FLAP: A Simple, Fair and Viable Scheme for Reducing Air Travel

By Richard Morrey
Senior Systems Development Manager
Twtter:@iguanaandy Email:spencerthehalfwit@gmail.com
Oxford, United Kingdom
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1 Introduction

Net zero emissions can only be achieved in time to avoid climate disaster if the exponential growth in air travel (see Figure 1) is immediately reversed (Lucas; 2019), but finding an effective and socially acceptable way of doing this is challenging. The obvious approach of green taxation is inequitable and fraught with political risk: the French government's attempt to introduce "eco tax" on fuel in 2018 had to be abandoned after weeks of rioting (Wilsher; 2018). Even positive financial incentives carry the risk of having a negative impact on social attitudes and therefore of becoming counter-productive (Raworth; 2017; pp118-122).

This paper proposes a simple, transparent scheme for reducing air travel globally with which the flying public can engage positively to help avoid catastrophe and which does not involve financial transactions of any kind. It is based on the following principles:

- Flying is a privilege, not a right.
- The aggregate distance travelled by air globally should be limited to a value that is within the "doughnut" of environmentally sustainable economic activity (Raworth; 2017; Ch1).
- Whatever distance of air travel is sustainable should be made available to all travellers on an equitable basis.

The paper goes on to show how existing international protocols, standards and systems for tracking air travel can be leveraged to deliver the software systems to support this, or other similar schemes, in a short period of time and at low cost. Finally it considers some of the undesirable scenarios that such a scheme might lead to and how they can be avoided or mitigated.

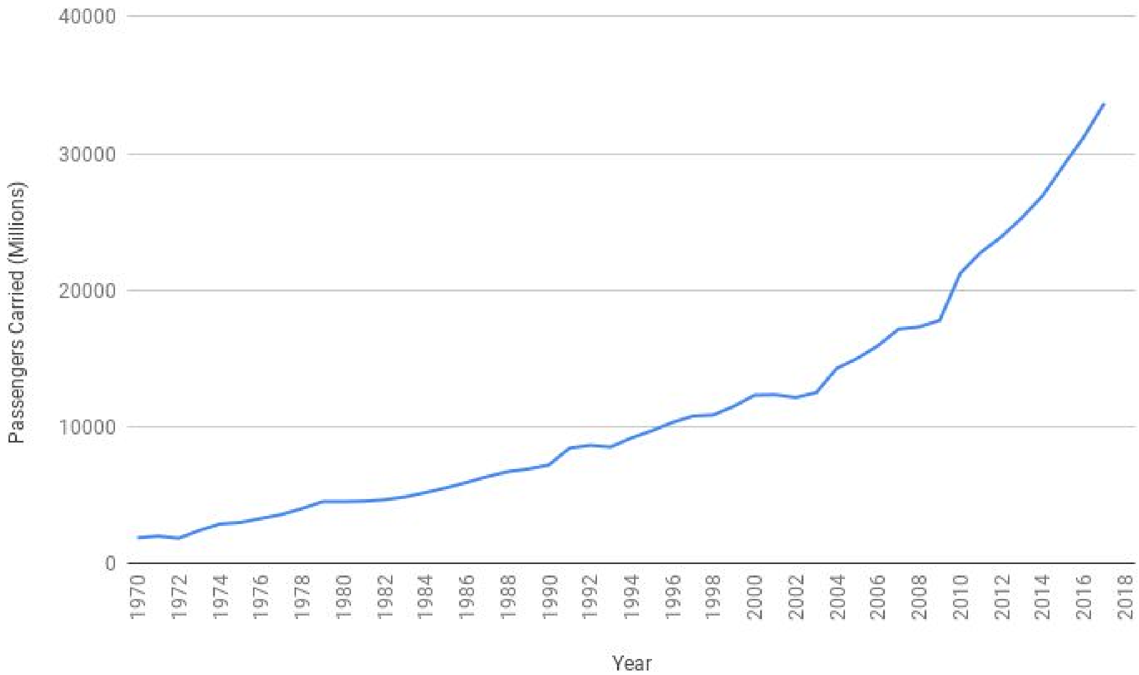

Figure 1 Air transport, passengers carried (World Bank; 2019)

2 Concept

The proposed scheme/system, FLying is A Privilege (FLAP), works as follows:

- Anyone with a valid passport can create a “Traveller” account with a balance of distance travelled in kilometres that begins at zero.
- FLAP tracks the distance flown by each traveller for each ”Trip” - typically outward and return journey but other patterns are allowed - and debits it from their balance.
- A traveller with a negative balance who is not “mid-Trip” is considered “grounded”, meaning they cannot start a new Trip.
- The aggregate number of kilometres that can be travelled over the course of a single day - the “Daily Total” - is set by the Administrator.
- At the end of each calendar day FLAP shares the Daily Total equally between all grounded Travellers and credits the balance of each accordingly. Thus the higher the number of grounded Travellers the less their balances are credited by each day.
- A grounded Traveller is automatically “cleared” to start a new Trip as soon as their balance returns to credit.

In essence Travellers cannot travel again until the distance they travelled in their previous Trip has been “backfilled” from the Daily Total. And crucially the total average distance flown per day cannot exceed the Daily Total set by the Administrator - regardless of Traveller behaviour.

Figure 2 and Figure 3 illustrate how this works for a simple scenario in which:

- All Trips are the same distance.

- There is one Traveller, Kate, who is a frequent flyer, wanting to take a Trip every day
- There are 5 other Travellers each of whom want to take a Trip once every 5 days.

Figure 2 shows a likely starting position for FLAP where the Daily Total is set the average distance currently flown - in this case two Trips. As this is enough to backfill all the Trips planned on each day no Traveller, not even the frequent flyer, has to delay their plans.

Over time the Daily Total is reduced and Travellers have to modify their behaviour. Figure 3 shows what happens when the Daily Total has been reduced to a value that can only support the plans of the less frequent flyers - in this case 1 Trip per day. The plans of Kate are much sooner and more heavily disrupted than those of the others[1] but she is still initially able to fly more frequently. However over time, as distance overdrafts build up in all Travellers accounts the system reaches a state when all Travellers are always grounded between Trips and all effectively travel the same distance.

FLAP aiims to follow the goals of “harm reduction”: to be pragmatic, non-judgemental, and user-friendly (Rafaeli and Woods; 2019; pp43-45). In a real-world scenario the hope is that this will lead to Travellers proactively engaging with its goals and changing their behaviour so the scenario shown in Figure 3 is never reached. However ultimately air travel has to be brought within the doughnut. Achieving that in an equitable way is surely preferable to turning air travel into the preserve of a small rich elite.

[1] Kate has to change plans at Day 3. Ricky will be the first of the others who have to do so, at Day 8, not shown.

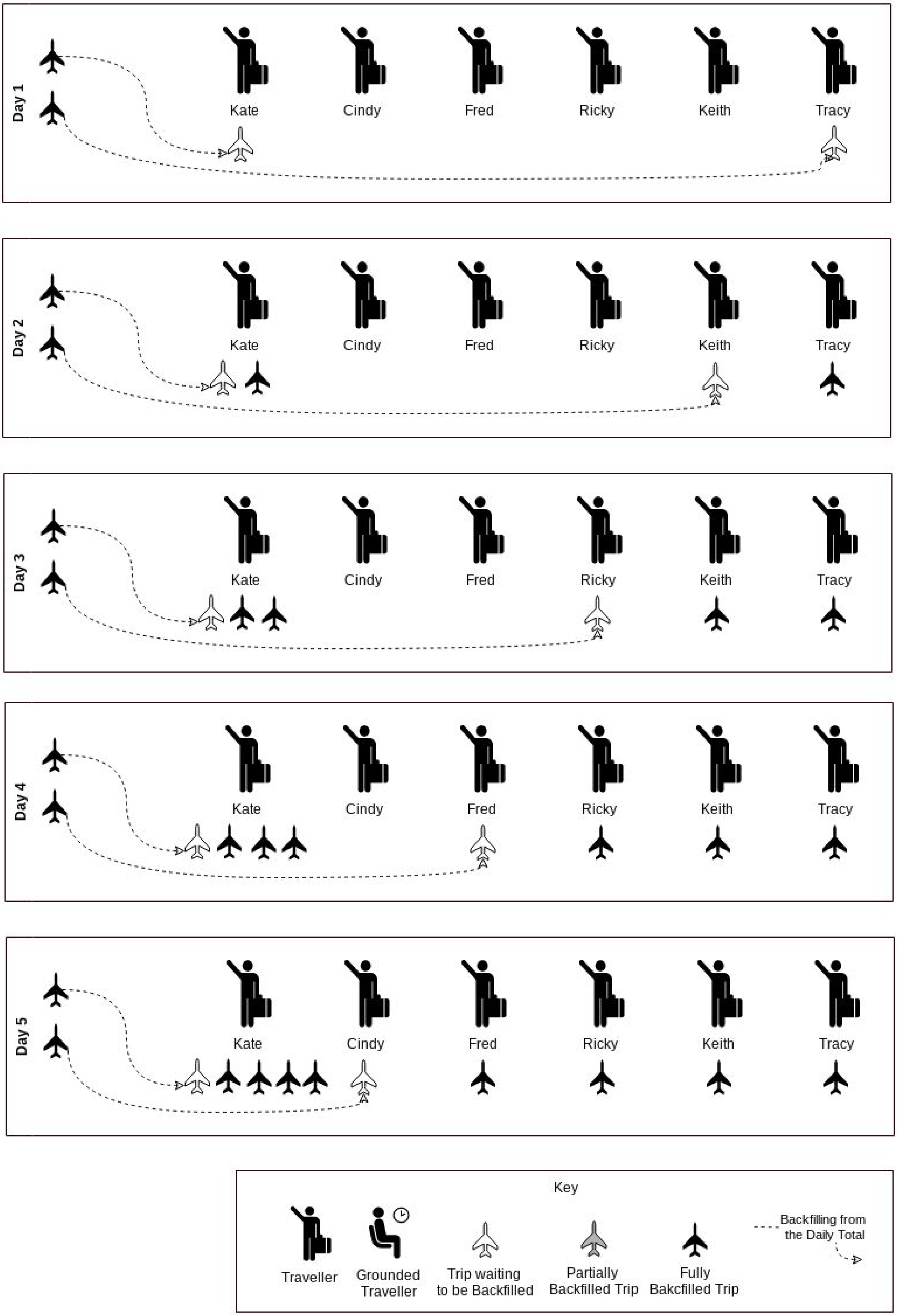

Figure 2 Daily Total of 2 Trips

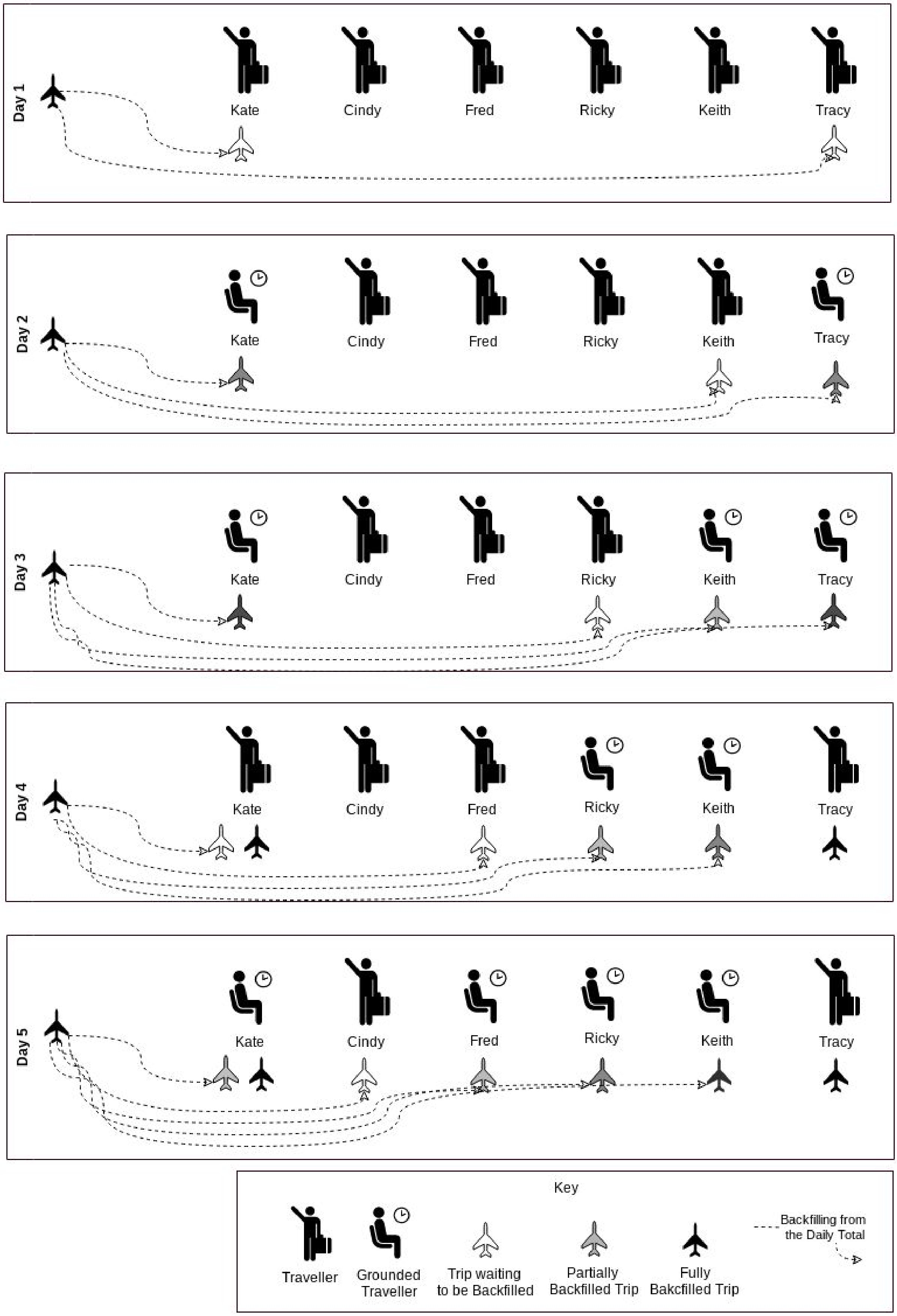

Figure 3 Daily Total of One Trip

3 In Practice

3.1 Flights, Journeys and Trips

In order to minimise the risk of Travellers being stranded far from home check-in is only ever refused at the start of a new Trip. A Trip is defined in terms of Journeys and Flights as below. These definitions are made with the aim of being simple, objective, and easy to calculate.

3.1.1 Flight

A Flight is a single flight in one airplane from one Airport (with an IATA code) to another. The Flight Distance is the shortest distance between the locations of the two airports (see 4.1). At the point of check-in for a fight, FLAP debits the Flight Distance from the Traveller's balance. Carriers are legally obliged to report the Flight and Traveller details for every check-in event.

3.1.2 Journey

A Journey is a sequence of one or more consecutive Flights by a single Traveller in which:

- Each Flight in the Journey is to a different destination.
- Each Flight in the Journey has a scheduled departure time within Maximum Flight Interval (e.g. 24 hours) of the previous Flight's scheduled arrival time.

3.1.3 Trip

A Trip is a series of one or more consecutive Journeys by the same Traveller where the gap between the scheduled departure date of the first Journey and the scheduled arrival date of the last Journey is not more than the Maximum Trip Duration set by the Administrator. By default a Trip is made up of two Journeys with the Trip automatically ending as soon as the second Journey is completed.

3.2 Grounding and Backfilling

Grounding and backfilling are the mechanisms by which FLAP directly controls the distance flown over time in a way that is flexible enough to allow for wide variation in the distance flown by individual Travellers.

3.2.1 Being Grounded and Cleared

At the point when a newly registered Traveller checks in for a new Flight FLAP creates a new Trip in their account. Further flights cause the status of that Trip to be updated, applying definitions given in 3.1, and the distance of each Flight to be debited from the Traveller's balance. When the Trip ends FLAP grounds the Traveller because they are no longer mid-Trip and their balance is overdrawn[2].

Each day FLAP divides the Daily Total into equal shares, one for each grounded Traveller, and credited to those Travellers' balances accordingly. Thus over time the Traveller's balance increases until it is in credit again. At this point FLAP clears the Traveller, allowing them to fly again. At the point of their next check-in FLAP creates a new Trip and the cycle repeats.

3.2.2 Reopening a Trip

In the real world travel plans get disrupted and don't always fit neatly into the default definition of a Trip. For this reason FLAP allows grounded Travellers to reopen their last Trip and add new Journeys to it, but only if this does not lead to the Maximum Trip Duration being exceeded and only at the expense of losing all the distance credited to their account since the reopened Trip first ended.

Note adding additional Journeys to a Trip delays but does not avoid the backfill of the total distance travelled.

3.3 An Example Itinerary

Following is an example showing how FLAP would work in practice for a single Traveller (Claire Planet) across three separate Trips. For the purpose of this example, FLAP parameters are set as shown in Table 1. With these values each day, on average, the Distance Total is divided into shares of size 50 km, calculated as 10 Billion ÷ 200 Million. Claire's Distance Balance over time is shown in Figure 4.

Name	**Value**
Daily Total (km)	10 Billion
Maximum Flight Interval (hours)	24
Maximum Trip Duration (days)	365
Average grounded Travellers	200 Million

Table 1 Illustrative Flap Scheme Parameters

3.3.1 The First Trip

Claire creates a new FLAP account using her passport details as credentials. She begins with a balance of 0 km and book a simple return flight from London Heathrow (LHR) to

[2] Whilst this is the most likely scenario at the end of a Trip it is possible that the final share of the backfill of the previous Trip provides enough credit to cover the whole of the next one.

Barcelona (BCN). At check-in for the outward journey FLAP confirms Claire is not grounded and so allows her to travel and creates a new Trip. At this point FLAP starts tracking the first Journey of a new Trip and debits 1147 km from her balance.

One week later Claire checks in at Barcelona for the return flight. FLAP allows her to travel because the Flight is recognised as the second Journey of an active Trip and debits another 1147 km.

Twenty four hours later FLAP automatically recognises the end of the return Journey and therefore the Trip. Claire is grounded. Each day after that her balance is credited with, on average, 50 km.

3.3.2 The Second Trip - Including a Two-Flight Journey

Forty six days later Claire's balance is back in credit and FLAP clears her to fly again. She books a return business trip, this time involving a connecting flight - from LHR to BLR (Bangalore) via FRA (Frankfurt),

At LHR on the outward Journey Claire checks in for the first flight only. FLAP recognises the start of a new Trip, and because her balance is in credit (6km), allows the check-in to proceed and debits the flight distance (655 km). Twelve hours after landing at FRA, Claire checks in for the flight to BLR. FLAP recognises this as part of the same Journey, allows check-in to proceed, and debits the flight distance (8053 km).

Three days later Claire checks in for the return Journey, this time for both flights at the same time. FLAP recognises this as the start of the second Journey of an active Trip and allows check-in to continue, this time debiting total Journey distance (8708 km). At FRA Claire does not check-in so FLAP is not invoked.

Twenty four hours later FLAP recognises the Trip has been completed and grounds Claire with her balance at -17,410 km. Daily credits of 50 km resume.

3.3.3 Reopening the second Trip

Thirty days later Claire wants to fly to Stockholm for a friend's wedding. Logging into FLAP she can see that their account is still 15,984 km in deficit and will take another three hundred and nineteen days to complete. She reopens the Trip, which clears her to travel but causes her balance to revert to -17,410 km. When she checks in at LHR for departure to ARN the distance between LHR and ARN (1446 km) is debited, and once again when she checks in for their return Journey. When she gets home Claire closes the Trip effectively grounding herself. Her balance is now -20,302 km and she will have to wait four hundred and seven days before flying again.

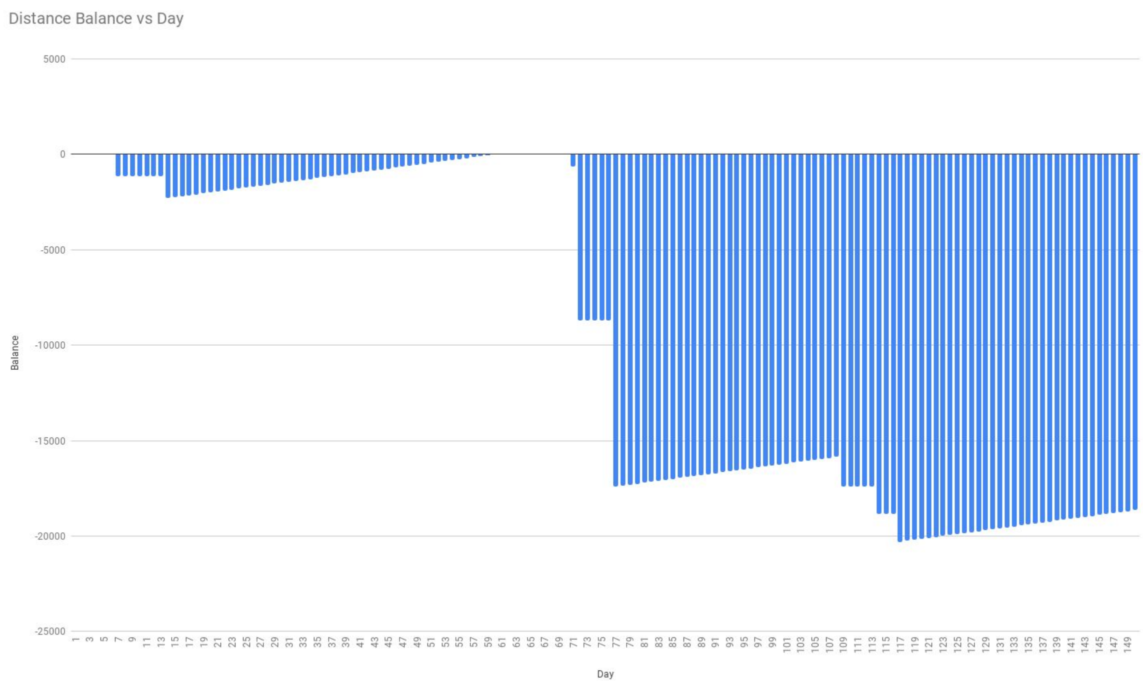

Figure 4 Claire Planet's Distance Balance

3.4 Administration

The administration of FLAP amounts, other than operation of the software system itself, to the setting of three parameters:

- Daily Total. The total distance shared out to Travellers each day for backfilling. Expressed in kilometres.
- Maximum Flight Interval (MFI). The maximum interval between Flights in a single Journey. Expressed in hours.
- Maximum Trip Duration (MTD). The maximum duration of a Trip before its completion is enforced by FLAP. Expressed in days.

Whilst tuning MFI and MTD can reduce Traveller disruption, Daily Total is by far the most significant of the three. It directly controls the total distance travelled by air each calendar day, on average. Conceptually there are three different ways to decide on the value. Each has its benefits and drawbacks.

3.4.1 Entirely Automatic Distance Total

The Distance Total is calculated automatically by FLAP according to an agreed algorithm that reduces the total over time to sustainable levels. The advantage of this approach is that no human decision making involved once the scheme is up and running, and therefore limited opportunities for pressure groups, specifically the Airline Industry, to exert undue influence. It also allows for the Daily Total to be automatically adjusted to allow for seasonal variations in flight volume.

3.4.2 Manual Distance Total

The Distance Total is set to a fixed value as decided by the Administrators, with that value being reviewed and adjusted on a regular cadence. This approach has the advantage that the Distance Total can be adjusted to account for such factors as improving aircraft fuel efficiency, or a significant unpredicted climate deterioration.

3.4.3 Semi-Automatic Distance Total

The Distance Total is calculated automatically according an algorithm, with that algorithm taking one or more arguments that can be set by the Administrators. This has the advantage that the core algorithm could enforce reduction over time, with the provided arguments only allowing for adjustments to the rate of reduction.

4 System Design, Implementation and Operation

4.1 Flight Reporting

The collection of commercial flight information is already an established practice, for reasons of law enforcement and national security. There are two widely used approaches - Passenger Name Records (PNR) (ICAO; 2010) and Advanced Passenger Information (API) (ICAO; 2014), each with their own standard data exchange formats: AIRIMP (IATA; 2019) and PAXLST(IATA; 2013). Both formats provide, along with a large amount of additional information, the data required by FLAP for each fight taken:

- Passport Number of Traveller
- Nationality of Traveller
- IATA Code of Departure Airport
- IATA Code of Arrival Airport
- Date/Time of Scheduled Departure
- Date/Time of Scheduled Arrival

International legally binding agreements enforce reporting of both PNR AND API by Carriers. The EU Directive 2004/82/EC has, since 2004, required all EU member states to require all Carriers to report PNR information to the appropriate national authorities (EU; 2014). Separately Carriers are required to provide via API via the Advanced Passenger Information System for all journeys to and from a significant number of participating countries (Wikipedia; 2019).

The existence of these programmes show that the kind of flight data reporting required by FLAP is entirely practicable and also provide an existing technical platform that FLAP could leverage at one of three levels:

- Receive flight information indirectly via existing programmes i.e. via National Governments.
- Require Carriers to report flight information directly to FLAP, but supporting existing AIRMAP and PAXLST standard for ease of integration.
- Design a new simple FLAP reporting format with cross-programming language tools and libraries to make integration as straightforward as possible.

4.2 Distance Calculations

The shortest distance between two sets of latitude/longitude coordinates can be easily approximated by applying the haversine formula (Rosetta Code; 2019). This approach isn't completely accurate, as the Earth is not perfectly spherical; and it does not allow for deviations from the shortest path for specific flights. However it has the benefit of being consistent, verifiable and easy to implement. The only prerequisite is a database table holding the global coordinates for all airports, which is keyed on IATA airport code and is updated to include any new airports before they start running commercial passenger flights.

4.3 System Design and Hosting

The core FLAP architecture is comprised of one central object-oriented database table of Travellers - with each record containing a history of Trips broken down into Journeys and Flights - and three on-going processes that update that table:

1. Flight Data Processing. Takes as input all incoming flight data and updates Trip Histories for the affected Travellers (see 3).
2. Trip Completion Enforcement. Iterates through Travellers with open Trips enforcing Trip completion and consequent grounding of Travellers.
3. Backfilling. A daily process that allocates an equal share of the Daily Total to all grounded Travellers, clearing those who are thereby returned to credit.

All three processes take as input current FLAP Parameters as set by the Administrator (see 3.4) and stored in a second table. Flight Data Processing also requires as input an Airport Locations table holding the latitude and longitude coordinates for each Airport code. This is so it can approximate the distance of each Flight reported (see 4.2)

Finally REST interfaces (Mulesoft; 2019) allow the following user interactions:

1. Travellers able to view their balance and Trip History and reopen their last Trip (see 3.2.2).
2. Administrators able to change FLAP parameters and update the Airport Table.
3. Carriers able to check whether any Traveller is cleared or grounded.

All of this is illustrated in Figure 5.

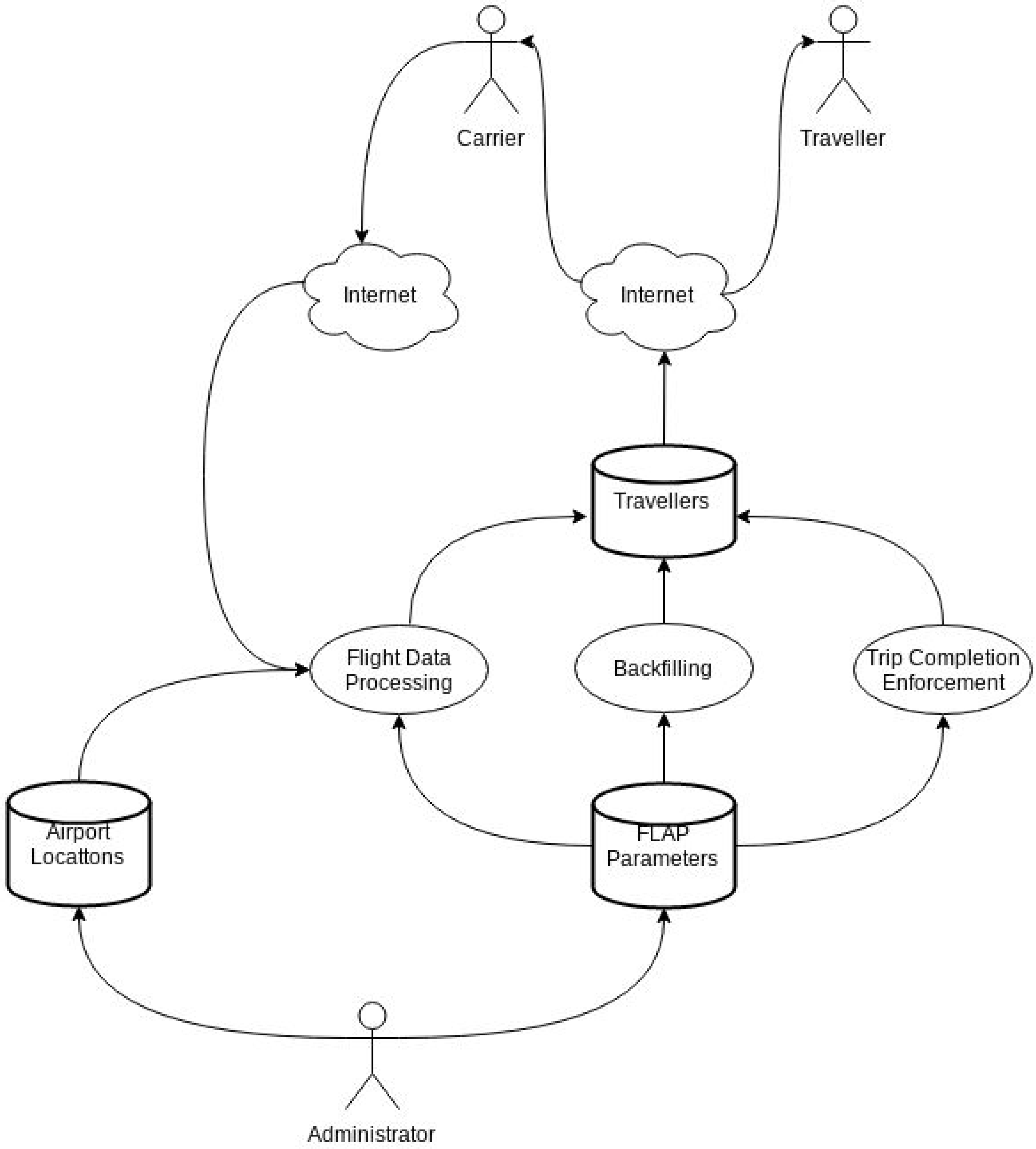

Figure 5 FLAP High Level Data Flow Diagram

In practice there would clearly be additional features - smartphone apps for easier interaction with the REST API, dashboards providing statistics, public website etc - but the core system is, by modern standards, very simple. The biggest challenge is around scalability but in the world of Big Data a table of 10TB with 1 Billion records, and a processes carrying out 1000 write operations per second into that table[3] are well within the capabilities of services offered by Cloud providers such as Amazon AWS, Google Cloud Platform and Microsoft Azure.

[3] Based on 100 million flights per day total, 1 billion Travellers total, and average 10Kb Traveller record size, order of magnitude estimates derived from (World Bank; 2019)

4.4 Security Risks

The FLAP system contains little personal data and no sensitive financial information. None of the public interfaces expose a means to cheat the system inorder to fly more frequently. Therefore by far the most likely attack is by an individual or organisation opposed to air travel reduction, and with the goal of disrupting its operation or otherwise bringing it into disrepute. Potential attack methods include:

- Denial-Of-Service attack against the system.
- Compromise of Carrier credentials in order to send spurious flight data causing wide-spread disruption to travel plans.
- Identity Theft, creating Traveller accounts using stolen passport details, thus preventing victims from viewing or managing their account.

The system design must incorporate measures to mitigate against such attacks, including:

- Easy and prompt revocation and reissuing of compromised user credentials.
- Easy rollback of the Flight Data Processing for specific Carriers and time frames
- Independent verification of individual Traveller registrations.

4.5 Cost

The author's SWAG estimate is that the FLAP system as outlined above could be developed by a team of 10 in one year, equating to a cost of the order of €1-10 million. However, an open source development, given the goals of the system, seems to be a feasible alternative that could result in a working system much faster and at a much lower cost.

If hosted by a Cloud provider then operational costs would be made up of the following

- Cloud Provider Charges. Of the order of €100,000 per month[4].
- Operations Team. This team need to ensure on-going operational health of the system, keep Airport Locations table up-to-date and manage security events. The author expects a permanent team of the order of 10-100 would be needed.

4.6 Administration

It would be feasible for individual nations to independently manage and enforce FLAP parameters for their own citizens. However participation of a "critical mass" of countries, both geographically (see 5.3.1) and in terms of aggregate distance flown, is essential and significantly divergent Distance Totals would inevitably lead to feelings of unfairness, undermining confidence in the scheme. Therefore it would be better if there were a single global FLAP Administrator, perhaps under the auspices of the United Nations Framework Convention on Climate Change (UNFCCC).

[4] Based on estimates in 4.3 and https://calculator.s3.amazonaws.com/index.html

5 Limitations, Flaws and Trade-offs

Like any other scheme, FLAP has its limitations, flaws and trade-offs. Some of the most significant of these are considered below, with possible variations on the basic system proposed to address them.

5.1 Balancing Business and Leisure Travel

Travellers who travel for both business and leisure may suffer more disruption than others under FLAP. In particular a backfill for a long distance business Trip could prevent them going on a planned family holiday, or vice versa. Whilst a change in this kind of lifestyle is obviously the ultimate goal, and there is the option of reopening Trips, without some kind of compromise in this area the scheme may prove unpopular.

One possible variation is as follows.

- There are two types of Trip: Business Trip and Leisure Trip.
- Travellers have a separate balance for each type of Trip.
- Backfills can run concurrently for the two Trip types.
- A new Trip can be started if the balance of the corresponding type is in credit.

This would enable Travellers to manage business and leisure travel separately. In practice the type of a Trip would be self-declared, so such a scheme would be vulnerable to abuse.

Ultimately the total distance travelled would still be limited by the Daily Total and the scheme would still achieve its key goals, at the cost of some additional complexity.

5.2 Unpredictable Backfill Completion Dates

The distance backfilled each day varies according to the Daily Total and number of grounded Travellers. The downside of this is that the date at which a Traveller is cleared cannot be confidently predicted and future Trips planned and booked. One way of mitigating this would be for FLAP to automatically estimate a completion date driven by algorithms taking account of previous backfill rates. This estimate could be made at the point when the backfill starts and become the binding date on which the Traveller is cleared. The Traveller's balance would not be affected and the remaining deficit would be still backfilled when the Traveller is next grounded.

5.3 Gaming

Any scheme aimed at restricting or changing human behaviour is likely to be subject to attempts to circumvent it. Some possibilities are considered briefly below.

5.3.1 “Short Hop” to Airports outside FLAP Jurisdiction

In practice it is likely that some countries won’t sign up to the scheme, creating opportunity for Travellers to take a “short hop” Journey (by air or otherwise) to an airport outside FLAP jurisdiction before embarking on their main journey. Some standard “penalty” distance for any Flight with a destination outside FLAP could be introduced but this would not impede short hops by means other than flying. The most effective mitigation is for FLAP to be adopted by as many countries as possible, such that short hop opportunities become limited and unappealing.

5.3.2 Impersonating other Travellers

By impersonating someone else, a Traveller could fly again before their backfill is complete. However FLAP identifies Travellers by means of passport number and issuing country, so the perpetrator would have to commit passport fraud - present a passport at check-in that is forged or not their own. It probably would happen occasionally but very few people would consider committing a crime of this sort merely so they could fly again sooner.

5.3.3 ”Never-ending” Journeys and Trips

The definitions of Journey (see 3.1.2) and Trip (see 3.1.3) intentionally provide flexibility to the Traveller. There is nothing to prevent someone chaining a series of short trips (such as sales visits) together into one Journey by ensuring the gap between each Flight is not more than the Maximum Flight Interval. Equally a Traveller is able to add as many Journeys as they like into a single Trip as long as they all fit within the Maximum Trip Duration. However ultimately the Trip ends and the entire distance travelled during the Trip has to be backfilled before the Traveller can fly again. The outcome is that the time the Traveller would have had to wait between shorter Trips is accumulated into one much longer waiting period at the end of one very long Trip. Backfilling is delayed, not avoided.

5.4 Disrupted Journeys

There is a risk that multi-Flight Journeys are disrupted to the extent that FLAP considers a delayed flight within an existing Journey the start of a new Journey. The risk can be partially mitigated using “through check-ins”, and in most cases the Traveller can simply reopen the Trip. However this is not allowed if it the Maximum Trip Duration has been reached. Advice can be given, not to plan Trips with a length close to the Maximum Trip Duration but there is no way of avoiding this scenario altogether. Some further mechanism to extend Trips beyond Maximum Trip Duration may therefore be necessary but, to avoid gaming, would have to be controlled by someone other than the Traveller.

5.5 Distance travelled doesn’t equate to CO_2 emitted

FLAP is driven by distance travelled which is not directly proportional to the amount of CO_2 emitted per Traveller. Other significant factors include:

- The fuel efficiency of the aircraft used.

- The passenger load factor (Wikipedia; 2019b), that is the proportion of occupied seats on the aircraft.
- The overhead of take-off,landing and taxiing, which accounts for 25% of the fuel consumption of an 800 km trip (Jung; 2010; p2).

All of these are measurable and could be incorporated into a scheme attempting to track directly the total CO_2 emissions caused by each Flight. This would have the advantage of encouraging airlines to reduce emissions - as Travellers would be motivated to fly with Carriers offering lower emissions for the same Journey. However such an approach would be more complex and opaque for the Traveller, as well as being open to gaming on the part of the airlines and aeroplane manufacturers.

Airlines are already motivated to reduce fuel consumption and maximize Passenger Load Factor for commercial reasons. The bias in FLAP against longer Flights could be mitigated by the addition of a fixed "distance overhead" for each Flight to account for the impact of take-off and landing.

5.6 Other types of Air Transport

FLAP specifically targets commercial passengers - it is a concept entirely based on distance travelled by people. There are three other significant types of air transport that are briefly considered below. Ultimately all types of air transport have the same fundamental issue that there is no viable technical solution to eliminate CO_2 emissions, meaning reduction is essential.

5.6.1 Military

Given the US Air Force alone consumes one quarter of the world's jet fuel (Saunders; 2009; p50), the military is certainly a significant contributor to global air transport emissions, and if climate breakdown is to be avoided these will have to be reduced. However this is only achievable through the action of national governments and is clearly out of the scope of the kind of scheme proposed here.

5.6.2 Air Freight

Air is by far the most environmentally damaging means of freight transport. In 2010 It caused 7% of total global trade-related freight CO_2 emissions in transporting only 0.3% of total goods by mass×distance (GreenAir; 2015). Even worse, air freight has been forecast to increase massively over the coming decades, both in absolute terms and as a proportion of overall freight travel (*ibid)*. It is clear that in all but the most niche areas air is not a sensible means of freight transport. Specious arguments justifying its use based on economic benefit to developing countries (ICAO; 2015) need to be rebutted and international laws put in place to heavily restrict the categories of goods that can be transported by air. Ultimately the problem of air freight is probably best understood and addressed in the context of trade-related freight generally - that is as a corollary of uncontrolled and unsustainable global economic growth, which must be curtailed.

5.6.3 Private Jets

Travel by private jet obviously represents a very small proportion of overall air travel and will only ever be available to a very small number of travellers because of cost. Therefore its exclusion from FLAP does not represent a significant risk to its effectiveness in managing the aggregate environmental impact of air travel. However it does provide a means for the very rich to effectively evade the scheme entirely, breaking the principles set out in 1. Also private jet travel generates far more CO_2 than commercial air travel by passenger distance travelled (IPS; 2009), so any increase could be used to support an argument that FLAP is self-defeating. Tracking travel by private jet in FLAP is technically feasible but politically challenging, as the EU parliament found when attempting to include private flights in the EU directive to collect passenger information for security reasons (EU; 2016), (IE; 2018).

6 Next Steps

The claims made about the impact of FLAP on Traveller behaviour need to be validated through modelling. An open source project should be set up with this as its first goal and the implementation of the core system as its second. Separately it is probably worth exploring whether the basic concepts of FLAP could be applied to other areas, particularly to road travel, with volume of fuel purchased rather than distance travelled being the core metric and “Driver identified by driver’s license” rather than “Traveller identified by passport” being the core user.

7 Conclusion

The on-going increase in air travel is not sustainable and must be reversed. Whatever approach is taken to achieve this will inevitably meet opposition from airlines, aircraft manufacturers and frequent flyers. This paper proposes a air travel reduction scheme that has the potential to be far less controversial, fairer, and more effective in reducing air travel than alternatives such as green taxation or rationing (Sodha; 2019). But of course FLAP is just one idea. There are no doubt many other possible approaches and, as discussed in Section 6, FLAP itself can have many variations. Perhaps the most important message of this paper is that such schemes, driven directly by and directly managing Traveller behaviour, are technically feasible, practicable and can be cost-effective.

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