D4.1 Behavioural Model Parameter Calibration

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BEACON

BEHAVIOURAL ECONOMICS FOR ATM CONCEPTS

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Abstract

This document provides the necessary behavioural background and calibration for the behavioural modelling requirements of the BEACON project. Firstly, it introduces and defines key behavioural concepts that are suited for modelling purposes. These are, in particular, Prospect Theory and Hyperbolic Discounting. The suggested concepts are explained in detail and their use case parameter calibrations are summarised. Secondly, it provides the methodology used to estimate the relevant parameters with the help of an online survey that has been distributed to a wide range of relevant participants such as flight dispatchers. While we have, unfortunately, not been able to collect sufficient responses to our survey, to directly estimate the parameters, we will make suggestions on the parameters to use based on existing literature and parameters calibrations.

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1 Introduction

1.1 Scope and Objectives

BEACON's general goal is to design new procedures to allow more flexibility to AU to steer their operations according to their business needs in case of disruption. As well, BEACON aims to evaluate the proposed procedures through new methods and tools able to take into account complexities of AUs' behaviours introducing behavioural economic techniques (bounded rationality, for example). Traditional economic theory relies on several fundamental assumptions which underpin the assumed process of agent decision-making. Traditional models therefore integrate these assumptions when prescribing expected behaviour and decision-making: utility maximisation, complete information and agent rationality. In reality, these assumptions are often violated by observable behaviour and thus, models must be adjusted if they are to properly reflect real-world behavioural phenomena. By testing these assumptions and measuring parametric outcomes of the underlying human biases, we can then update models accordingly.

With that goal in mind, this document has three purposes:

(i) to introduce and define key behavioural concepts that are suited for modelling purposes. These are in particular Prospect Theory and Hyperbolic Discounting. The suggested concepts are explained in detail and their use cases parameter calibrations are summarised.

(ii) to provide the methodology to estimate the relevant parameters with the help of an online survey that has been distributed to a wide range of relevant participants such as flight dispatchers.

(iii) to suggest suitable model parameters based on existing literature and parameters calibrations for the modelling of agent behaviour in the small-scale modelling experiments of WP4 and the large-scale simulations of WP5.

1.2 Structure of the Document

The document is structured as follows:

- Section 1 introduces the document explaining its aim and scope and describes the structure of the report.
- Section 2 introduces the main behavioural models that we will be utilising as part of BEACON.
- Section 3 provides a detailed overview of the behavioural survey and the respective approach to calibrate the model parameters.
- Section 4 describes the actual calibration results/findings of the parameters.
- Section 5 concludes this document.

2 Behavioural Models

The rigid assumptions and hypotheses made by classical approaches when modelling certain economic mechanisms can sometimes produce unrealistic results, thus not revealing real-life results and their associated consequences. Behavioural economics presents a considerable opportunity to advance the quality and rigour of simulation models by delivering essential understanding of human behaviour and decision-making fed by several disciplines (psychology, neuroscience, economics and decision science).

This challenge will study the inclusion of behavioural economics within the decision-making of airlines in situations where they face ground delays due to demand capacity imbalances in the airspace system. A suitable framework should take into account the main pillars of behavioural economics. The following behavioural phenomena are closely tied to the decision-making of interest within the ATM agents represented within developing models for the BEACON project. Therefore, we have prioritized these parameters for integration into these models.

2.1 Prospect Theory

A very well-established set of behavioural principles centre around what are known as “framing effects”, or how a representation of information presented to us impacts our decision-making and/or behaviour. These effects are best understood and simplified by using models and frameworks, and within the decision-making evaluation of the air traffic management modelling for the BEACON project, one framing effect framework we have focussed on is known as prospect theory.

Prospect theory is a descriptive model developed by Kahneman and Tversky [1] describing how people make choices under uncertainty and has been applied to a wide range of economic settings including consumption choice, labour supply and insurance [2]. The main idea behind prospect theory is that individuals make decisions based on their experienced value of losses and gains relative to a fixed reference point. This is in contrast to standard utility theory as introduced by von Neumann and Morgenstern [3] where utility is generally calculated based on net wealth. Moreover, prospect theory uses a value function that is s-shaped: being concave in the gain domain and convex in the loss domain. This describes how individuals tend to be risk-averse in the concave part of the value function (gain domain) and risk-seeking in the convex part of the value function (loss domain) [4]. Additionally, the value function is steeper for losses than it is for gains, which indicates loss-aversion.

Tversky and Kahneman [5] suggest the following formulation of the value function (see Figure 1 for a visualisation), where x denotes the loss or gain relative to the reference point and they empirically estimated $\alpha=\beta=0.88$ and $\lambda=2.25$:

$$v(x) = \begin{cases} x^{\alpha} & for\ \ x \geq 0 \\ -\lambda(-x)^{\beta} & for\ \ x < 0. \end{cases}$$

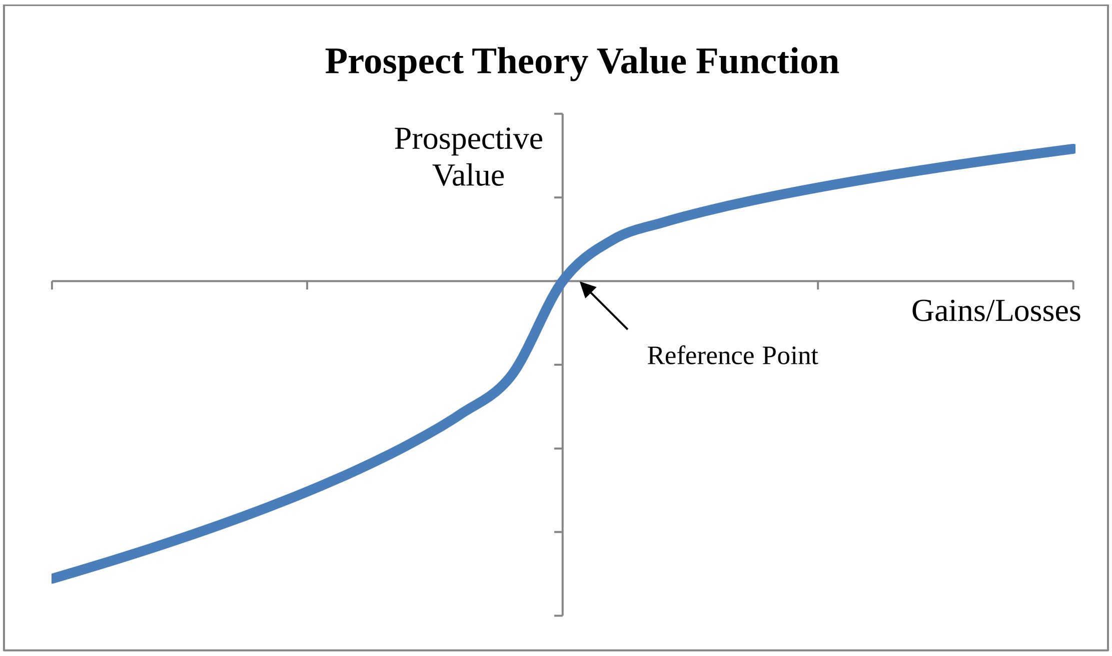

Figure 1 Prospect theory value as a function of the gains/losses relative to a fixed reference point ($\alpha=\beta=0.5$, $\lambda=2.25$)

Another important distinguishing feature in the framework of prospect theory is what Kahneman and Tversky [1] call decision weights. The idea behind decision weights is that people assign weights to certain outcomes that differ from objective probabilities (Figure 2). More specifically, people tend to overweigh low probabilities and they tend to underweight high probabilities [6].

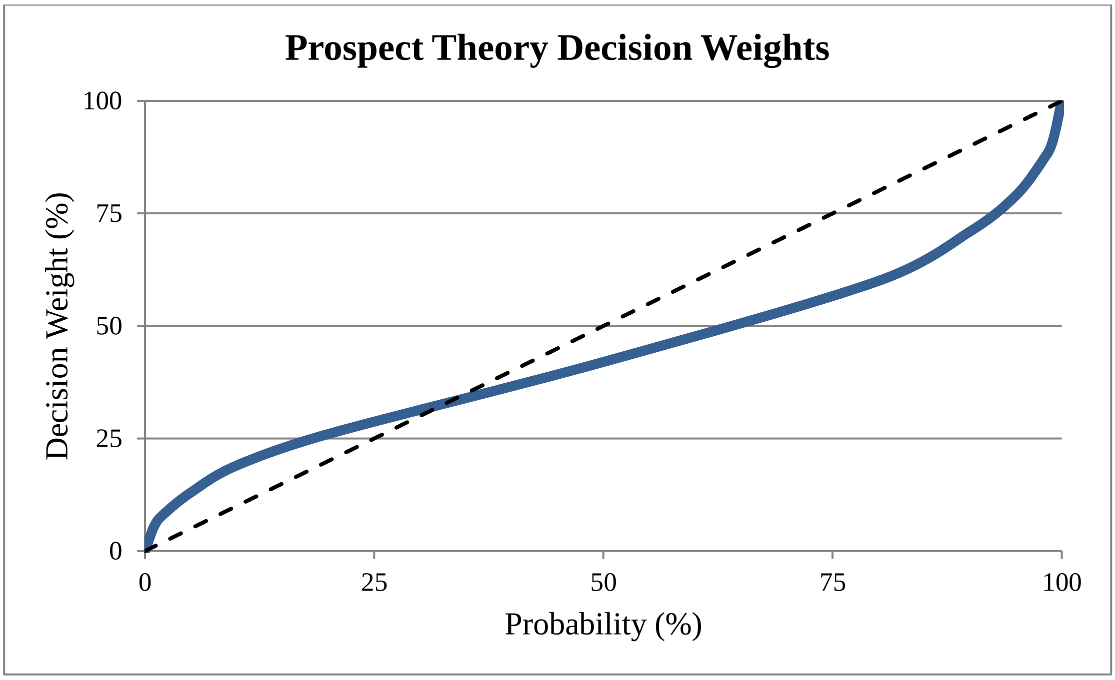

Figure 2 Prospect theory decision weights versus objective probability.

In the context of Air Traffic Management, Prospect Theory might be observed, for example, in a decision as to how to use Credits in prioritisation. Under the BEACON prioritisation mechanisms under test, the flexibility with which agents can allocate our proposed credits to either gain delay credits by accepting extra delay, or spend credits to favour important flights of the AU, will be impacted by the associated mental processes underlying Prospect Theory (e.g. Loss Aversion). An agent viewing spent credits in a loss frame may resist or delay in paying for protection on these higher priority flights, thus increasing a potential delay for the flight itself. Conversely, gains of an equal value, as discussed above, are undervalued in comparison to the valence of “felt” loss, and thus are less enticing when eliciting behaviours. In this situation, an agent quite predisposed to a high level of loss aversion and with steeper curves of a modelled Prospect may be less inclined to accept a delay credit under a certain value in order to accept a delay. By understanding to what degree these gain and loss parameters are measurable, we can properly “price” these delays.

2.2 Hyperbolic Discounting

In choice evaluation, the expectation of when a reward is received is as important as the amount of the reward itself. Sooner, smaller amounts are often favoured over larger, later amounts, to varying individual degrees [7]. These preferences and measured indifference levels between delayed rewards in individual decisions make up subjective discount rates [8]. Making trade-offs of this kind, while employing the self-control required to delay consumption is mental work. Heuristics are used unconsciously by people making these decisions for the purpose of efficiency. However, limiting this cognitive exertion often results in biases [9]. Additionally, the preference to consume sooner tends to be inconsistent over different timeline lengths. This hyperbolic discounting fallacy is at odds with rational decision-making which would predict the consistent preference over time.

Exponential discounting as described above, is time-consistent, and is modelled by the falling reward value being discounted by an increasing factor over time, which is to say that the “dis-count rate” is constant. Hyperbolic discounting, in comparison, is a time-inconsistent form of temporal discounting whereby the subjective value within shorter timeframes fall more rapidly, and at points further in the future, these discount rates fall more slowly in longer delay periods.

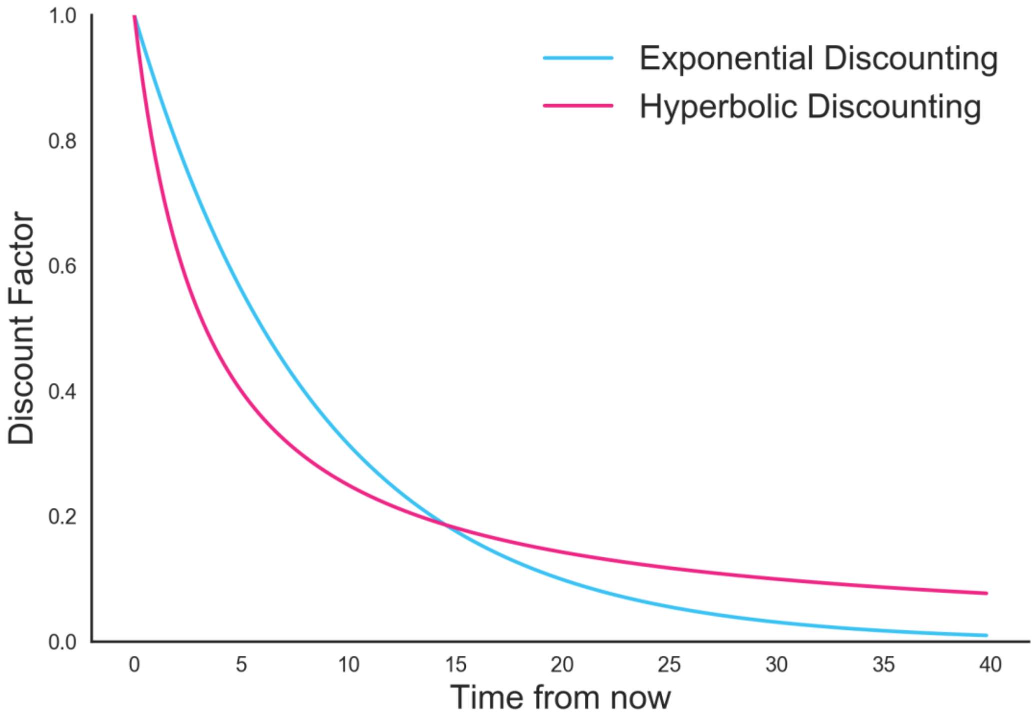

Figure 3 Hyperbolic discounting versus exponential discounting.

While well-established as a phenomenon, mechanisms by which temporal discounting comes about are numerous. Many theories have been proposed over time to explain the difficulty in delaying consumption, attempting to specify underlying characteristics and causes related to these irrational choices. Today, an interactionist approach has been largely accepted by behavioural scientists and has effectively overtaken any one theory to predict likely outcomes of temporal discounting, or "present bias" [10].

In the context of the mechanisms used for prioritisation under UDPP, any time delay on receiving credits as proposed in Flexible or Credit points mechanisms (or indeed any Monetary-based market-based mechanisms), will be treated differently based on the amount of delay and the amount of credit gained. If, for example, an agent is faced with a choice in which they stand to gain a number of credits to allow a near-term flight to be delayed, or instead to delay a later, but more "lucrative" flight which would on average allow them to gain further credits to use for an upcoming critical delay, they may, based on hyperbolic discounting, overvalue the smaller, sooner reward over a larger payoff overall by delaying the later flight.

3 Methodology and Survey

In order to estimate the parameters for Prospect Theory and Hyperbolic Discounting in the specific context of BEACON, we designed a survey that was sent out to a large group of flight dispatchers. In particular, we distributed the survey via the professional connections of our consortium partners and the advisory board who emailed their relevant contacts the direct link to our survey. Moreover, we shared the survey link with EUFALDA and publicised it via the BEACON website and LinkedIn page in order to increase the reach and thus the number of participants completing our survey.

The primary goal of the survey was the estimation of the parameters for Prospect Theory and Hyperbolic Discounting as described above. In addition, we also added a number of questions and tasks in order to get a glimpse at the prevalence of other common biases. While these biases do not directly form part of the BEACON modelling as they are not as easily represented by mathematical models, they are nonetheless of general interest and could inspire future research. In summary, we investigated the behavioural biases and patterns as described in the following sections.

3.1 Prospect Theory

There are three different sections of the CPT questionnaire. One includes lotteries in the domain of gains, one within the domain of losses, and the third, a mixed lottery. Compared to the survey used in the original study by Booij et al, we adapted the survey for BEACON to estimate relevant Cumulative Prospect Theory parameters to calibrate our model. In the original study, the payoffs and costs were stated in currency terms which we adjusted for the purpose of our study to be expressed in *credits* which act as the currency in the context of BEACON and were briefly described to the participants and how they relate to the hypothetical slot swapping mechanism(s):

> *In the following questions we will ask you to make a number of choices based on you being a flight dispatcher. Imagine there is a mechanism allowing airlines to swap slots amongst each other in the case of regulation. The mechanism makes use of "credits" which can be used as the (non-monetary) currency for these swaps and might e.g. be equivalent to a minute to delay.*

Once described, a series of seven lotteries in the gain domain were presented, and participants were asked to evaluate and determine the maximum amount of credits they would “pay” to participate in each of the respective lotteries. The amounts of credits and percentages of each outcome varied between the seven questions.

> *Imagine you are offered the lotteries below. Please indicate the maximum amount of credits you are willing to pay to participate in the lottery:*
>
> *10% chance to win 10 credits*
>
> *90% chance to win 100 credits*

I am willing to pay at most the following number of credits to play the lottery______

Next, two lotteries framed in the loss domain were presented, and participants were asked to evaluate and determine instead, the maximum amount of credits they would pay to *not* participate in each of the lotteries, that is, the maximum amount they would pay to avoid the lottery altogether. As before, the amounts of credits and percentages of each outcome varied between the seven questions.

The following lotteries involve losses. Imagine you have to play these lotteries, unless you pay a certain amount of credits beforehand. What is the maximum amount you would be willing to pay, to avoid playing the lottery? This corresponds to buying an insurance that saves you from suffering potential losses.

40% chance of losing 80 credits

60% chance no loss, no win

I am willing to pay at most the following number of credits to avoid the lottery_____

Finally, a mixed lottery was presented which then asked participants to determine the number of acceptable credits that would be deemed by the participant as necessary to win, for them to decide to participate in the lottery with a 50/50 chance of losing 25 and 100 credits, respectively.

In the following lotteries, you have a 50% chance to win or lose credits. The potential loss is given. Please state the minimum amount of credits X for which you would be willing to accept the lottery.

50% chance of losing 25 credits

50% chance of winning X credits

To make the lottery acceptable X should be at least the following amount of credits:______

See Appendix for full transcript of the lottery details.

To represent Prospect Theory function, we use the classical specification of Tversky and Kahneman [5] for lotteries in gains as follows:

$$CPT = \big(1 - \omega_+(p)\big)v(A) + \omega_+(p)v(B)$$

And for lotteries on losses as:

$$CPT = \big(1 - \omega_-(p)\big)v(B) + \omega_-(p)v(A)$$

where A and B are the payoffs of the lottery (A < B), p is the probability to obtain the higher outcome B, ω± are the probability weighting functions in gains/losses, and v the value function. ω± and v are given by:

$$v(x) = \begin{cases} x^{\alpha} & for\ \ x \geq 0 \\ -\lambda(-x)^{\beta} & for\ \ x < 0. \end{cases}$$

And the standard weighting function is given by:

$$\omega_{\pm}(p) = \frac{p^{\gamma}}{\left(p^{\gamma} + (1-p)^{\gamma}\right)^{1/\gamma}}$$

with the parameter γ = γ± ∈ (0, 1] describing the amount of over- and underweighting.

The estimation of the parameters for individual subjects is a difficult task requiring a large amount of lottery questions to obtain relatively reliable results. Therefore, similar to Tversky and Kahneman [5], we therefore estimate the median answers of the subjects to derive the average of the parameters. The parameter values of α and β as well as γ– and γ+ vary from 0 to 2. We then implement a simple brut force grid minimisation of the error between the median answers and the prediction based on our model parameters and the above formulae.

3.2 Hyperbolic Discounting

To elicit the present bias or hyperbolic discounting parameters using our survey, we used a well-established method of Monetary-Choice Questionnaire (MCQ), from Kirby et al [8]. This set of trade-offs is self-administered and made up of a series of 27 monetary choice questions, one by one, used extensively in literature to derive subjective discount rates. The 27-item questionnaire provides a choice between a smaller immediate amount of money and a larger amount of money after a delay in time. For example, “Would you prefer a) $28 today or b) $30 in 179 days?” (all questionnaire items can be found in Appendix C). Participants saw instructions to make a preferential choice between two rewards shown on screen, each taken one at a time. Again, as with the Cumulative Prospect Theory choice elicitation, the units of credits were used in place of monetary rewards and described as follows prior to the 27 intertemporal choices:

> *Imagine the credits you have won in the previous lotteries are being credited to you, and in some cases, there will be a delay. You will now complete a 27-choice task; click the 'next' arrow when you are ready. As before, you are a flight dispatcher and there is a mechanism allowing airlines to swap slots amongst each other in the case of regulation. The mechanism makes use of "credits" which can be used as the currency for these swaps and might for example be equivalent to a minute of delay.*

See Appendix for full set of task's monetary choices and descriptions.

With the determined choices, we then score the set of responses in the procedure using a modelling spreadsheet which derives a value of discount rate such that responses elicit a discounting "curve", steeper for higher levels of hyperbolic discounting, and shallower curves denoting less impulsivity/present bias, according to a set of established reference curves. Note that there are two ways of scoring the questionnaire, either by a logistic regression function with individual responses, or by hand scoring to obtain an estimate of k.

Before any hypothesis testing can be performed, the raw data of the Delay Discounting Task had to be analysed to derive each participant's discount rate. This modelling is performed using Microsoft Excel based on a model created at the University of Kansas by Kaplan et al [11]. Each pattern of choice in the questionnaire implies an estimation of subjective discount rate per participant. Below is the function representing the delay discounting model used to derive subjective implicit discount rates.

$$V = \frac{A}{1 + kD}$$

Where V is the value of the delayed outcome, A the value of the delayed reward, D the time delay length and *k* the discount rate.

The value of *k* is derived such that a result in indifference between the amounts is reached (indifference *k* values provided below in Table 1). If, for instance, a participant chooses the smaller, sooner amount, this means the subjective discount rate for that larger amount is higher than the accompanying indifference *k* value (and vice-versa). Choice pattern allows a calculation of the participant's overall discount rate. As in Kirby's study, to account for inconsistency of choice, those *k* values with highest resulting consistency between k values were used. Geometric mean between *k* values were used in the event of any ties and k distributions were normalized using natural logs. Higher *k* values (and when transformed using logs, less-negative figures) suggest a preference for smaller sooner rewards, higher temporal discounting, present bias and impulsivity/lack of self-control. Indifference rates of calculated k values (the degree of discounting) for each question (i.e., when the subjective value of the immediate and delayed rewards are equivalent) are as follows:

Question	k at indifference
13	.00016
1	.00016
9	.00016
20	.00040
6	.00040
17	.00040
26	.0010
24	.0010

12	.0010
22	.0025
16	.0025
15	.0025
3	.0060
10	.0060
2	.0060
18	.016
21	.016
25	.016
5	.041
14	.041
23	.041
7	.10
8	.10
19	.10
11	.25
27	.25
4	.25

Table 1 Questionnaire Questions, and Their Associated Discount Rates (k) at Indifference

3.3 Other Measures

In addition to our two key behavioural parameters for the model calibration, we sought to additionally measure several other behavioural phenomena which are tangentially related to both prospect theory, hyperbolic discounting and overall behaviours we believe to be related to the work of a dispatcher making decisions under uncertainty within the context of air traffic management. The following sections introduce and describe these measures and how they were included in the study.

3.3.1 Risk Tolerance

Risk tolerance is a term describing the amount of risk people prefer to take when making decisions. This can apply to many contexts, for example, financial (opting to save money in a cash account, rather than investing in riskier equity markets), health related (whether to smoke cigarettes or be physically active), but also, risk tolerance determines situations or behaviours an individual will regard as risky or not (such as over- or underestimating the likelihood of experiencing a negative event). For the purposes of our survey, we have focussed on subjective overall willingness to take risk.

While previous research has found some trends in the heterogeneity of risk tolerance between individuals and groups [7], we included one specific measure to elicit this risk preference from our sample group of survey participants, to investigate whether there may be trends amongst/between individuals or subgroups of participants in their overall willingness to take risk. For this we used the German Socio-Economic Panel Study (SOEP) question [8] . This German Socioeconomic Panel (SOEP) simply measures risk tolerance using a self-reported question on a Likert scale, directly asking participants to indicate their "willingness to take risks" in general. For our survey we used the following question:

> *"Please answer the below question on a scale from Unwilling to take risks (0) to Fully prepared to take risks (10).*
>
> *Are you generally a person who is fully prepared to take risks or do you try to avoid taking risks?"*

3.3.2 Anchoring and Adjusting

When evaluating a decision or estimating a cost or benefit, the first piece of information we receive is often relied upon with disproportionate weight. This is known as "anchoring bias" and is a cognitive error when we interpret new information only from the reference point of the initial "anchor". Because this prevents an objective evaluation of any of the provided subsequent information, judgement can be skewed and cause failures to update appropriately when evaluating a decision.

This phenomenon is well-studied, robustly evidenced and, perhaps more concerningly, can be elicited by values which are entirely irrelevant to the information presented following the anchor. For example, digits of an individual's social security number used as an anchor or reference point has shown to have an impact, in some literature, on price evaluations for consumer products [14].

For the purposes of our survey study, we combined a traditional exercise in anchoring with the context change of a real-world air traffic management scenario in costing. The question was randomised such that half participants were "anchored" on a lower estimate, and half were given a higher anchor, but otherwise both scenarios were identical. Both groups were then asked to answer with an exact estimate for the proposed scenario. This arbitrary anchor, we would expect, creates an average significant difference between the two groups' estimates.

> *You are an airline manager. Imagine that you ask a colleague in ops to estimate the cost of incurring a 30-minute delay for a medium-haul flight your airline operates in Europe. This estimate is for the "first" 30min of delay and not an additional 30min after already having incurred a delay.*
>
> *You explain that you need an estimate of the cost, in order to plan how much buffer to put in your schedule* next season. They should include all passenger, crew, maintenance, and network costs.

Condition 1:

> *Do you think the colleague in ops will estimate a cost above or below EUR 1 000 per 30-min delay?*
>
> *Above EUR 1000*

Below EUR 1000

Condition 2:

Do you think the colleague in ops will estimate a cost above or below EUR 10 000 per 30-min delay?

Above EUR 10,000

Below EUR 10,000

Both Conditions:

How much do you estimate the exact cost would be in EUR per 30-min delay, when you work it out post-season?

3.3.3 Overconfidence

Overconfidence describes a bias in judgement of one's own knowledge or accuracy of knowledge and/or skill in any number of domains. It is well established in literature and leads to detrimental decision making and judgement due to subjective miscalibration of skill or knowledge and beliefs around these.

To elicit a parameter of overconfidence, commonly we ask for participants to express their confidence in either specific beliefs or when answering questions. Confidence is consistently higher than typical measures of accuracy when measured. Common parameters to elicit a measure of precision-type overconfidence involves studies in which participants are asked to indicate how precise their knowledge is by specifying a 90% confidence interval around estimates of specific quantities. We elicited this measure of overconfidence in our survey by using a three-minute time constrained set of questions for participants to provide their 90% confidence intervals (i.e. a low and high estimate between which they were 90% sure the correct answer to the question falls). And we would expect that the interval would have the answer 90% of the time, i.e. on average for 9 out of the 10 questions. What research tends to suggest is that the correct answer is actually as low as 50%, which means the band of confidence for many individuals is far narrower than their knowledge accuracy represents.

The questions used to obtain 90% confidence intervals from participants of the survey are as follows:

The following question asks you for a low guess and a high guess so that you are 90 percent confident that the true answer lies between your low guess and your high guess.

1. How old was Martin Luther King, Jr. when he died?

2. How long, in miles, is the Nile River?

3. How many countries were members of OPEC in 1989?

4. How many books are there in the Old Testament?

5. What is the diameter, in miles, of the moon?

6. What is the weight, in pounds, of an empty Boeing 747?

7. In what year was Wolfgang Amadeus Mozart born?

8. How long, in days, is the gestation period of an Asian elephant?

9. What is the air distance, in miles, from London to Tokyo?

10. How deep, in feet, is the deepest known point in the ocean?

3.3.4 Outcome Bias

Outcome bias occurs when, retrospectively, an individual evaluates the quality of a decision after the outcome of that decision is already known. We tend to determine that, rather than the process of decision evaluation, the outcome of the decision holds higher value. This is a cognitive error, because the calculation of the decision in question cannot solely be judged by its outcome as it is influenced largely by chance or by factors that are contextual or environmental (i.e. out of the decision-maker's control). Thus, the process by which a decision or conclusion has been determined is the valuable variable in assessing a decision's quality. In literature, participants are presented with hypothetical situations and asked to decide and score a decision, either given information that the decision ended in a positive or negative result and comparing the retrospective evaluation of the decision process. The decisions they are asked to evaluate are made by others (in various contexts, commonly medical, and monetary gambles) and they are given the outcomes of those decisions. When asked to rate the quality of the thinking, the competence of the decision maker, and the willingness to trust the decision maker to make a decision for the participant, the evaluation was based heavily on the outcome being presented as favourable. Even when asked, participants tend to state that they shouldn't base these judgements of decision quality on outcomes, and yet mostly they do.

For the purposes of our study, we created a context of decision-analysis of a manager's deployment of Air Traffic Flow Management. Again, messaging was randomised between 2 groups of survey participants: one had a better outcome and one had a worse outcome.

Please evaluate a manager's decision to deploy an ATFM (Air Traffic Flow Management) slot control system, on a scale from fully incorrect and unjustifiable (-3) to fully correct and justifiable (+3):

The airline is losing EUR 10 000 / day due to slot delays on an unprofitable route. Other routes are not so badly affected by delays. The slot control system could reduce these delay costs by 50% (EUR 5,000 / day). The route would then be more viable. The slot control system does not always save costs, with a 10% chance of making delays worse, and the route would have to be cut.

Condition 1:

After reviewing the data and discussing the risks, the manager recommended deploying the new system. After 4 weeks of fine tuning, it was a success, and the route continued to operate.

Condition 2:

After reviewing the data and discussing the risks, the manager recommended deploying the new system. The delays were made worse, and the route had to be cut from the network.

Both groups were then asked to evaluate the decision on a scale from -3 (fully incorrect and unjustifiable) to +3 (fully correct and justifiable).

3.3.5 Demographic Information

In addition to investigating the above behavioural concepts and ideas, we also asked the participants a number of control questions, such as gender and age which have been shown to influence decision-making and risk-taking in various contexts [7].

For the purposes of understanding the population sample as well as drawing correlational data between characteristics of participants and their behavioural measure scores and parameter results, we asked participants for some demographic and employment information:

Region

Gender

Age

Level of Education

Role in ATM

Years of Experience

The survey itself was designed using Qualtrics survey design software and data was collected fully anonymous after participants declared their informed consent to participate and the treatment of their data.

4 Parameter Calibration

Unfortunately, the response rate to our survey is at present significantly below our expectations so that we are unable to calibrate the parameters for Prospect Theory or Hyperbolic Discount based on the survey responses alone, as we had planned. Currently only one response was received from the invited participants, while we estimate that we require around at least 20 participants to be able to calibrate the parameters in a meaningful way. In order to proceed with the project, we propose the use of parameters based on previous studies and research, that will form the basis of the simulation models. While we continue working on the simulations in this and the next work package (WP5), we leave the survey open and will follow up with another reminder to distribute/complete the survey in a bid to reach a sufficient number of responses.

Specifically, in addition to re-sharing the link to survey throughout our partners and our communication channels online (LinkedIn, etc), the consortium partners have collaborated to re-word the invitation to the survey, better refining its explanation and tailoring the messaging to highlight its importance within the research of BEACON. We remind participants that these choice tasks are, while not a direct task involved in their job, an indication of their decision-making process and thus beneficial to understand. For example:

> *Whilst the survey questions are framed around generic concepts such as credit lotteries, which may appear unrelated to your duties, these are standard questions used across this field and will be mapped directly to dispatcher-related trade-offs. Please bear with the survey, answering all the questions with your preferred choices (there are no right or wrong answers).*

As soon as we reach a meaningful number of responses, we will be able to calibrate the models based on the collected data and use these parameters values for the simulations. The results of our calibration will then be reported as part of Deliverable D5.1. In the remainder of this section, we summarise some of the findings in the literature around parameter values for Prospect Theory and Hyperbolic Discounting.

4.1 Suggested Parameters Based on Literature

4.1.1 Prospect Theory

Booij et. al [9] collected and summarised parameter estimations from a number of papers using the exact same form of prospect theory function that we are using. While not all of the papers estimate all of the required parameters and some of them use a different form of probability weighting from the one use by Tversky and Kahneman [5], their paper gives a great overview of the range of parameter values as can be seen from their summary which is displayed in Figure 4. Given the popularity of the paper and that their parameters are often referenced, we suggest the use of the parameters of the initial Tversky and Kahneman [5] paper to be used in the interim while we continue to collect answers via our survey and will hopefully be soon in a position to fit our own context specific parameters.

Moreover, we do not believe that the parameter values will significantly alter the model output as long as the general properties of prospect theory are maintained. In addition, the Tversky and Kahneman [5] parameters appear to be somewhere in the mid-range of the parameter comparison thus comprising a sensible choice as interim parameters.

Functional Form	**Estimates**				**Properties****				**Authors**
Utility	α	β	λ		E.	T	I	N	
Power:*	.88	.88	2.25		md	c	n	25	Tversky and Kahneman (1992)
$U(x)=$	.22				ml	c	n	1497	Camerer and Ho (1994)
$x^{\alpha}1(x\geq 0)$	.50				ml	c	n	420	Wu and Gonzalez (1996)
	.39	.84			md	c	n	64	Fennema and van Assen (1998)
$-\lambda(-x)^{\beta}1(x<0)$	.49				md	c	y	10	Gonzalez and Wu (1999)
	.89	.92			md	c	y	40	Abdellaoui (2000)
	.61	.61			ml	b	n	2593	Donkers et al. (2001)
			1.43		md	c	n	45	Schmidt and Traub (2002)
		.97			md	c	n	35	Etchart-Vincent (2004)
	.91	.96			md	c	n	41	Abdellaoui et al. (2005)
	.68	.74	3.2		ml	b	n	1743	Tu (2005)
	1.01	1.05			md	c	y	181	Fehr-Duda et al. (2006)
	.72	.73	2.54		md	c	n	48	Abdellaoui et al. (2007b)
	.81	.80	1.07		ml	c	y	90	Andersen et al. (2006)
	.71	.72	1.38		ml	c	y	158	Harrison and Rutström (2009)
	.86	1.06	2.61		md	c	y	48	Abdellaoui et al. (2008)
Probability weights.	δ^{+}	γ^{+}	δ^{-}	γ^{-}					
TK-92:		.61		.69		c	n	25	Tversky and Kahneman (1992)
$w(p)=$		.56				c	n	1497	Camerer and Ho (1994)
		.71				c	n	420	Wu and Gonzales (1996)
$\frac{p^{\gamma}}{\left[p^{\gamma}+(1-p)^{\gamma}\right]^{\frac{1}{\gamma}}}$		.60		.70		c	y	40	Abdellaoui (2000)
		.67				m	n	51	Bleichrodt and Pinto (2000)
		.76		.76		c	y	90	Andersen et al. (2006)
		.91		.91		c	y	158	Harrison and Rutström (2009)
GE-87:	.84	.68				c	n	420	Wu and Gonzalez (1996)
$w(p)=$	.77	.69			md	c	n	40	Tversky and Fox (1995)
	.77	.44				c	y	10	Gonzalez and Wu (1999)
$\frac{\delta p^{\gamma}}{\delta p^{\gamma}+(1-p)^{\gamma}}$	.65	.60	.84	.65		c	y	40	Abdellaoui (2000)
	.82	.55				m	n	51	Bleichrodt and Pinto (2000)
			1.10	.84		c	n	35	Etchart-Vincent (2004)
	.98	.83	1.35	.84		c	n	41	Abdellaoui et al. (2005)
	.87	.51	1.07	.53		c	y	181	Fehr-Duda et al. (2006)
Prelec-1:		.74				c	n	420	Wu and Gonzalez (1996)
$w(p)=$		.53				m	n	51	Bleichrodt and Pinto (2000)
		.413		.413		b	n	2593	Donkers et al. (2001)
$\exp\left(-(-\ln p)^{\gamma}\right)$		1.00		.77		b	n	1743	Tu (2005)
Prelec-2:	1.08	.53				m	n	51	Bleichrodt and Pinto (2000)
$w(p)=$	2.12	.96			ml	m	y	80	Goeree et al. (2002)
$\exp\left(-\delta(-\ln p)^{\gamma}\right)$	1.76	1.05			md	c	y	78	van de Kuilen et al. (2009)

Notes: Adopted names and notations do not form a convention, and are used for convenience. +/– denote gains/losses.
* The utility functional is specified on the complete real axis, where λ represents the loss aversion coefficient. The displayed utility function is based on the assumption $\alpha > 0$ and $\beta > 0$, which is mostly found empirically. The function has a different specification for other parameter values (Wakker 2008).
** Properties: E(estimator): *m*ean; me*d*ian (*md*); *m*aximum *l*ikelihood (*ml*); T(task): *c*hoice; *m*atching; *b*oth; I(incentives): *y*es (random lottery incentive scheme/Becker de Groot-Marschak procedure); *n*o (fixed or no payment).

Figure 4 Empirical estimates of prospect theory using different parametric functionals [9]

4.1.2 Hyperbolic Discounting

The Kirby Delay Discounting questionnaire has been validated [16] and used consistently in measuring hyperbolic discounting in research and clinical and laboratory data show consistent correlation of hypothetical and actual rewards [17]. Myerson, Baumann & Green [18] further investigated, collected and summarised several methodologies for scoring these questionnaires to affirm the consistency of the resulting parameters. Finally, Kirby et al [8] have, in several studies, shown the stability of these measures across time and between contexts, both within populations and outside. We used the exact form of the questionnaire in our study herein to obtain our estimations for hyperbolic discounting parameters [19]. This evidence, taken together, gives us confidence in utilising the below range of parameter values from Kirby et al [20], to be used in the interim while we continue to collect answers via our survey and will hopefully be soon in a position to fit our own context specific parameters. Again, we do not believe that the parameter values will significantly alter the model output as long as the general properties are maintained.

Test–Retest Correlations Between ln(*k*) Estimates

	Test–Retest Interval					
	5 Weeks		1 Year		57 Weeks	
	Sessions 1–2	95% CI	Sessions 2–3	95% CI	Sessions 1–3	95% CI
Number of participants	81		37		46	
Mean ln(*k*)	.77	.67–.85	.71	.50–.84	.63	.41–.77
ln(*k*) for small rewards	.71	.58–.80	.71	.50–.84	.59	.36–.75
ln(*k*) for medium rewards	.75	.63–.83	.71	.49–.83	.61	.38–.76
ln(*k*) for large rewards	.66	.51–.76	.59	.33–.76	.57	.33–.73

Note—CI, confidence interval.

Within-Session Correlations Between ln(*k*) Estimates for Different Reward Magnitudes

	Reward Magnitude Pairs					
	Small–Medium		Small–Large		Medium–Large	
	Correlation	95% CI	Correlation	95% CI	Correlation	95% CI
Session 1 (n = 99)	.81	.73–.87	.79	.70–.85	.83	.75–.88
Session 2 (n = 81)	.88	.82–.92	.84	.75–.89	.92	.88–.95
Session 3 (n = 46)	.88	.78–.93	.92	.85–.95	.95	.90–.97

Figure 5. Parameter estimates of hyperbolic discounting using between and within session correlations.

4.1.3 Summary of Model and Parameter Choice

The below table summarises the suggested model formulation as well as the interim parameters to use as part of the modelling in WP4 and WP5.

	Suggested Model Formulation	Suggested Model Parameters
Prospect Theory Value Function	$v(x) = \begin{cases} x^{\alpha} & for\ \ x \geq 0 \\ -\lambda(-x)^{\beta} & for\ \ x < 0. \end{cases}$	*x* denotes the loss or gain relative to the reference point with *α* = β = *0.88* and *λ* = *2.25*
Prospect Theory Weighting Function	$\omega_{\pm}(p) = \frac{p^{\gamma}}{(p^{\gamma} + (1-p)^{\gamma})^{1/\gamma}}$	p denotes the probability of the outcome with $\gamma^{+} = 0.61$ and $\gamma^{-} = 0.69$
Hyperbolic Discounting	$V = \frac{A}{1 + kD}$	A denotes the value of the delayed reward, D the time delay length and *k* the discount rate with *ln(k) = 0.77*

Table 2 Summary of Model Formulation and Parameters.

4.1.4 Anecdotal Evidence from an Advisory Board Survey

While our current sample size for the survey is well short of the required number of participants to calibrate any of our behavioural parameters, we did also conduct a short survey with the members of our advisory board prior to our first advisory board meeting. The goal of said survey was mainly to make the advisory board members aware of potential biases, in particular, by showing them the data of the questions/tasks they had answered themselves. As such, the survey did not include the questions required to estimate the Prospect Theory or Hyperbolic Discounting parameters, it did, however, contain a few questions that are either identical to the ones in the actual survey and one question that directly relates to Prospect Theory parameters.

Loss Aversion

One of our questions in the advisory board survey is very closely related to the Prospect Theory parameters, in particular to estimate the loss-aversion parameter lambda. In the question we asked the participants the following:

Imagine that you are given the opportunity to play a 50/50 gamble whose outcome will be determined by the toss of a coin. If the coin toss comes up tails, you lose EUR 500. If the coin toss comes up heads, you win EUR 5,000. You can choose to accept the gamble, or you can choose to reject the gamble.

Out of the participants 3 (43%) reject the gamble and 4 (57%) accept the gamble, thus the three participants who rejected the gamble suffer more from losing EUR 500 than they benefit from gaining EUR 5,000. Moreover, we asked our participants to imagine a 50/50 gamble where they lose EUR 500 if the coin toss comes up tails but win a different amount if the coin toss comes up heads. The participants then indicated the lowest amount they would have to win in this gamble and yet still accept the risk. As it turns out, the average minimum gain for the bet across the participants was EUR 5,714 (the median is EUR 5,000). In other words, the loss-aversion factor is approximately **ten**, meaning that losses are ten times as hurtful as a gain of the same size is pleasant.

Contained within Prospect Theory, the phenomenon of Loss Aversion may present within the context of an agent's decision-making under conditions of uncertainty. There is a potential scenario when bidding at an auction (for an ATFM slot, for example), that an AU bids a disproportionately high amount on a slot they had previously been allocated, in order to avoid 'losing' that particular slot.

4.1.1.1 Overconfidence

4.1.1.2

Similar to the main survey, we asked the advisory board members to indicate ranges for general knowledge questions so that they are 90% confident the true answer lies within their specified range. As previously mentioned, our participants would, on average, be "well-calibrated", i.e. neither displaying overconfidence nor displaying underconfidence if 90% of the answers fall within the specified ranges. Table 3 summarises the percentage of the answers that fell within the confidence range by question and overall. As can be seen, only one third of the answers overall fell within the specified ranges. In other words, our participants were largely overconfident in the accuracy of their knowledge.

Overconfidence may present within AUs who have a greater belief that their flights will not be delayed. These agents may underestimate the likelihood of a negative event causing delay and, as a result, mis or under-allocate credits in anticipation of using these credits to provide high-priority flights with delay avoidance bids with other airlines or the network manager.

Question	Answer	Answer within range
Martin Luther King's age at death	39	43%
Length of the Nile River (km)	6650	29%
Number of countries that are OPEC members	13	71%
Number of books in the Old Testament	39-49	17%
Diameter of the moon (km)	3476	0%
Weight of an empty Boeing 747 (tons)	148-220	33%
Wolfgang Amadeus Mozart birth year	1756	43%
Gestation period (in days) of an Asian elephant	645	0%
Air distance from London to Tokyo	9590	57%
Deepest (known) point in the oceans (meters)	11,033	29%
Total		**33%**

Table 3 Results of the overconfidence accuracy for the advisory board survey.

4.1.1.3 Outcome Bias

We also asked participants for evaluation of the managers performance to measure the outcome bias amongst our participants as previously introduced by randomly assigning the favourable outcome and the not-favourable outcome to our participants. The participants who were displayed the favourable outcome evaluated the manager's decision on average with 2.00 and the participants who were displayed the less favourable outcome evaluated the **identical** decision on average as 1.67. As we see, the group with the positive outcome evaluated the decision of the manager more favourably than the decision of the manager with the negative outcome, despite all other things being equal.

Evaluating decision-making ex-post following any type of swap, trade, or “purchase” of time credit or slot may be viewed by an AU or other agent as a good decision only based on the outcome. For example, if an agent wins a bid for a favourable slot, they may mis-attribute this as a success when in reality, their process for reaching their amount for a winning bid was indeed flawed, and they overspent on the auction. The outcome was “successful” but the process by which the decision was made was flawed, and focussing only on the outcome skews the agent’s perception of the decision, and does not facilitate learning or better continued process for these decisions in the future.

5 Conclusion

The aim of BEACON is to to design new procedures to allow more flexibility to AU to steer their operations according to their business needs in case of disruption, by analysing and testing different mechanisms for extended slot swapping and use behavioural economics to understand all bias and consequences of each mechanism on the network and participants. While new market mechanisms are introduced and evaluated as part of BEACON, one novelty is the introduction of complexities of AUs' actual behaviours using behavioural economic insights.

This document introduced and defined some of the behavioural concepts that are most suited in the context of BEACON. These are in particular Prospect Theory and Hyperbolic Discounting as they are mathematically well-formulated and thus can be implemented as part of small- and large-scale simulations of WP4 and WP5. In order to calibrate the behavioural models for the specific context of ATM, we designed a quantitative survey that was sent out to a large number of AUs. Unfortunately, the number of responses remains very low and we are at present unable to calibrate the model parameters based on the responses received. To overcome this issue, we looked at the existing literature and proposed parameters to be used in the simulations, while we continue to increase the number of survey participants in a bid to be able to do our own parameter calibrations, which will then substitute the proposed parameters based on previous research. This approach will satisfy all possible scenarios going forward. For example: in the case where we do not receive sufficient responses, we can confidently proceed with the simulations using the parameters taken from existing literature. These behavioural phenomena are both well-established in research, and thus the estimates for the parameters we have chosen have a vast amount of sample data collected in studies over time. In the other case, where we *do* obtain a sufficiently large number of survey responses to calibrate our own parameter values, we will not only be able to use context specific parameters for the simulations, but we will also be able to compare the survey-calculated parameters to the existing literature, which may provide some additional insight with regards to our flight dispatcher population. Moreover, collecting our own data will allow us to evaluate if the behavioural models (Prospect Theory and Hyperbolic Discounting) are a better representation of flight dispatcher decision making than classical economic models (Expected Utility Theory and Exponential Discounting).

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Appendix - BEACON Survey

Start of Block: Consent Form

Consent **"Behavioural Economics concepts (BEACON) in Air Traffic Management (ATM) research study"**
We are part of a study team working on the SESAR Joint Undertaking funded BEACON project (under the Horizon 2020 Research and Innovation programme). The consortium undertaking the study is composed of six partners – two universities, two small-medium enterprises, EUROCONTROL and an airline (for details see https://www.beacon-sesar.eu/) We are looking for volunteers to participate in completion of an online survey to help calibrate the models that investigate the impact of decision-making by flight dispatchers and duty managers in the fleet management in cases of disruptions caused by air traffic flow management regulations. In particular, the study is looking at the feasibility of extending the user defined prioritisation process (UDPP) to allow multi-prioritisation processes e.g. encompassing departure slots, regulation slots, arrival manager slots in the management of airspace and exchange of slots between airlines. To properly capture the behaviour of flight dispatchers, duty managers or equivalent in these situations, the BEACON consortium will make use of the discipline of behavioural economics. Effects on human decision making such as risk-aversion, or attitude towards the magnitude and timing of rewards will be explored, in order to take these effects into account in the design of the new prioritisation mechanisms developed by BEACON. In order to properly calibrate the aspects and effects of behavioural economics within the daily roles of flight dispatchers and duty managers, we need your input. **Are you currently employed as a flight dispatcher or duty manager (or equivalent)? If yes, or if you have recently held a similar position (within the last five years), we would like you to take part in this survey:**
- you will be asked a number of short questions with multiple choice answers (or open questions). - you do not have to answer any questions should you choose not to, and you can skip to the next question. - we are not collecting any identifiable data which could be traced back to you as an individual. We are however requesting some information (which is optional for you to answer should you wish to) around your gender, length of time in the role, designation of role (job title selection provided by the study team), type of airline company you are or were employed with. We would like to collect this information to help us in the analysis of the data to be collected in the survey, as in the behavioural economics studies has been shown that gender may affect personal behaviour (for example, see (Guenther et al, 2021)), experience and position type may affect the quality of the answers (i.e. how close they would be to a fully trained flight dispatcher), and the airline type may have an impact on the type of operations participants are used to and thus biased towards. - you may withdraw your data as provided in this survey at any stage prior to the final question screen. If you do not click on the final arrow button, your answers will not be recorded. - all information collected will be stored securely with restricted access only to the study team who will either be

collecting or analysing the results. - information you provide will only be stored for 10 years and will remain anonymous. - the data (anonymised and aggregated) may be used in future research publications. - I understand results of the study will become available at https://www.beacon-sesar.eu/ website, but will not be shared with me individually as my contact information is unknown. - the study may not benefit me personally but will benefit the wider ATM sector. - I understand that I am not obliged to participate and my identity will remain unknown even to those collecting the results. If you have any questions about the survey or research study please **contact:** Maddie Quinlan (maddie@thisissalient.com) or Benno Guenther (benno@thisissalient.com) . If you have any complaints about the survey or the research please **contact:** Harry Charrington, Head of School,
Architechture and Cities, University of Westminster
h.charrington@westminster.ac.uk
+44 20 7911 5000 ext. 67161
Please save a copy of this information sheet for future reference about the survey and also in case of queries or complaints. Thank you for your attention. If you agree to take part in this survey, and therefore provide your consent to participate in the research study, please press choose "Yes, I want to take part." By selecting 'Yes, I want to take part.' I understand that I am agreeing to participate in the research study through the completion of this survey and that I am free to withdraw up to the point of submitting the responses by pressing the "Submit" button at the end of survey. I have understood the aim and objectives of the study and my proposed role within it, and I provide my consent in light of the information provided to me by the study team.
The survey takes about 15 minutes to complete.

○ No, I do not want to take part. (1)

○ Yes, I want to take part (2)

Skip To: End of Survey If "Behavioural Economics concepts (BEACON) in Air Traffic Management (ATM) research study" We a... = No, I do not want to take part.

End of Block: Consent Form

Start of Block: Credit description

Credit Description In the following questions we will ask you to make a number of choices based on you being a flight dispatcher. Imagine there is a mechanism allowing airlines to swap slots amongst each other in the case of regulation. The mechanism makes use of "credits" which can be used as the (non-monetary) currency for these swaps and might e.g. be equivalent to a minute to delay.

End of Block: Credit description

Start of Block: CPT Gains

*

CPTG1 Imagine you are offered the lotteries below. Please indicate the maximum amount of credits you are willing to pay to participate in the lottery:

10% chance to win 10 credits
90% chance to win 100 credits

I am willing to pay at most the following number of credits to play the lottery:

____

*

CPTG2
40% chance to win 0 credits
60% chance to win 100 credits

I am willing to pay at most the following number of credits to play the lottery:

____

*

CPTG3
10% chance to win 0 credits
90% chance to win 100 credits

I am willing to pay at most the following number of credits to play the lottery:

____

*

CPTG3
40% chance to win 0 credits

60% chance to win 10,000 credits

I am willing to pay at most the following number of credits to play the lottery:

____

*

CPTG5
90% chance to win 0 credits
10% chance to win 100 credits

I am willing to pay at most the following number of credits to play the lottery:

____

*

CPTG6
40% chance to win 0 credits
60% chance to win 400 credits

I am willing to pay at most the following number of credits to play the lottery:

____

*

CPTG7
40% chance to win 0 credits
60% chance to win 400 credits

I am willing to pay at most the following number of credits to play the lottery:

____

End of Block: CPT Gains

Start of Block: CPT Losses

*

CPTL1 The following lotteries involve losses. Imagine you have to play these lotteries, unless you pay a certain amount of credits beforehand. What is the maximum amount you would be willing to pay, to avoid playing the lottery? This corresponds to buying an insurance that saves you from suffering potential losses.

40% chance of losing 80 credits60% chance no loss, no win
I am willing to pay at most the following number of credits to avoid the lottery:

____

*

CPTL2 40% chance of losing 100 credits60% chance no loss, no win
I am willing to pay at most the following number of credits to avoid the lottery:

____

End of Block: CPT Losses

Start of Block: CPT CE

*

CPTCE1 In the following lotteries, you have a 50% chance to win or lose credits. The potential loss is given. Please state the minimum amount of credits X for which you would be willing to accept the lottery.
50% chance of losing 25 credits 50% chance of winning X credits
To make the lottery acceptable X should be at least the following amount of credits:

____

*

CPTCE2 50% chance of losing 100 credits 50% chance of winning X credits
To make the lottery acceptable X should be at least the following amount of credits:

____

End of Block: CPT CE

Start of Block: Temporal Discounting Task

HD Desciption Imagine the credits you have won in the previous lotteries are being credited to you, and in some cases, there will be a delay. You will now complete a 27-choice task; click the 'next' arrow when you are ready. As before, you are a flight dispatcher and there is a mechanism allowing airlines to swap slots amongst each other in the case of regulation. The mechanism makes use of "credits" which can be used as the currency for these swaps and might for example be equivalent to a minute of delay.

End of Block: Temporal Discounting Task

Start of Block: kirby

HD1 Would you prefer...

○ 54 credits today (1)

○ 55 credits in 117 days (2)

HD2 Would you prefer...

○ 55 credits today (1)

○ 75 credits in 61 days (2)

HD3 Would you prefer...

○ 19 credits today (1)

○ 25 credits in 53 days (2)

Q95 Would you prefer...

○ 31 credits today (1)

○ 85 credits in 7 days (2)

Q96 Would you prefer...

- ◯ 14 credits today (1)
- ◯ 25 credits in 19 days (2)

Q97 Would you prefer...

- ◯ 47 credits today (1)
- ◯ 50 credits in 160 days (2)

Q98 Would you prefer...

- ◯ 15 credits today (1)
- ◯ 35 credits in 13 days (2)

Q99 Would you prefer...

- ◯ 25 credits today (1)
- ◯ 60 credits in 14 days (2)

Q100 Would you prefer...

- ◯ 78 credits today (1)
- ◯ 80 credits in 162 days (2)

Q101 Would you prefer...

- ◯ 40 credits today (1)
- ◯ 55 credits in 62 days (2)

Q102 Would you prefer...

- 11 credits today (1)
- 30 credits in 7 days (2)

Q103 Would you prefer...

- 67 credits today (1)
- 75 credits in 119 days (2)

Q104 Would you prefer...

- 34 credits today (1)
- 35 credits in 186 days (2)

Q105 Would you prefer...

- 27 credits today (1)
- 50 credits in 21 days (2)

Q106 Would you prefer...

- 69 credits today (1)
- 85 credits in 91 days (2)

Q107 Would you prefer...

- 49 credits today (1)
- 60 credits in 89 days (2)

Q108 Would you prefer...

- 80 credits today (1)
- 85 credits in 157 days (2)

Q109 Would you prefer...

- 24 credits today (1)
- 35 credits in 29 days (2)

Q110 Would you prefer...

- 33 credits today (1)
- 80 credits in 14 days (2)

Q111 Would you prefer...

- 28 credits today (1)
- 30 credits in 179 days (2)

Q112 Would you prefer...

- 34 credits today (1)
- 50 credits in 30 days (2)

Q113 Would you prefer...

- 25 credits today (1)
- 30 credits in 80 days (2)

Q114 Would you prefer...

- 41 credits today (1)
- 75 credits in 20 days (2)

Q115 Would you prefer...

- 54 credits today (1)
- 60 credits in 111 days (2)

Q116 Would you prefer...

- 54 credits today (1)
- 80 credits in 30 days (2)

Q117 Would you prefer...

- 22 credits today (1)
- 25 credits in 136 days (2)

Q118 Would you prefer...

- 20 credits today (1)
- 55 credits in 7 days (2)

End of Block: kirby

Start of Block: SOEP General

SOEP - Timer Timing

- First Click (1)
- Last Click (2)
- Page Submit (3)
- Click Count (4)

SOEP Please answer the below question on a scale from **Unwilling to take risks (0)** to **Fully prepared to take risks (10)**.

	0 (11)	1 (12)	2 (13)	3 (14)	4 (15)	5 (16)	6 (17)	7 (18)	8 (19)	9 (20)	10 (21)
Are you generally a person who is fully prepared to take risks or do you try to avoid taking risks? (1)	○	○	○	○	○	○	○	○	○	○	○

End of Block: SOEP General

Start of Block: Anchoring

A Timer Timing

- First Click (1)
- Last Click (2)
- Page Submit (3)
- Click Count (4)

A - Text You are an airline manager. Imagine that you ask a colleague in ops to estimate the cost of incurring a 30-minute delay for a medium-haul flight your airline operates in Europe. This estimate is for the “first” 30min of delay and not an additional 30min after already having incurred a delay.
You explain that you need an estimate of the cost, in order to plan how much buffer to put in your schedule next season. They should include all passenger, crew, maintenance, and network costs.

End of Block: Anchoring

Start of Block: Anchoring Measure 1

A - 1k Do you think the colleague in ops will estimate a cost above or below EUR 1 000 per 30-min delay?

○ Above EUR 1 000 per delay (1)

○ Below EUR 1 000 per delay (2)

A - 10k Do you think the colleague in ops will estimate a cost above or below EUR 10 000 per 30-min delay?

○ Above EUR 10 000 per delay (1)

○ Below EUR 10 000 per delay (2)

End of Block: Anchoring Measure 1

Start of Block: Anchoring Measure 2

A - Exact How much do you estimate the exact cost would be in EUR per 30-min delay, when you work it out post-season?

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End of Block: Anchoring Measure 2

Start of Block: OC Timing Info

Q141
The following question, asks you for a low guess and a high guess so that you are 90 percent confident that the true answer lies between your low guess and your high guess. You have **3 minutes** to submit your answers for the item.

Please resist the temptation to look up any of the answers and submit your honest guesses. As a reminder all data will be collected anonymously so that answers cannot be attributed to you individually.

End of Block: OC Timing Info

Start of Block: Overconfidence

Q140 Timing
- First Click (1)
- Last Click (2)
- Page Submit (3)
- Click Count (4)

Overconfidence For the following items, please indicate a low guess and a high guess so that you are 90 percent confident that the true answer lies between your low guess and your high guess.

	Low Guess (1)	High Guess (2)
How old was Martin Luther King, Jr. when he died (in years)? (1)		
How long is the Nile River (in km)? (4)		
How many countries are members of OPEC? (5)		
How many books are there in the Old Testament? (6)		
What is the diameter of the moon (in km)? (7)		
What is the weight of an empty Boeing 747 (in metric tonnes)? (8)		
In what year was Wolfgang Amadeus Mozart born? (9)		
How long is the gestation period of an Asian elephant (in days)? (10)		
What is the flight distance from London to Tokyo (in nautical miles)? (11)		
How deep is the deepest known point in the ocean (in meters)? (12)		

End of Block: Overconfidence

Start of Block: Outcome Bias

Q71 Please evaluate a manager's decision to deploy an ATFM (Air Traffic Flow Management) slot control system, on a scale from fully incorrect and unjustifiable (-3) to fully correct and justifiable (+3):   The airline is losing EUR 10 000 / day due to slot delays on an unprofitable route. Other routes are not so badly affected by delays. The slot control system could reduce these delay costs by 50% (EUR 5,000 / day). The route would then be more viable.   The slot control system does not always save costs, with a 10% chance of making delays worse, and the route would have to be cut.

End of Block: Outcome Bias

Start of Block: Outcome Bias Measure

Q72 After reviewing the data and discussing the risks, the manager recommended deploying the new system. After 4 weeks of fine tuning, it was a success, and the route continued to operate.

	-3 (2)	-2 (3)	-1 (4)	0 (5)	1 (6)	2 (7)	3 (15)
How do you rate the decision? (1)	o	o	o	o	o	o	o

Q73 After reviewing the data and discussing the risks, the manager recommended deploying the new system. The delays were made worse, and the route had to be cut from the network.

	-3 (1)	-2 (2)	-1 (3)	0 (4)	1 (5)	2 (6)	3 (7)
How do you rate the decision? (1)	o	o	o	o	o	o	o

End of Block: Outcome Bias Measure

Start of Block: Demographics Base/Universal

Q88 Finally, please answer a few questions about yourself.

Q137 In which region are you located?

- Europe (1)
- North America (2)
- Asia (3)
- South America (4)
- Australia (5)
- Africa (6)
- Antarctica (7)

Q91 What is your gender?

- Male (1)
- Female (2)
- Other (3)
- Prefer not to say (4)

Q89 What is your current age?

- 18 - 24 (1)
- 25 - 31 (2)
- 32 - 38 (3)
- 39 - 45 (4)
- 46 - 52 (5)
- 53 - 59 (6)
- 60+ (7)

Q90 What is the highest level of school you have completed or the highest degree you have received?

- Less than high school degree (1)
- High school graduate (high school diploma or equivalent including GED) (2)
- Some college but no degree (3)
- Associate degree in college (2-year) (4)
- Bachelor's degree in college (4-year) (5)
- Master's degree (6)
- Doctoral degree (7)
- Professional degree (JD, MD) (8)

Q104 What best describes your role within flight dispatching (either in your current position or a previous position you held for 5 or more years in the past)?

- ◯ Flight planning (1)
- ◯ Slot management (2)
- ◯ Mission support (3)
- ◯ Shift leader dispatch (4)
- ◯ Back office (5)

Q135 How many years of experience do you have in flight dispatching?

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Q143 Please share with us any comments you may have with regards to this survey.

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Q142 This is the end of the study. Please click the final "next" button to complete the study. Thank you for your participation.

End of Block: Demographics Base/Universal