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The 'Open Enough Challenge' — investigating tensions in open innovation approaches to aerospace R&D

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Original article

Abstract

In this paper, we investigate the transformative potential that emerging eVTOL- / drone-technology exerts on the relationship between established aerospace R&D processes and their adaptation of open innovation (OI) approaches. Empirically, we draw on the ethnographic and digital ethnographic study of two open innovation challenges, the Boeing GoFly-Prize and the Airbus Deep Drone Challenge. We investigate how tensions emerged in the negotiation process between open and closed innovation approaches throughout the challenges and which measures were taken to mediate them. The concept of 'infrastructuring tensions' is applied to shift the perspective from tensions as unwelcome hindrances to integral parts of this negotiation process that require maintaining and that are indicative of opportunities in the adaption of OI approaches.

We differentiate the investigation in terms of the challenges': a) frameworks toward shared eVTOL-innovation; b) accessibility for their participants; c) compatibility between internal R&D processes, market requirements, and participants' expectations.

We conclude that such challenges are examples of what we consider 'flattening innovation', a process that builds on open innovation approaches, yet cannot fully employ them. Instead, we observed an interplay where challenges that are communicated as fundamentally open require continuous navigation and re-evaluation to both satisfy participants' demands for accessible open formats as well as companies' demands for compatibility toward their own R&D processes and available markets.

Keywords

- open innovation
- innovation challenge
- eVTOL
- drones
- social media
- infrastructuring tensions
- flattening innovation

Authors contributions

A – Preparation of the research project
B – Assembly of data for the research undertaken
C – Conducting of statistical analysis
D – Interpretation of results
E – Manuscript preparation
F – Literature review
G – Revising the manuscript

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Abbreviations

ADAC – General Club of German Automobile owners (Ger. Der Allgemeine Deutsche Automobil-Club)

A.I. – Artificial Intelligence

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None declared.

AR – Augmented Reality
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DDC – DeepDrone Challenge (Airbus)
eVTOL – Electrical vertical takeoff- and landing- (vehicle)
GFP – GoFly-Prize (Boeing)
OI – Open Innovation
PAV – Personal Aerial Vehicle

Introduction: Opening the open-innovation black-box: A clean new paradigm or a mess of constitutive tensions?

Open Innovation is commonly presented as a contemporary solution to meet the ever-increasing innovation-needs of corporations and high-tech societies as a whole [1]. Be it in the form of 'outside-in' – using external sources for the enrichment of internal R&D processes 'inside-out' approaches – promising quick commercialization of products by opening up internal R&D toward external actors – or mixed approaches [1], OI is supposed to aid in creating innovative products that meet changing market demands [2]. One example for outside-in formats of OI is that of the Innovation-Challenge: Here, a more or less restrictively formulated challenge is set out by a company or stakeholders that, once completed by external engineers / innovators / tinkerers, etc., promises incentives such as monetary rewards, prizes and / or opportunities for future cooperation.

At the same time however, and despite the transformative impact that it is rightfully associated with, OI appears as a black box: While an open approach toward innovation is proclaimed, it is not immediately apparent how this openness is performed in practice and whether there even could be a complete turn toward this open modus innovatio or if it remains a label that obscures negotiation processes that are not as cleanly cut 'open' behind closed curtains.

While a wide range of studies exploring the outcomes of and the frameworks underlying such OI challenges have been conducted in the last years [i.e. 3–5] we identified a lack of studies that investigate the tensions emerging between opening up technological innovation on one hand and creating compatibility with internal R&D processes on the other hand. This process seems particularly relevant in cases where OI is adapted by highly hierarchical corporations like, in this example, established players in the field of aerospace.

Empirically, the paper draws on participatory observations as well as virtual ethnography of two highly visible Innovation-Challenges in the field of (e) VTOL- / PAV-Innovation, sponsored by the two largest, international aerospace companies: The GoFly-Prize by Boeing and the Deep Drone Challenge by Airbus. Both challenges aimed at driving innovation in the emerging field of PAVs or, colloquially known 'Flying Cars', a supposedly new way of aerial transport that is based on recent advances in (e)VTOL technology. Both companies, Airbus and Boeing have long been established players in the field of aerospace as a whole and therefore are used to a hierarchical, traditional aerospace R&D-approach, as their products usually require the coordination of countless engineers, mechanics, managers, etc. Therefore, keeping this rather strict, top-down logic of innovation in mind, connecting established R&D-approaches to this new, open mode of innovation – as represented by OI-challenges – offers an interesting opportunity for studying the process of creating compatibility, observing emerging tensions throughout this process and the negotiation of those tensions between these fundamentally different modes of innovation.

In the context of this shift, selecting PAVs / flying cars from the vast scope of aerospace innovations for such challenges seems to not be an arbitrary choice: eVTOL-technology – both small (drones) and big-scale – promises to afford conceptual and practical simplicity in development, as demonstrated by the ever-increasing number of start-ups in this field. Chen Rosen, 'Air' [6] CTO and Co-founder emphasized this in a 'behind the scenes' interview:

> [...] at a certain point you understand [...] the simplicity of drones and the ease of flight that we are already used to from camera drones, for example. If we can combine that into an aircraft that carries people, then again, this will make things a lot more approachable, a lot more easy to use, at lower costs that existing aircraft. [7]

In this sense, fields of technological innovation that were once restricted to large companies which could afford the substantial R&D investments and had access to the required know-how and personnel are now at the chance of being transformed into more open innovation spaces, potentially benefitting from the integration of a diverse set of actors and the adaption of more disruptive innovation processes, such as OI-challenges. Given those restrictions, OI challenges have been rather uncommon in the field of aerospace up until this point.

On the flipside however, eVTOL-technology also connects to a variety of different communities and expectations. Whereas, on one hand, it may simply be considered yet another innovation in the large area of aerospace research, it also connects to hobbyists, enthusiasts and tinkerers who not necessarily share the practices or goals commonly associated with traditional aerospace corporations.

Subsequently, our analysis focuses on and highlights emerging tensions that such assemblages of actors around eVTOL technology entail. Here, our perspective differs from other accounts of OI challenges by conceptualizing such tensions as integral part of the challenges themselves and therefore of their underlying infrastructures as both effects and indicators of a continuous negotiation process that, step by step, creates a framework for the transformation of established innovation practices.

To systematically explore this process the paper follows three main steps:

A) Introducing the challenges, contrasting their specifics and categorizing them according to distinctions drawn in previous research on open innovation formats.
B) A comparative analysis of how actors in both challenges negotiated frameworks for technological innovation, accessibility for new actors and compatibility with their existing logics of R&D.
C) A reflection on the promise of open innovation, contrasted to the concept of ‘flattening innovation’ as a continuous negotiation-process, characterized by the navigation and careful balancing of tensions throughout.

To properly contextualize these steps, the paper adheres to the following structure:

First, it provides an overview of the concepts of open innovation and challenge formats in contemporary innovation literature as well as delving into a perspective of constructive tensions as outlined in previous work on studies of societal transformation.

In this part, we introduce this paper’s core concept of ‘flattening innovation’ as a procedural take on the negotiation of open vs. Closed innovation. Here, our key takeaway lies in the observation that practicing open innovation is not necessarily equal to a complete turn toward this new paradigm but instead occurs step by step in a back and forth between closed and open innovation where stakeholder expectations, material affordances and challenge infrastructures are continuously navigated, connected and disconnected toward an equilibrium where both sides are aligned close enough to allow for new forms of innovation, but not any closer. Furthermore, we also consider the role that virtual components in general and Social-Media in particular, thus far, have been described as playing in OI to provide a basis for differentiating the usage of digital contents in the two case studies below.

Second, we outline the employed methodical framework. Here, both the specific ethnographic methods that were chosen to conduct research on those two challenges as well as the overarching perspective of flat ontologies and their relevance to the topic at hand are presented and discussed.

Third, it introduces and analyzes the two case-studies, the Boeing GoFly Prize and Airbus Deep Drone Challenge, according to the points A–C above and investigates how the negotiation of both innovation spaces aligned with the initial goals of the challenges, as formulated by their organizers.

Fourth, the paper summarizes this comparison’s results, highlighting key aspects that differentiate the means of creating and maintaining compatibility between the organizations and the participants’ contributions and how they engaged with emerging tensions between them. In the last, speculative part of this paper, we draw on our research to outline potential future OI challenges in the field of eVTOL development with this navigation of expectations and affordances in mind.

Conceptual framework: Open innovation or flattening innovation?

Since its first systematic proposal by Chesbrough [8] as ‘[...] a paradigm that assumes that firms can and should use external ideas as well as internal ideas, and internal and external paths to market, as the firms look to advance their technology’, the concept of Open Innovation has seen plenty of attention both by scholars and corporations alike that attempt to, through following open approaches toward innovation, adapt to increasing demands on innovations and decreasing R&D-budgets [9].

Despite possible concerns that the increasing focus on the open innovation paradigm could be a temporary occurrence or that it might even undermine the intellectual property of the innovators themselves [10], this movement has not only sparked a new mode of interaction between potential users/customers and companies that ensures that their products hit the mark, it also challenges the way we think about the relationship between markets and companies altogether [2]. As an explicit counter to closed innovation – the idea that R&D is to be primarily conducted within a company's borders, open innovation aims at reaching out to external developers and innovators who primarily act out of their own interest in the topic, curiosity, or dedication to the future development of the company that they innovate for / with [10].

While we fundamentally agree with the conviction that great potential comes with the opening up of internal innovation processes to incorporate the knowledge and talent from outside actors, we observe a current gap in the relevant literature that highlights and investigates tensions that emerge when corporations or organizations open up sometimes highly hierarchical and strictly organized R&D-structures toward external actors. Even though, as can be observed in the cases below, there is a clear move toward open innovation, we believe that adapting, in this case, OI-challenge formats, does not happen without the continuous negotiation and navigation of tensions between such companies, organizers, and participants. In this sense, we re-conceptualize the idea of 'open innovation' from an absolute end goal toward a process of 'flattening innovation' where all associated stakeholders are continuously required to modify challenge frameworks by negotiating accessibility and compatibility throughout the events.

To match actors in demand for external innovators with those capable and willing of offering innovative solutions, online ideation-platforms have been highlighted as highly valuable tools [3,9,11]. Here, aside from the previously mentioned, internal motivations such as an interest in the topic or their own curiosity, external motivators such as monetary prizes are offered to those who solve pre-defined problems [9,11]. Interestingly, while 'the Internet' – for example as an overarching meta-platform to connect companies / 'Seekers' and 'Solvers' [9] – has been highlighted regarding its potential to drive open innovation, more specific analyses of how digital contents may be integrated within the process of solving non-exclusively digital innovation challenges has thus far received little attention. Of course, such an investigation may not be required in instances where the expected innovation is itself entirely digital and therefore inherently compatible with virtual contents, however, in other instances where the expected solution connects to both concrete and digital worlds [12], this interplay may require a more detailed analysis. This will prove particularly relevant in the case studies introduced below, as we take such hybrid contents into consideration in the mediation process between the open and closed characteristics of such challenges.

In the context of investigating tensions in-between modes of innovation as a whole as well as in regard to hybrid contents, the concept of 'infrastructuring tensions' [13] proves helpful in two ways: First, it sensitizes for a perspective on tensions as an integral part to the negotiation process between actors and concepts of open and closed innovation. Whereas tensions emerging within any endeavor could be regarded as inconveniences that should be eliminated from altogether, this notion acknowledges that tensions are indicative of a process of aligning stakeholder expectations of how an adaptation of OI should occur. In this sense, tensions become an integral part of such formats themselves and may be considered essential in Kuhn's sense [14]. Second, combining the idea of essential tensions with that of infrastructuring work [15,16] highlights the continuous repair work and the necessity to maintain a careful balance between allowing tensions to manifest themselves but, at the same time, not letting them get out of hand in a way that the challenges would diverge in a destructive way. Here, 'infrastructuring tensions' also highlights the iterative aspect of flattening innovation: They serve both as initial guidelines to connect stakeholder expectations into a negotiation-process, as well as tools to measure and refine potential conflicts.

Based on these insights, we introduce a procedurally oriented take on open innovation to more adequately describe the highly intricate interplay between involved actors and their expectations throughout the challenges below toward an alignment of expectations of innovation: We describe this process as a 'flattening of innovation'. We conceptualize the process in this way to sensitize for the tensions and processes of negotiation that could otherwise remain hidden under the veil of 'open' innovation as an absolute. When we write about 'flattening innovation' in the context of open innovation, we do not presume 'open' as a fact but rather question the 'open enough' behind it. Obviously, such challenges, as will be demonstrated below, exhibit many characteristics of open innovation challenges and may therefore be rightfully regarded as such, however, this does not entail a complete and unquestioned commitment toward such openness. Instead, the negotiation processes we observed seem to walk the line between what would be considered open or closed innovations in an iterative process.

Methodical considerations: A realist perspective on innovation-processes

Overall, our analytical approach was informed by an ontologically flat framework, which allows us to put an explicit focus on the material affordances provided by (in these cases) eVTOL technology. While we acknowledge that there are aspects to both challenges that are not reducible to mere material aspects, such as the narratives they are embedded within, a realist perspective enables us to trace the connections and frictions between technological foundations and the frameworks and expectations of organizers and participants. This is especially relevant in the relationship between, on one hand, an increasing trend toward OI formats in general and the application of these formats to the field of eVTOLs on the other hand which is, in turn, embedded in the broader field of aerospace innovation.

To explore how connections between company-internal and -external innovation processes were created and how emerging tensions were navigated in the case of the challenges below, as well as to investigate the role that concrete and virtual infrastructures played in that process, this study employs a mix of ethnography and virtual ethnography [17,18]. To complement the traditional field studies, interviews and participatory research carried out for the DDC, we decided to employ a digital ethnography-approach for the GFP to expand this study into the online realm, enabling us to analyze online content provided by the organizers and subsequent community interaction [19–21]. Furthermore, since this paper aims to analyze the navigation of openness and closedness in open innovation challenges and, subsequently, emerging tensions, we put a particular emphasis on the employed means of integrating virtual communities into physicalized events [22] and how it contributed to the overall 'openness' of the GFP.

Whereas both the qualification phase of the DDC, as well as the DDC-finale itself have been accompanied through a participatory, ethnographic perspective, the GFP has been investigated primarily through an analysis of the contents published by the organizers and the associated participants, both regarding the physical events as well as associated, digital contents. The latter includes, for example, a thorough content analysis of knowledge material, as provided by the organizers of the GFP on YouTube in the form of a multi-part lecture series on the basics of rotorcraft design, a series of announcements and recaps as well as presentations of the competing teams.

The analysis of both challenges was conducted through a mix of investigating established factors from existing literature such as, for example, their Openness, what type of innovation they aimed at (incremental vs. radical), or how they integrated global memory in the overall OI-process [8–10,23,24], as well as expanding upon them by asking for the role they played in negotiating tensions between internal and external R&D and how those impacted the challenges' outcomes.

Case studies: Two aerospace giants and their approaches toward flattening innovation

Common ground between the challenges

What both initiatives, the Boeing GoFly Prize and the Airbus Deep Drone Challenge, have in common is the creation of organisational frameworks for external actors to participate in – usually – rather closed and highly hierarchical innovation-processes in the field of aerospace. Here, both companies face the same challenge: Connecting the technological particularities that are being afforded through eVTOL-technology (see Chen Rosen above: Simplicity of construction, cost efficiency, approachability) to the challenges and, in term, their internal R&D-programmes. Both companies, respectively the organizers they involved in these formats, created OI-challenges, setting out and, throughout the challenges, adjusting a series of highly specific demands that would need to be met by participants and offered financial incentives for solutions that met their defined goals.

Challenge summary: The Boeing GoFly-Prize

In a first step, the demands for this challenge were formulated rather loosely, building on an emotional narrative of 'Remember when you were a child and wanted to fly?'[25]. This quote is of particular interest, as it provides the framework the challenge operates within: Even though there was a strong extrinsic motivation to participate (see prizes down below), the challenge built on the participants' curiosity and their intrinsic motivation to build a new, innovative flying vehicle. A rough outline of the goals of the GoFly-Prize has been provided in the following paragraph:

> We challenge you to create a device where we look to the sky and say, "that person is flying." The device is for a single person, but what it looks like or how it works is up to you. We welcome revolutionary design, and while all devices must be able to fly a person, you have the option to use a mannequin to simulate the user and can operate the device as a remotely piloted or autonomous UAV. The device should function safely in both crowded cities and rural areas; it should be lightweight and manoeuvrable enough so that anyone can move it around, and it should be quiet not only for the user, but also for the general public. We are propulsion agnostic, but like all great inventions, the device should be user-friendly – almost an extension of the user's body, and provide the thrill of flight. [25]

Here, it should be noted that the organizers highlighted the possibility of using any propulsion-system, however, in line with the quote from Chen Rosen above, all participants chose electric propulsion systems, which hints at the latent affordances by eVTOL technology to connect the teams to the challenges.

In addition to this first, very open description of what the challenge demands from its participants, a more detailed set of guidelines put specific restrictions around how flight was to be demonstrated and, overall, which further features would be required from the to-be-developed vehicles. While some of those restrictions might be considered a bit on the harsh / restrictive side and possibly contributing to the grand prize not having been claimed at the point of writing this paper, the overall innovation framework of the challenge may still be considered one that aimed toward radical instead of incremental innovation.

These guidelines include basic aspects such as:

- A required minimum of 20 minutes flight time.
- The capability of carrying an operator or dummy at weight of 200 lbs (~90 kg).
- Covering at least 6 nautical miles (~11 km) of ground track.
- Reaching at least 30 knots (~55 km/h) of airspeed at some point during the flight.

which may very well be considered reasonable. Furthermore, the challenge included advanced requirements regarding both general operation and safety-measures that may have contributed to tensions emerging between participant's visions and organizer's expectations such as:

- A minimum, unobstructed operator field of view of a 90° cone.
- The craft being moveable on a hard surface without powered aids by a single individual.
- The craft being capable of landing in a 30 ft (~9 m) diameter, 12 ft (~3,6 m) high, circular envelope.
- The necessity for teams to periodically submit safety-reports on single-point system failures, propose design mitigations, etc.

In addition, the guidelines structured the overall challenge timeline in its three main stages of qualification as well as provided insights into the challenge's scoring-system [25].

As for incentives to participate, the GoFly-Prize offered several smaller prizes throughout the three phases of the challenge, a one million USD Grand Prize to the eventual winner of the challenge as well as a 100.000 USD Disruptor Prize by Pratt & Whitney. While the disruptor prize was awarded at the finale of the challenge in February of 2020, the 1 mln USD Grand Prize has not been awarded yet and is, as of the writing of this paper, apparently still available for the taking.

Below, figure one shows the winner of the Pratt & Whitney 100.000 USD disruptor prize, the craft 'Tetra 3' by Tetra team. Both in comparison to other designs developed in this challenge as well as in the overall landscape of eVTOLs, it represents a novel take on the concept of tail sitters / tilting body designs that has not been explored in this form before.

Figure 1. Winner of the Disruptor Prize 'Tetra 3'

Finally, regarding the sites the challenge took place at, the rather simple setup of two pylons 0,5 nautical miles (~930 m) apart allowed / allows it to be easily reproducible across the world, entailing a lower barrier of entry, which contrasts to some of the challenge's rather specific demands.

Challenge summary: The Airbus Deep Drone Challenge

This challenge's demands were more specific and less based on an emotional, but instead on a stricter, rational narrative of tackling specific aspects of PAV development through A.I.-implementation. The challenge itself broke down into two sub-challenges that addressed:

A) The autonomous navigation of a pre-defined route following pre-recorded tower voice commands in varying degrees of acoustic distortion ('DroneBot').

B) The autonomous navigation through an obstacle-course where the drones would have to adapt to unforeseen disruptions, represented by cardboard-boxes labelled with QR-codes ('Pathfinder').

The organizers described those two challenges as:

> [...] aimed toward pushing software-development using A.I. in the context of flying taxis. [For DroneBot:] While such flying cars are expected to be organized through an automated system eventually, such a system is not yet broadly available, therefore classic correspondence between aircraft and tower remains a fallback system, which would also be applicable in case of a system outage. Here, the challenge for A.I. was to filter interference/noise from tower commands as well as to adhere to the rules of radiotelephony and the NATO alphabet. For Pathfinder, a series of scenarios were selected that connect to potential uses of the CityAirbus, such as rescue operations as an alternative to the ADAC-Helicopter. Here, the aircraft needs to autonomously fly toward the rescue area, following the best and fastest route, as well as responding to spontaneously emerging events. Aside from physical obstacles, in-scale virtual obstacles have been included in the parcours. [26]

In contrast to the GFP, this more commercialized and streamlined approach toward eVTOL-innovation was therefore closely aligned to Airbus' own current R&D. As one Airbus-employee summarized at the challenge's finale:

> You [the participants] are doing exactly what we are doing over there [Airbus Drone Centre], just on a smaller scale.

He hereby highlighted a focus on the transferability of the participant's solutions toward the CityAirbus project and possibly future, associated projects. While this focus necessarily entailed a more restrictive framework for participants' innovations, and therefore restricted the participants to more incremental instead of radical, overarching innovations, it also led to a simpler process of evaluating the teams' success. In contrast to the GoFly-Prize, the winners of the prizes for the Deep Drone Challenge (50.000 EUR in total) were awarded at the end of the final event. In a conversation with one of the challenge's organizers, he joked about this, one day prior to the final event:

> No matter what happens, we will get rid of those 50.000 tomorrow. Maybe you [talking to me, directly] should have brought a drone too [laughs]. If it flies, there is a chance of winning if everybody else fails. [transl. from German]

Whereas the GoFly Prize only secondarily included an assessment of potential business cases of the participants' designs, the Deep Drone challenge much more explicitly embraced this commercial logic. A key figure behind the overall initiative and the DDC in particular hereby clearly stated the motivation behind the challenge:

> We hope that the participants of the Deep Drone Challenge push each other to great outcomes and that the competition helps to establish Ingolstadt as a region for unmanned flight. Maybe, some of the prototypes can become a business idea and a startup later on that can then be further developed in the region [...]. [27]

This strong regional focus (Ingolstadt / Manching, Bavaria) was also demonstrated in the challenge's spatial framework: While the challenge, similar to the GoFly prize, was conducted in multiple stages and therefore, participants had the chance to test their vehicles on site months prior to the final event, the demands – particularly of the 'Pathfinder' sub-challenge – remained highly specific and therefore not easily reproducible at other sites outside the dedicated testing-space at the Drone Centre in Manching.

On the day of the finale, the participating teams were invited to a small hangar at the Drone Centre (see Figure 2) for both a final opportunity to test their vehicles and, afterward, the finale, where the evaluation of the participants' approaches in both tracks ('Dronebot' and 'Pathfinder') was conducted. It is noteworthy that the finale itself was postponed one year in total due to Cov19-restrictions – While initially planned for 2020, the finale was eventually conducted in 2021, however, under numerous restrictions like mask-mandates, mandatory COVID-tests, etc.

Figure 2. The final day of the Challenge at the Airbus Drone Centre Manching [26].

Comparative summary

Before analyzing the challenges in terms of their approaches toward infrastructuring tensions, the table below provides a side-by-side comparison of some key aspects that characterize both challenges. It breaks down into general categories and virtual categories as introduced in previous scholarly work. In a third section, this table also introduces the key tensions in both challenges that will be outlined in detail below.

Table 1. Overview of the challenge characteristics

	Boeing GoFly Prize	Airbus Deep Drone Challenge
General Aspects		
Category of open innovation [1]	Coupled	Coupled (focus on outside-in)
Desire vs. solution [2]	Both	Solution
Motivation to participate [11]	Intrinsic & Extrinsic	Intrinsic & Extrinsic
Degree of openness [8,10]	Rather open	Rather closed
Incremental vs. radical innovation [10,23]	Radical (with restrictions through regulations)	Incremental (with an explicit focus on commercial use)
Organisations of external environments [24]	Multiple spaces of testing (easily reproducible)	One space of testing (non-reproducible)
Virtual Aspects		
Speed of interaction [10]	Medium, longer lasting	High, short-term
Global memory [10]	Providing both a knowledge-base as well as archiving participants' progress	Providing summaries and compilations
Community-building [10]	Both on- and offline	No focus on community-building
Spatial spread of participants [10]	Yes, but only on a low-integration level through social media [22]	No spread of participants outside of the challenges themselves
Number of participants [10]	Large number of potential participants via online-formats	Restricted number of participants exclusively through pre-selection
Categories from Analysis		
Main tensions	Disconnect between the open challenge outline and highly specific challenge guidelines	Disconnect between perceived and performed challenge openness
Mode of negotiating tensions on-site	Introduction of additional prices and keeping the challenges open for future participants	Adding more time outside the scoring phases to demonstrate technology
Mode of negotiating tensions through digital infrastructures	Provision of an online database to be connected to physical events by the participants	Integration of virtual components directly into physical environments to introduce additional contingencies

Analyzing the challenges: Infrastructuring tensions toward a flattening of innovation processes

The investigation of both challenges revealed that tensions between their open characteristics and attempts to tie challenge outcomes to established, closed logic of aerospace R&D were prevalent. Those manifested themselves in two distinct ways: For the GFP, the main observed tension occurred between above-described initially very open challenge outset ('We challenge you to create a device where we look to the sky and say, «that person is flying».') and the subsequent, highly specific challenge demands. This was mediated through the integration of social media contents, most prominently an online lecture series that served to establish a common knowledge basis for participants to refer to as well as the awarding of the 'disruptor price' that, in contrast to the 'grand prize' seemed more open and therefore more commensurable with the overarching promise of radical innovation this challenge outlined.

For the DDC, the main tension occurred somewhat in the opposite direction: The challenge outset was much more specific and therefore less open, subsequently measures were taken to re-introduce a degree of openness into the sub-challenges. Those took the shape of 'Freestyle' in the 'DroneBot' sub-challenge, an opportunity for participants to demonstrate additional drone capabilities that did not fall strictly into the challenge outset, as well as the use of augmented reality to introduce contingencies into the 'Pathfinder' sub-challenge and therefore reward participants whose designs proved more adaptable than others. Below, we detail those observations and break them down into how they impacted the overall challenge-frameworks, their accessibility and their compatibility to internal R&D and perceived market requirements.

The Boeing GFP: Navigating between un-awarded prices and radical innovation

In contrast to the DDC, the GFP was designed initially as a much more open and therefore potentially more disruptive challenge. This was reflected in the participant's designs, that ranged from the beforementioned 'Tetra3'-tailsitter all the way to the 'Dragonair' (Figure 3), a highly intuitive approach to PAVs where the vehicle was controlled through the motion and balancing of the pilot's body instead of classic, distinct axis inputs through (remote) control.

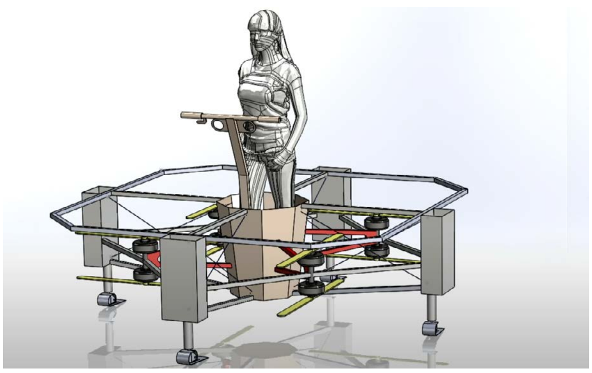

Figure 3. Team 'DragonAir's' design for the GFP – Drawing [28]

Despite those very inspired and highly disruptive approaches, the overall Grand Prize remains unclaimed. Especially given the awarding of the before mentioned Disruptor Prize to the Tetra Team, this hints at a disconnect between the initial challenge outset and the evaluation of the participants' solutions. If judged harshly, one could interpret this outcome as an indicator for a failed challenge, however – be it for PR-reasons or out of genuine conviction, the GFP-organizers just recently published a follow-up-video to the challenge that states 'Today, the idea of personal flight is within reach, thanks to the GoFly community' [29]. If judged more benevolently, one could regard this statement as an indicator for a re-assessment of the challenge's outcomes and therefore a shift in its framework that, despite not being formally completed, the challenge introduced a variety of disruptive innovations into the eVTOL-landscape that could be valued as such without, for example, completing the formally required flight-distance. This short video is of particular interest, as it connects to the previous mode of negotiating tensions in the challenge: From the beginning of the challenge, the organizers provided an nline knowledge-repository in the form of a series of Master Lectures, 44 distinct video lectures that make up the majority of total videos posted on the GoFly Prize YouTube channel (63 in total [30]) with a usual playtime of between 50 and 60 minutes each. Those master lectures include topics such as *Helicopter Flight Dynamics and Control*, *The History of Aviation in the Urban Core*, *A Test Pilot's Expertise on Conceptual Design* and many more.

Their approach toward negotiating tensions in creating compatibility with established R&D-practices was thus highly knowledge-driven: The information they provided online creates a high degree of accessibility of the knowledge-creation process e could be tied to specific participant practices, informing their design-choices by providing a basic understanding of what might or might not be feasible, creating a common ground for the participants to base their designs on. In this context, it is noteworthy however, that all videos published on this channel (still) have their comment sections open for discussions, which – at least in theory – creates a high degree of accessibility of the knowledge-creation process on this channel [22], however, this was not explicitly encouraged in any of the videos. Therefore, despite their focus on sharing knowledge, this transfer may be considered as mainly uni-directional / top-down, which might, in turn, have limited the degree to which the 'GFP community' as a whole (both direct participants and its online community) might have impacted the challenge's shared foundation by adding further content or knowledge to this repository. From a community-perspective, there were a couple of attempts at opening up such a discussion like a comment by Aditya Kapoor (Figure 4) under the Master Lecture on Ducted Fans who pointed out:

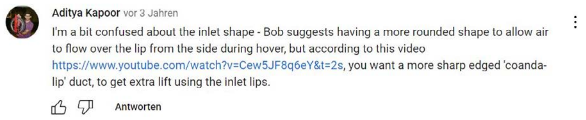

Figure 4. Screenshot – Aditya Kapoor on duct inlet shapes [31].

Unfortunately, this – from a research-perspective – very interesting and worthwhile comment and the discussion it might have sparked has not been engaged with at all, which is a shame, especially since the number of detailed comments like this one, under any Master Lecture, was very limited.

Overall, the tensions emerging throughout the GFP can be described as stemming from a conflict between the challenge's initially very open outset being broken down into highly specific achievements that, in turn, limited its openness. The measures implemented to navigate those tensions both occurred through knowledge-sharing as well as a re-contextualization of the challenge's outcomes as contributing to a larger, shared vision of PAVs where the specific challenge goals were subjugated under a narrative of creating new opportunities for the PAV-market.

The Airbus DDC: Re-introducing openness into a restricted innovation challenge

Whereas the GFP started from an open approach toward its challenge, the approach chosen by the DDC's organizers started from a more restricted framework. Subsequently, the tensions that emerged throughout it revolved around the struggle of integrating more disruptive, open approaches into the sub-challenges. On the upside, this restricted framework – that was further exacerbated by the challenge breaking down into two sub-challenges – improved accessibility in the sense that, in contrast to the GFP, participants only had to focus on a couple selected criteria for their designs to successfully compete. Unlike the GFP, there was very little variety in the drones' physical design – most of them stuck rather close to an off-the-shelf drone-kit by Holybro that was provided to the teams by the organizers. The team that eventually won the DroneBot sub-challenge even used an off-the-shelf DJI Drone with modified software. While this does not make the challenges themselves easier per se, it drastically limits the factors that need to be considered by the participants, leading to less open and more in-depth approaches that could be considered more directly compatible with the specific R&D-processes (at Airbus) this challenge was set up around.

In this context, we regard the integration of augmented reality elements into the "Pathfinder" sub-challenge as an attempt to loosen up this rather restricted framework, introducing a degree of contingency that the participants' drones had to deal with autonomously as they emerged. Those elements included cardboard-boxes labelled with large QR-codes and QR-code-labelled gates for the drones to pass through. The usage of these codes served two purposes: First, it allowed the drones to navigate the environment and to identify certain objects as such, for example, virtual representations of obstacles like accidents or emergency vehicles. Second, it allowed the DDC's organizers to – during and after the event – use recordings from the drones' perspective on social media, where those QR-codes had been visually replaced by the virtual obstacles they were referencing (Figure 5). As a result, the recordings show an augmented reality perspective where concrete and virtual elements coexisted next to each other.

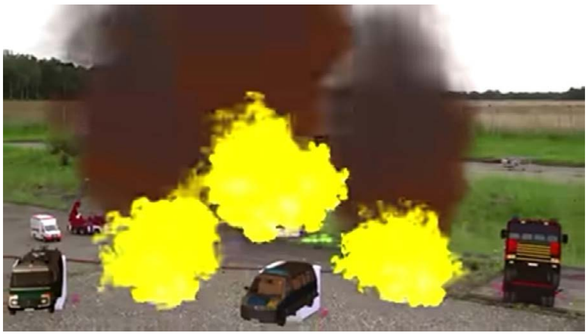

Figure 5. Augmented Reality 'through the drones' eyes' [32].

Interestingly, this approach of integrating digital contents into the physicalized challenge entailed an inherent difficulty to understand how well / whether the drones were performing their tasks without, as a spectator, being able to see the world through the drones' perspectives. From an outside view, the QR-Codes were just that, blocky, black and white codes that did not mean anything to the human eye. On the other hand, they meant a lot more to the drones themselves, leading to occasional difficulties in interpreting the drones' behaviour without the necessary insight into the meanings behind the QR-codes for spectators. This affected the ‘Pathfinder’-challenge in particular, where such QR-obstacles were used extensively. Whereas the ‘DroneBot’ challenge could be understood by listening to the pre-recorded voice-commands directed at the drones and then observing the drones to see if / how they would react accordingly, the pathfinder challenge was only in part understandable from the outside. While one could still tell if a drone successfully passed through a gate, it was not apparent at all from a spectator’s point of view, whether their interaction with the QR-cardboard-boxes, respectively the obstacles they referenced, was adequate.

As for the ‘DroneBot’ sub-challenge, further steps toward re-introducing openness into the challenge were taken: Aside from having to comprehend increasingly distorted tower voice commands in a very short timeframe, a part of the time was reserved for Freestyle, an opportunity for participants to demonstrate additional features or capabilities that they included in their design. Interestingly, not only was this opportunity not taken up by most of the teams, as they preferred to spend the extra time on re-trying missed voice commands, attempting to complete the formal part of the challenge, but the evaluating jury themselves seemed to show little interest in this Freestyle. This was particularly apparent in the case of one team that outfitted their drone with an emergency parachute system. Despite this being the only team that included something ‘out-of-the-box’ into their design – although parachutes for drones are by no means a novelty in themselves – there was no interest by any of the organizers or jury to attend a demonstration. Even though the team was eager to show off this feature outside the formal scoring period and despite them having been given explicit permission to do so, all jury members and organizers had already left the scene when the team demonstrated this. While I was still on site at this point in time, taking videos for the organizers, one of them explicitly told me that there would be no need to record this parachute demonstration. This left both me and the team who, undoubtedly, were proud of this feature disappointed, as it seemed at that time that the Freestyle-part of the challenges was only introduced as a formality, not out of genuine interest for unique out-of-the-box solutions. From the perspective of this paper, we read this disinterest as an indicator of infrastructures being set up to mediate tensions between open and closed innovation, however, they broke down in this moment when they were not maintained through any sort of interest by the organizers or jury.

Summary: Setting up ‘open enough’ challenges by maintaining tensions

In this last chapter, we summarize the challenges’ approaches toward flattening the divide between internal and external, open and established innovation practices. We highlight those in terms of the frameworks underlying the challenges, the steps they took to ensure their accessibility and compatibility toward innovation-processes outside those challenge formats. Subsequently, we reflect on the notion of ‘flattening innovation’ in contrast to ‘open innovation’ and ask if the promise of open innovation may only be considered feasible as ‘open enough’ in the sense that neither side, open or closed innovation, could ever be fully actualized without negotiation processes.

To conclude, we discuss opportunities for future challenge-formats in the field of eVTOL innovation, building on the previous analysis and the advantages and shortcomings of each of the challenges and sub-challenges.

Both challenges created iterated frameworks to introduce external actors into a field of classically highly hierarchical and closed off innovation-processes. They shared a focus on the field of eVTOLs, however, whereas the GFP started off from a rather open perspective, providing basic knowledge infrastructure for its participants, the DDC started from the opposite side of the spectrum, setting up highly specific challenges and subsequently setting up structures to re-introduce a degree of openness, such as the provision of timeslots for freestyle demonstrations and contingency through the integration of augmented reality infrastructures. On a more general note, especially regarding the DDC, it is noteworthy how even strict innovation frameworks could be considered necessary for open innovation to be implemented successfully from a perspective of navigating tensions. While one could argue that any restrictions beyond a very basic outline might be detrimental to the innovative potential the participants could manifest, however, it could be argued that especially for challenges that aim toward connecting outside, creative potential to established and usually non-open R&D-environments might be necessary in this context.

Accessibility for participants to join the challenges was created in the GFP by building on a strong emotional narrative of using eVTOL-technology to transport a single person and a very open description of the technologies that could be employed to achieve this goal. On the flipside however, this limited accessibility to achieving the challenge, as the initial motivator and the final requirements to complete the challenge diverged substantially in terms of their criteria and openness toward what could be considered a success. While measures are required to assess the participants' performances, the grand prize not being claimed by any of the participants hints at this disconnect between the initial outline and the criteria for evaluation and therefore at a failed negotiation of emerging tensions. For the DDC, accessibility was created through the provision of drone-kits to the participants to establish a shared baseline as well as the restriction of eVTOL-innovation to a small field of using A.I-routines for navigation and communication. Furthermore, both challenges were set up in multiple stages, selecting promising participants for the next steps and eliminating what have been considered non-promising participants from the challenges. This decision may be considered as expanding and limiting accessibility at the same time: On one hand, it decreases accessibility as it limits the amount of teams that could compete in the challenges, on the other hand, the teams that qualified for the subsequent steps in the challenges received additional attention, such as – in the case of the DDC – the opportunity to test their drones on-site prior to the challenge event itself, or – in the case of the GFP – the opportunity to share their approaches and the challenges they faced in dedicated, short video formats that were subsequently shared via the official GFP YouTube-channel.

Compatibility of the challenges to established aerospace R&D was achieved primarily through a focus on the emerging field of personal aerial vehicles, specifically those employing electric propulsion systems. Since this trend only recently emerged in the field of aerospace innovation, it could be argued that hurdles to enter it or to contribute disruptive innovations were more likely than, for example, in classic aircraft development. This is mirrored in the ever-increasing number of new start-ups in this field that, as the quote from Chen Rosen (above) demonstrated, build on the relative conceptual simplicity of such approaches. In this sense, both the circumstance that this is a rather new field as well as the affordances of these particular technologies combined allowed the participants to relatively easily connect to state-of-the-art developments. As for the challenges themselves, their thematical restrictions further exacerbated this relationship: While the DDC chose a rather narrow field of innovation, the use of A.I.-algorithms to navigate obstacles and to respond to tower commands that was of particular interest to, Airbus. In contrast, the GFP ensured basic compatibility to established aerospace R&D-processes through the provision of the beforementioned, online knowledge database of Master Lectures. Even though one might argue whether all of these lectures were necessary or even applicable to the development of eVTOL vehicles, they provided a point for participants to connect to established knowledge and good practices.

In conclusion, both challenges demonstrated a turn toward more open approaches in aerospace R&D that is likely to continue in the future. As our analysis showed however, this turn should not be understood as a mere adaption of an ideal framework to open innovation. Instead, we propose a conceptualization as 'flattening innovation', a process that is characterized by the navigation of tensions between involved stakeholders that aims at opening up innovation yet cannot fully follow through with this promise at any point in the challenges' lifecycles. We traced this process in terms of the categories above (Framework, Accessibility and Compatibility) by investigating the interplay between challenge conception, material affordances (here: of eVTOL technology) and emerging tensions. Whereas factors such as simplicity and modularity of construction that are associated with eVTOL / drone technology played a significant role in the viability of flattening aerospace innovation toward the inclusion of external actors in the first place, this did not occur without the necessity for continuous repair work. This became apparent throughout both case studies where elements that aimed at opening innovation were followed by elements that aimed at closing innovation and vice versa. In this context, we regard emerging tensions that manifested themselves in situations like the beforementioned disinterest in the participants' parachute system (DDC) both as preconditions as well as consequences for this negotiation process: On one hand, they provided insights into potential issues of aligning expectations and practices, pointing to friction areas where further balancing would be required. On the other hand, they resulted from those very balancing acts, giving insights into the measures' viability and providing perspectives for reflection.

As our cases show, 'flattening innovation' can therefore be understood as an ongoing process comprised of a set of improvised and rather spontaneously implemented practices of adaptation, integration, exclusion, connection and disconnection, that aim towards the realization of open innovation. The key for succeeding in this endeavour is to flatten the frameworks of innovation processes just far enough to make them accessible and simultaneously achieve compatibility. The grade of flattening and the correct moment for the closing of the innovation process seem to be determined by the negotiation processes that occur during the challenges (as seen with the non-claimed price and the not-engaging with YouTube formats). Open-Innovation (challenges) therefore should not be understood as a pre-definable goal that is to be reached via a challenge format but only in the navigation of emerging tensions. We therefore propose to view this form of innovation-challenges not as 'Open-Innovation challenges' but as 'Open Enough-Innovation challenges', to account for the improvised, messy approaching more open modus innovatio that is not pre-determined by fixed categories or expectations.

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