclusive method for cities to enhance their readiness for the forthcoming technology. The method is applied to the city of Brisbane (Australia's third largest city) to explicate the practicality of interrogating city technology readiness in the context of aerial passenger drones, highlight jurisdictional and governance tensions, and detail learnings from implementing the method with implications for smoothing the transition to implementing transformative technologies.

Keywords: Transformative technology, autonomous aerial vehicles, technology adoption methods technology readiness

Cities with flying cars in a not-so-dystopian future

In 1927, Fritz Lang brought forward a dystopian vision of future cities in the visually stunning silent film, *Metropolis*; characterised by the densely packed skyscrapers, with aviation placed at the heart of the city. Aviation has since been elevated as a core economic feature of cities, with Kasarda's (2004) Aerotropolis and Stevens, Baker and Freestone's (2007) Airport Metropolis concepts focusing on the interdependence and synergistic opportunities of cities and air transport infrastructure. Within the context of urban planning, aviation has almost always been seen with respect to its utility for connecting cities to the rest of the world – allowing planners to promote ground transportation routes that align with passenger and cargo movements through the urban and hinterland environments, and that zoning appreciates the noise footprint and physical separation of structures required of flight activities. However, any science fiction fan seeing the 1989 sequel, *Back to the Future II*, saw a future where the skies above cities were not filled with aircraft, but with flying cars. When everyone has a flying car, there's little need for the *Metropolis*-style airport at the heart of the city. Fast-forward three decades, and suddenly we are in a future where personal on-demand aircraft are becoming a reality.

In 2018, Uber Elevate announced its intentions to begin commercial flight operations of a fleet of electric vertical take-off and landing (eVTOL) aircraft, which would open up new transportation opportunities for on-demand aviation (Uber Elevate, 2018). This proclamation suddenly became more real when Bell (an established helicopter manufacturer) announced its partnership agreement with Uber Elevate as the preferred supplier of air taxis at the Consumer Electronics Show in January of 2019 (Engadget, 2019). Projections estimate that an eVTOL flights dramatically reduce travel times, for example commuting 55.4miles between San Francisco and San Jose could be reduced from 1hr 40mins to just 15mins but only cost 16.2% more than a regular uberX fare (Uber Elevate, 2016). Essentially, Uber Elevate is proposing on-demand personal intra-urban air transport that will be priced to be available to the general public. While much of the focus for the rapid emergence of the technology has been on the readiness of the technology for the market, there is a question posing as the proverbial elephant in the room:

What is the readiness of cities to adopt this near-future technology?

For some cities, the approach appears to be akin to a technology start-up company, where experimentation and failing fast to learn success (see Zellner and Campbell, 2015), frames their risk appetite. Abu Dhabi for example, announced its appetite to trial the (at the time commercially untested) Ehang 184 drone taxi in early 2017 as part of the city's goal to automate at least 25% of intra-city journeys by 2030 (Olsen, 2017). Singapore also gave the green light to German company Volocopter to begin inner-urban flight testing as soon as the second half of 2019 (Robertson, 2018). While city-states may have the available urban densities, funding and alignment of governance structures to facilitate the rapid integration of technologies into their urban fabrics, cities that are framed by speed-limiting bureaucratic and regulatory hurdles may struggle to prepare their urban infrastructures, stakeholders and interconnected systems for adopting autonomous and/or piloted airborne drone taxi systems. This paper proposes a framework that could be used by cities to self-evaluate their current maturity or readiness for this technology, as a means of helping cities prioritise and resource activities that (if desirable) pave the way for airborne taxis. The framework is discussed in the context of Brisbane, Australia, due to the progressive policy environment for unmanned aircraft systems (UAS), and highly interconnected and overlapping jurisdictions that highlight potential complications for technology adoption.

Adapting a Big Data adoption model for airborne drone taxis in cities

For a decade, Big Data has been seen as the technology that all organisations, cities included, should buy into. While a plethora of authors have provided advice on specific technologies and skills required to make *Big Data happen* in organisations, Davenport and Harris (2017) provided clarity to organisations, large and small, when it came to understanding *are we ready for Big Data, and if not, how do we get ready for it?* Their DELTTA model and stages of analytical maturity provide sounding boards for organisations to evaluate their capabilities and deficiencies against an array of criteria that are essential for creating technology adoption strategies. DELTTA, as a model specifically developed to make explicit the functional requirements of Big Data, stands for the way the organisation uses (D)ata, how data is treated as an asset for the (E)nterprise, the level of support for Big Data approaches by the organisation's (L)eadership, how data is used to support the defining and achievement of (T)argets, the resourcing of (A)nalysts to support the organisation's aspirations and use of data, the integration of the (T)echnology required to advance Big Data use in the organisation, and the sophistication of (A)nalytical techniques applied within the organisation. These functional requirements become the criteria by which an organisation assesses its resourcing and competence to determine the *maturity* of the organisation with respect to Big Data. Davenport and Harris (2017) define five levels of maturity: Stage 1: Analytically impaired; Stage 2: Localised analytics; Stage 3, Analytical aspirations; Stage 4: Analytical companies; and Stage 5: Analytical competitors. There are finite descriptors for each level of maturity for each of the DELTTA criteria, which can be found in Davenport and Harris' (2017) book.

By assessing the maturity of an organisation across each criteria, areas of strength and liability can be identified to aid decision making for resourcing, change, and development. By deconstructing the model into a process to first create the criteria for the model, and then populate the model with objective levels of maturity, a framework can be created to assess the readiness of a city for a new technology. This is demonstrated in the following section, where this approach has been applied to the context of Brisbane, Australia.

A framework for assessing the readiness of Brisbane for airborne drone taxis

Mobilising Healey's (2007) revelation that "the relation between planning activity and its context […is…] an activity in which context and activity are co-constitutive and co-generative", the act of reviewing and refining a planning jurisdiction's capabilities and readiness for a new technology creates a moment of opportunity to refresh its assumptions of power and inclusion in the context of technology adoption. This presents the first step of the process for creating the framework – *defining the reference group*. For example, transportation networks in Brisbane have largely been negotiated between State and Local Government planning jurisdictions. The prospect of including an intra-urban airborne transportation option into the city's suite of transportation modes (which currently include public rail and public bus, along with roads, toll roads, toll tunnels, etc.) legitimises new stakeholders with legitimate power to require specific design features and system oversight of how the airborne drone taxis intend to interface with the built environment. These stakeholders include the Civil Aviation Safety Authority (CASA), the country's aviation safety regulator); and Air Services

Australia (ASA), the country's airspace operator. Further, it's important that experts in the technology are legitimised into creating the framework in order to ensure that any assessment of readiness is accurate to the technical requirements. Experts could include design engineers of shortlisted airborne drone taxi operators, academics with rich technical knowledge of UAS requirements, or independent UAS engineers. Any attempt to construct the technology readiness framework for airborne drone taxis should include these stakeholders.

The second step in the process is to *define an array of criteria* relevant to the contextual and institutional requirements of readying the city of the technology. Deconstructing Davenport and Harris' (2017) original model provides some insight into the normative aspects required for technology adoption. This includes (1) the compatibility of existing infrastructure systems to take advantage of the new technology, (2) how stakeholders appreciate and include the utility of the technology into its operating fabric; (3) the interest and support of top leadership with respect to the technology; (4) the prevalence of use of the technology to achieve relevant goals for stakeholders; (5) the human resource capabilities and capacities to understand and apply the technology to support the goals of stakeholders; (6) the technical/physical requirements to support the adoption and use of the technology; and finally (7) the level of sophistication applied to integrate the technology into existing and emergent routines. In the context of the technology – airborne drone taxis – the criteria for the framework are defined in this paper as:

1. *System compatibility:* How will airborne drone taxis interface with the urban environment (i.e. need to take-off and land)? What hazards exist, and will they require specific standards for identifying sites for operations (i.e. are there existing sites, or is there a need to build new/bespoke landing pads to accommodate the technology)?
2. *Stakeholder adoption:* To what extent do residents, workers, tourists, etc. expect the technology to be desirable and in demand for their daily activities? How will the placement / availability of landing pads impact on the ability of airborne drone taxi services to be adopted into the routines of residents and other travellers?
3. *Leadership support:* To what extent to leaders of salient stakeholder organisations demonstrate a willingness to adopt, even champion, the inclusion of airborne drone taxis?
4. *Integration:* To what extent can the technology improve the city's goals for "an easy commute", "connecting communities" and "embracing innovation" (Brisbane City Council, 2019)?
5. *Expertise:* To what extent are planners empowered to transform the urban environment to leverage the opportunities created by airborne drone taxis?
6. *Infrastructure:* To what extent is the city and its stakeholder willing to invest in creating new or adapting old spaces to integrate airborne drone taxis into the urban environment?
7. *Scheduling:* To what extent is the city and its stakeholders able to adapt existing transportation routines and behaviours to create seamless flows of people with the support of airborne drone taxis?

These seven criteria provide a starting point from which levels of maturity can be defined - between veritable luddite and world-leading exemplar - for the integration of airborne drone taxis into the fabric of the city. Defining the maturity levels is the third step in developing the framework and requires careful consideration of the practicalities of bringing together diverse stakeholder needs to pre-empt the opportunities and hurdles that are possible in the context being examined. The example below provides some insight to the levels of maturity expected from the diverse array of interests present in the case of Brisbane:

- *Stage 1: Unwilling to participate.* This is characterised by stakeholders who are potentially hostile or unwavering in their opposition to the notion of airborne drone taxis in Brisbane.
- *Stage 2: Cautious but willing.* This is characterised by stakeholders who may distrust the technology, or distrust one another, but are open to negotiate and review the facts to determine if the technology is plausible.
- *Stage 3: Recognition of importance*. This is characterised by stakeholders who agree on the potential utilities, benefits and hurdles present for the technology, and are actively seeking opportunities to solve problems and create synergies amongst stakeholder interests. This could include the reserving of space in carparks for future landing pad developments and changes to regulations.
- *Stage 4: Realised value.* This is characterised by stakeholders who have adopted new processes and invested in change to support the adoption of airborne drone taxis. This could include the creation of new organisations and/or regulatory bodies to support and oversee operations and physical changes to the urban environment.
- *Stage 5: Hallmark of the city*. This is characterised by stakeholders who actively champion the technology with external stakeholders, demonstrating that airborne drone taxis have become a distinctive feature of living in Brisbane. This could be characterised by joined-up infrastructure to ensure flows of people from one mode of transport to another is seamless.

With the levels of maturity now defined, the fourth step is *applying the framework to the context* – mobilising the expertise and diverse views amongst the reference group to critically evaluate the readiness of the city to the technology. This requires careful consideration for how each of the levels would be characterised for each criteria, essentially creating a five by seven evaluation matrix that would be applied to the context of adopting airborne drone taxis into the city's suite of transportation options.

The research framed in this paper has not progressed beyond this point at the time of writing. However, the remaining steps in the process are easy to explain and will of course be more difficult to implement. Step five requires *open consultation amongst stakeholders* to explain the maturity of the system of stakeholders, as well as identifying the maturity levels of individual stakeholders. This allows for transparency in identifying strengths and limitations amongst stakeholder capabilities, capacities, and compatibilities of their interests with one another. Davenport and Harris (2017) suggest that when planning to shift from one level of maturity to the next it is prudent to do so only after all criteria have reached a similar level. That is, it may be a fruitless exercise to invest energy and resources to enhance Infrastructure from Stage 3 to Stage 4 if Stakeholder Adoption remains at Stage 2, as a sceptical community may only become more resistant to negotiations if development was to take place before they had their concerns heard and advocated.

What is important to recognise for the framework is that it is a live tool that should be (step six) *updated throughout* the course of attempting to evaluate and potentially adopt a technology into the city's ways of doing things. The framework encourages ongoing critique and development, and maintaining an eye on how debates and decisions for resourcing transformative change impact on the overall *health* of the multi-stakeholder technology adoption effort. As such, the framework is presented as a tool for planning and technology decision making.

Transformative planning requires tools to foster agility

Planning for transformation often focus on socio-spatial and institutional dimensions (Friedman, 1987). In this paper, the focus is at the level of specific culturally embedded assumptions and habits (Healey, 2007) with respect to the task of adopting a specific technology into already defined planning regimes and relationships. That is, by undertaking the task of preparing the urban environment, stakeholders and interfaces between the city and other jurisdictions (i.e. civil aviation authorities / regulators) the city acts as a facilitator between the service providers (airborne drone taxi operators) and its market. Without the support of local planning initiatives, technologies that require specific physical interfaces and social awareness are impeded, if not totally rejected, from the possibility of technology adoption. Even if the populace of the city is in favour of adopting a specific technology, if the physical environment is not suitable, then the ability for the technology to operate is void. For this reason, it is imperative that cities continually scan the environment for emerging trends and technologies that may require a significant change in the physical environment, and poll its populace for their desirability. Where there is an expected desire and positive outcome for the city, the use of a systematic approach to investigate, understand, decide and act on emerging technologies is prudent, and fosters the agility of the city to more readily adopt transformative technologies as the technologies mature in the technology readiness scale.

For those who used to look up with awe at helicopters flying executives around Manhattan, it appears that your day to take to the sky is coming soon. The airborne drone taxi won't be the last technology to transform cities, but it appears that it will be the next.

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