Draft

MINISTRY OF HEALTH
MANATŪ HAUORA

Using Bluetooth Technology in Contact Tracing

Ministry of Health
2nd November 2020

Jon Herries – Data & Digital

Draft

Contents

Draft

Executive Summary

The purpose of this document is to build and share a common understanding of how Bluetooth technology and digital data could be integrated into the National Contact Tracing System and the Contact Tracing process.

The document describes the current processes and systems in place along with the strategic direction provided by Cabinet. This is then complemented with the intent of the programme along with a summary of current evidence and intelligence from researchers and other jurisdictions.

This suggests we should consider Bluetooth as an aid to contact tracing rather than a replacement. This is largely due to the known technical limitations of the technology.

Coverage is fundamental to how the solution can support contact tracing, however the amount of coverage should be considered as supplement to the existing process and other controls such as QR codes and third party data, rather than in isolation.

A key question to be answered is the impact of this on the number of people managed in an outbreak. Rates of notifications for different settings in other jurisdictions appear to be driven by coverage, population density, the signal thresholds, time thresholds and the volume of social interactions (affected by lock downs).

Next, there are some key differences between a centralised and de-centralised model. In a centralised model, the relationships between the case and close contacts is known to the contact tracer, potentially exposing illegal acts, immoral behaviours or situations of deprivation. Exposing these may reduce participation in groups that have low trust of government. The alternate model leaves revealing the relationship in the hands of the contact. This relies on the contact participating in the contact tracing process.

As a part of the work a conceptual model has been developed to help understand the components that influence and drive the use of digital data. This highlights four aspects:

1. **Context** – understanding the outbreak, case and exposure event of interest are important when using the data
2. **Constraints** – a number of constraints need to be worked within to ensure that the notification doesn't cause more problems than it solves
3. **Risk stratifying** – understanding how we stratify groups is important as this helps us define who receives which message and call to action
4. **Messages and calls to action** – given the context and constraints, there is a need to understand effectiveness and participation when messages are determined.

Implementation planning needs to consider that this is a new tool for contact tracing. The document describes some key processes and initial settings for an EN implementation – should that proceed. Consideration has been given to MoH policy and the governments algorithm charter when implementing a system such as this.

These considerations have been summarised into three principles for implementation with an operational governance group to review the use of the system through implementation in order to minimise risk and maximise the benefit to New Zealand. These principles are:

1. Use an Active Learning approach to ensure that we learn from using the system
2. Start from a manual process before automating
3. Start from conservative settings before choosing more aggressive settings

Draft

Background

MINISTRY OF HEALTH
MANATŪ HAUORA

Draft

Data & Digital Problem Statements - grouping the problems

This shows the different business problems identified by Data and Digital as a part of the COVID-19 Response. The highlighted pieces show how interconnected these problems are when considering digital technology to support contact tracing.

Public and whanau

Providers

Policy Makers

Communications

- 1. How do we communicate better with the public?
- 2. How do we communicate better with health workers?

Intelligence

- 3. How can we get patients to collect data for us?
- 4. What are the privacy implications of sharing data in this situation?
- 5. How do we collect the right data to plan well?
- 6. What do we do to analyse the data?
- 7. How do we share information more about hospital demand/capacity

Managing patients effectively

- 8. How do we more effectively manage initial triage for the system
- 15. How do we know the contact tracing has been completed
- 9. How do we get more virtual care in the health system
- 10. Where do the lab tests go?
- 11. Where does the self-isolation data go?
- 12. How do we collect data from the CBACs?

Coordination

Supply Chain workstream

- 13. What do we need to do to secure the supply chain for technology (new and maintenance)

Out of scope

- 14. How do we manage the process of NHCC more effectively?

WHO Pandemic Planning Guidance

Draft

What is the role of Technology?

No one solution will let New Zealanders confidently be a part of society while also ensuring we maintain our independence and freedoms.

We need to consider that there are a number of technology actions that together will provide us confidence that we can enter a new normal for society.

Our approach to technology considers that:

1. Just because we can use technology to solve a problem doesn't mean we should
2. We should be thinking about how we deliver in line with our long term strategy
3. If we come out of this without foundational components that can be reused – we have missed out
4. We should be thinking about good, better and best, probably in parallel.

The operational response for Data and Digital, including in this programme will conform to these expectations.

Strategy

Digital Health Strategic Framework	We are building an interoperable ecosystem

Cabinet Principles

Public Health efficacy	Respect for Privacy	Freedom of movement	Technical Feasibility & data access
Our efforts need to make our Public Health response more effective	Our efforts need to build trust with our communities, not erode it	Our goal of a recovering economy relies on maintaining this	We need solutions that can scale quickly and work together

Delivery

Value for Money	Our options need to conform to tax payer's expectations
Capacity & Capability	We need to deliver the solutions using the right people in the right order
Creating reusable assets	Minimise regretful spend

Draft

COVID-19 Business Functions

This shows the different business functions currently in place or in development for the COVID-19 response along with who operates them.

	Pre-Border	Border Management	Community
	Health Declaration; MIQ Booking; **Triage Change of Policy and Compliance**	Border Entry Management; **Exemption Application Management**; Quarantine/ Isolation Management	Health and COVID Information and Advice; **Public Daily Symptom Checker**; **Exemption Application Management**; Self-Isolation Management
Testing	**Pre-arrival**	Border Staff Test Surveillance; MIQ Testing	PHU; General Surveillance; Hospital; Primary Care
	Ordering; Recording	Logistics; Results	Follow up
Vaccination	Pre-Border Check	Border Delivery	Hospital Delivery; Primary Care Delivery; Outreach Delivery; General Walk up
	Ordering; Recording	Logistics	Follow up

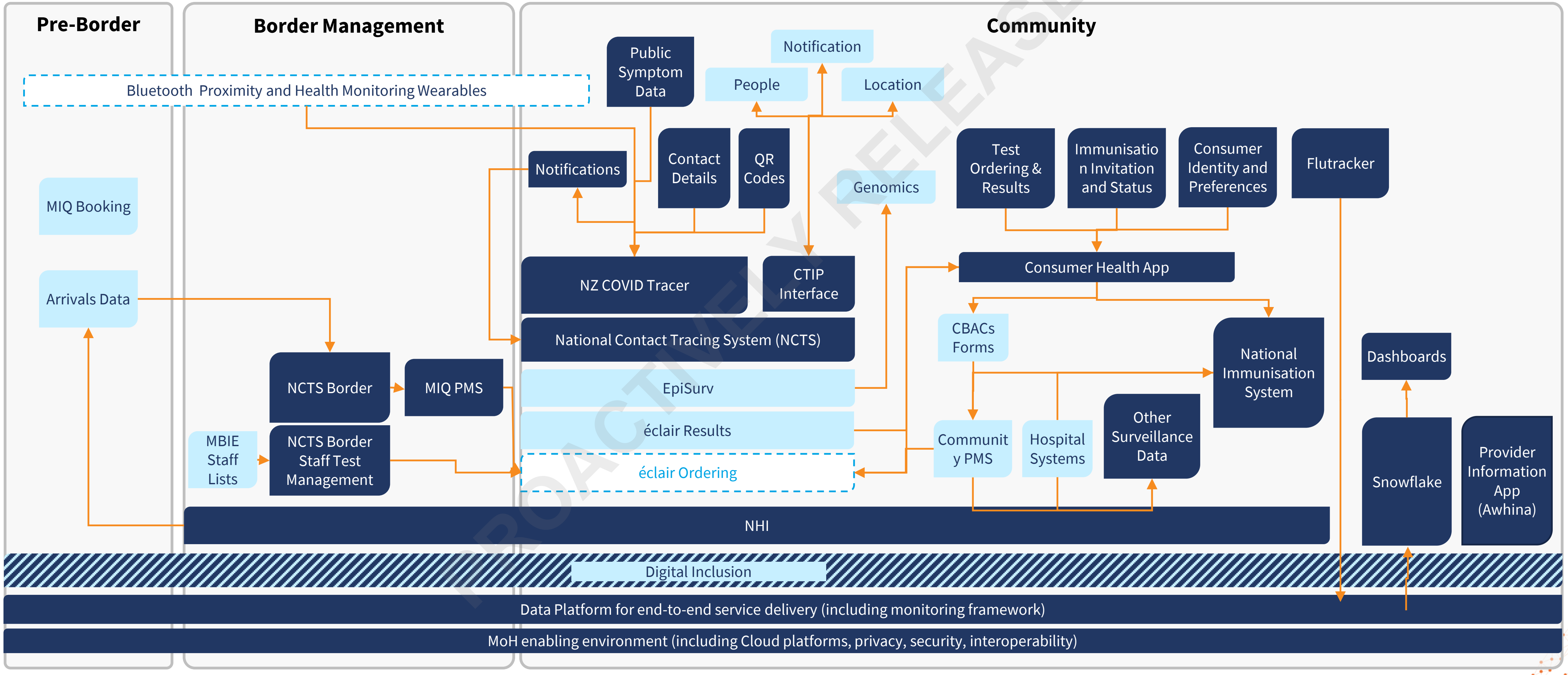
Contact Tracing	Initial Contact with Case	Case Interview	Close Contact Identification, Triage and calls	Cluster Creation	Daily Health Check
Third party data	Iwi Data	Transport Data	Other Data		
Healthcare & Social Services	Hospital Services	Primary Care	Mental Health & Addiction	Whanau Ora	Community Services
Records	Person Identification	Records Management	Data Sharing		
Public Health Services	Disease Surveillance	Performance Monitoring	Analytical Projects		
Response Coordination	AoG Collaboration	COVID Directorate	Ministerial Oversight	Health system collaboration	Public Communications

Function – Operated in collaboration; Function – Operated by MoH; Function – Operated by the sector; **Function** – Under development

Draft

COVID-19 Digital & Data Landscape

This shows the current state of technology solutions for the COVID-19 Data & Digital response.



Draft

Framework for Digital Contact Tracing Data

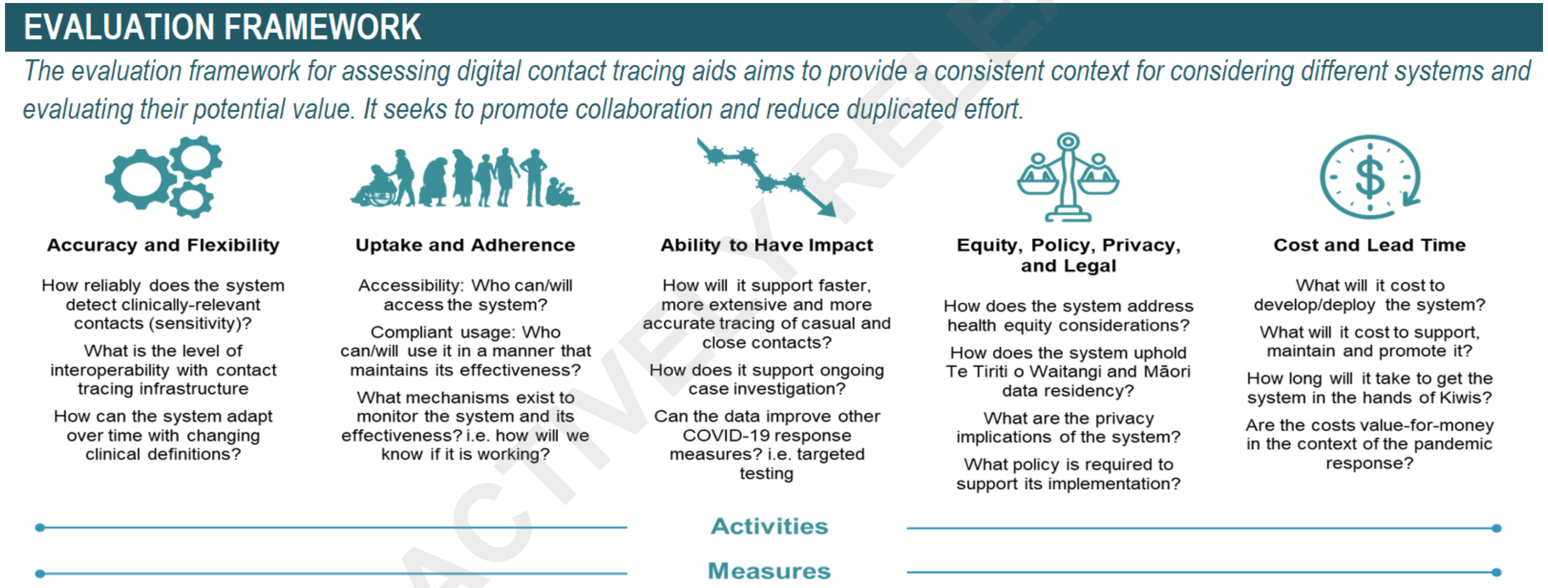
MINISTRY OF HEALTH

MANATŪ HAUORA

Draft

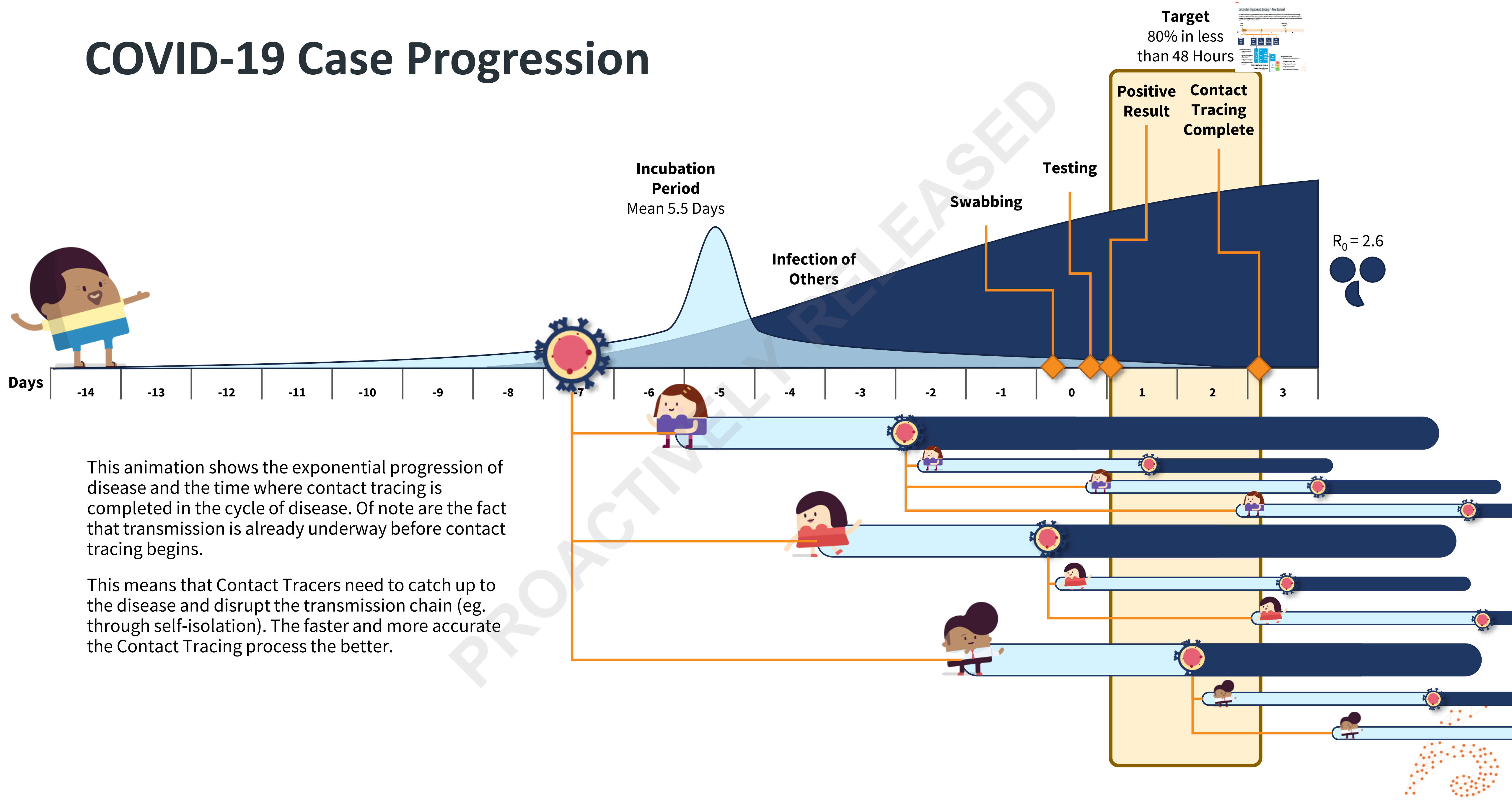
Programme Approach to Digital Contact Tracing

The intent of this document us to describe digital contact tracing sources and what to do with this data when it is collected. This shows the evaluation framework for the programme and the key questions and actions being undertaking in the context of improving contact tracing. There are other elements of the programme that relate to the performance and feasibility of technology that aren't covered in this document.



Questions	What are peoples intentions?	What are peoples actions?	How do we use this information?
Actions	Survey and Panel Groups	• Recruitment Questionnaire • Use of wearable • Collecting data from the wearable and/or app • Case investigations to go with the data • Close out questionnaire	**Scenario planning and modelling using data, technical and clinical experience**

COVID-19 Case Progression



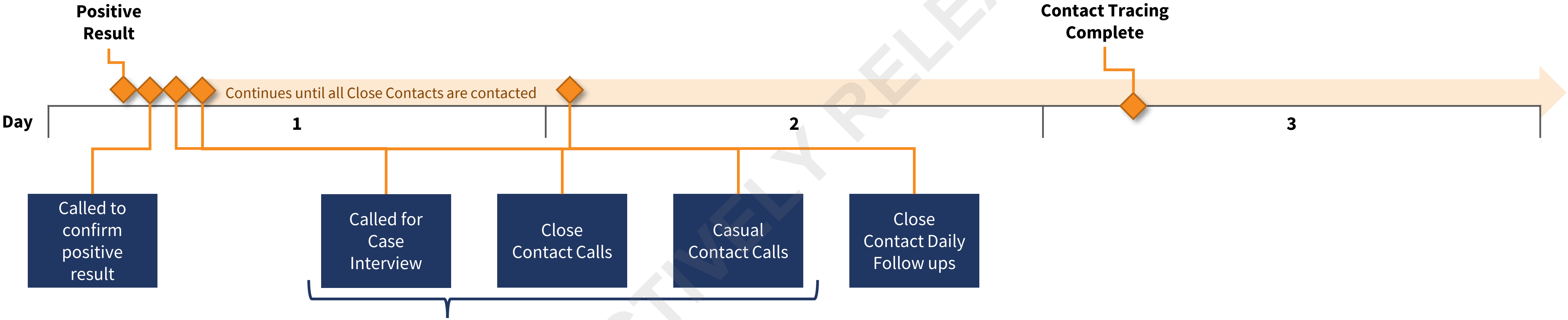
This animation shows the exponential progression of disease and the time where contact tracing is completed in the cycle of disease. Of note are the fact that transmission is already underway before contact tracing begins.

This means that Contact Tracers need to catch up to the disease and disrupt the transmission chain (eg. through self-isolation). The faster and more accurate the Contact Tracing process the better.

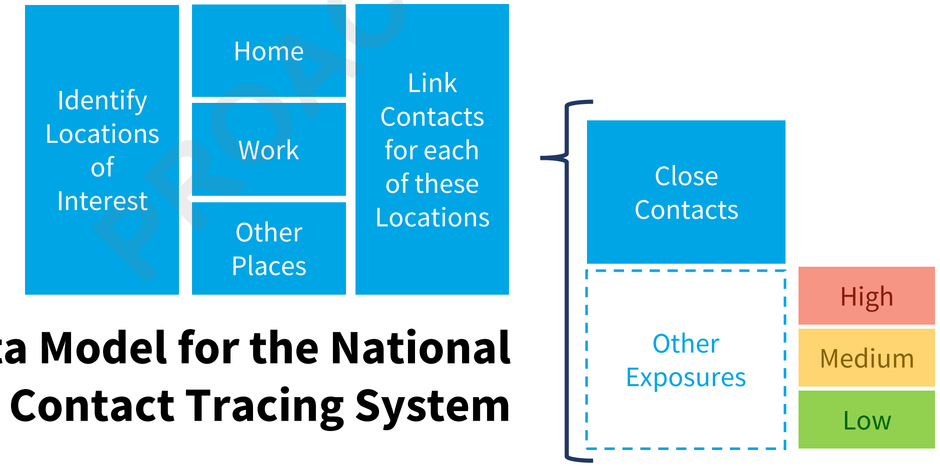
Draft

Understanding contact tracing in New Zealand

This shows how the contact tracing process works, the conceptual data model used for contact tracing and the business problems often associated with collecting this data. This should inform the solutions for improving contact tracing. Of note the information is collected as a consequence of a case interview. These technologies can supplement a case interview – particularly in order to help find places and people to contact, but the case interview seeks to identify risk, connections to other cases and high risk areas for investigations (ie. Exposure Events).



Business Problems - Locations
- Finding the places you don't remember
- Consistently identifying locations or Exposure Events
- Identifying locations of high risk
- Connecting people to a location-based cluster



Data Model for the National Contact Tracing System

Business Problems - People
- Getting in touch with people (contact details)
- Minimising duplication of people
- Finding people you don't remember
- Finding people you don't know
- Increasing speed of isolation/testing cycle

Understanding different technologies

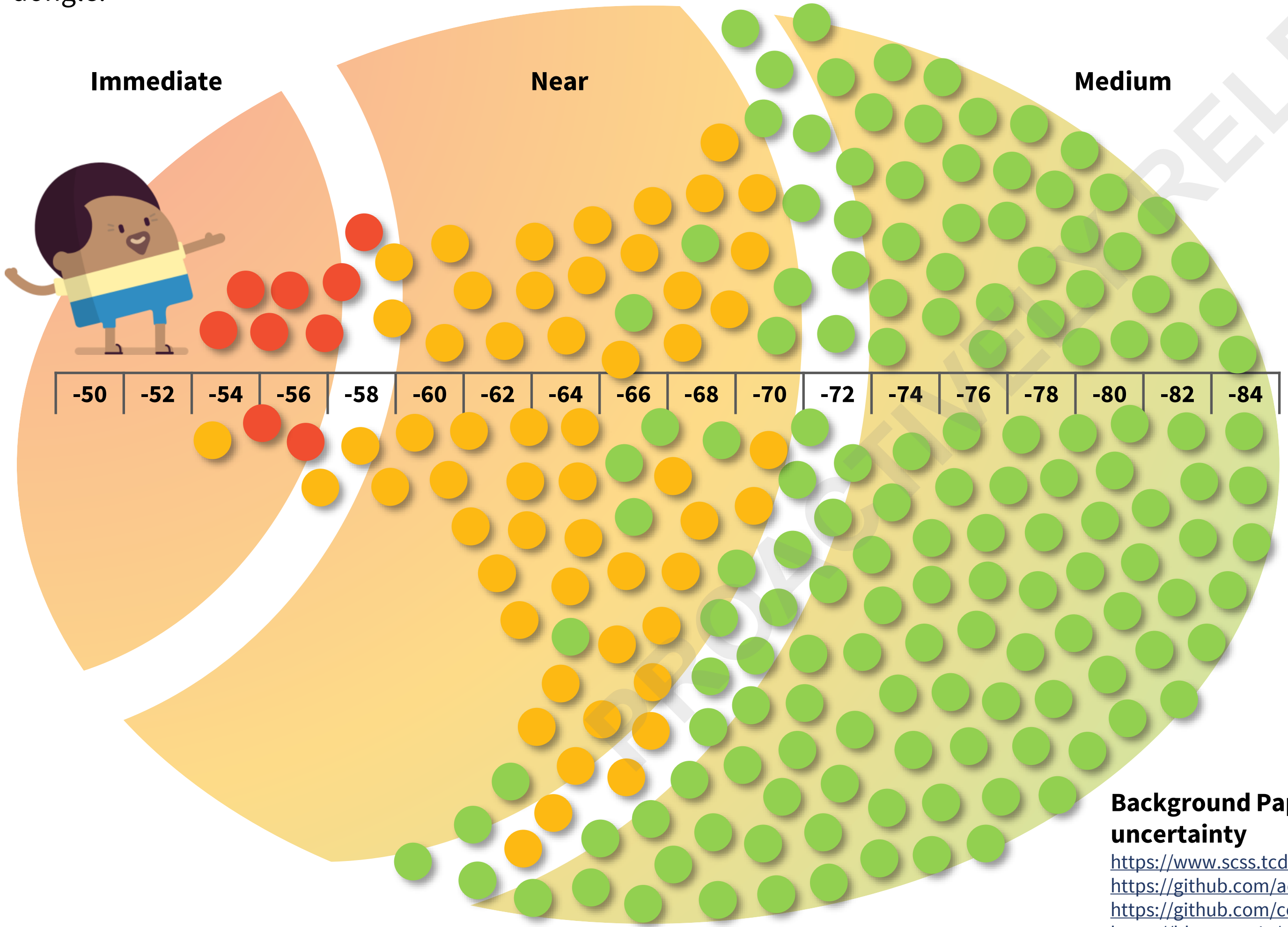
This shows the different types of potential technology that could be used for Digital Contact Tracing. Data models are of interest – particularly centralised vs decentralised, with decentralised models being less open to potential abuse.

	Bluetooth	GPS	Self-Report	Bluetooth Beacons	Third party data	Wifi	UWB	QR Code	Mobile Network	NFC
Key Description	Uses signal strength to measure how far apart users are	Uses GPS satellites to provide a location of the individual	People collect information in their normal way about who they go near and where they go	A beacon broadcasts a code identifying a location that is collected by a user	Allows users to contribute their existing data from other sources or be notified from other sources	Allows automatic check ins and detection of visitors	Passive collection of proximity. Uses time of flight to measure distance between users	Scanning a code results in a standardised record to create a history of visits	Data about phone locations collected by mobile network operators	A tags broadcasts a code identifying a location that is collected by a user
Collects	Proximity	Location - physical	Proximity & Location - physical & virtual	Location – physical & virtual	Location – physical & virtual	Location – physical & virtual	Proximity	Location – physical & virtual	Location – physical	Location – physical & virtual
Benefits	Doesn't record location	Passive if collected	Private except for asking stangers for their details	More passive than scanning a QR code	Low Cost Passive	Low cost Passive	Good at proximity & location with beacons	Low cost		Low cost
Risks	Accuracy Coverage Participation Privacy	Battery Significant Privacy risks Resolution & accuracy	Poor accuracy, consistency and participation	Potential privacy risks if these collect and broadcast	Potential privacy risks	Potential privacy risks if these collect and broadcast	Availability Cost	Participation is required	Resolution Significant Privacy risks	Faster than QR Codes
Examples	COVIDCard Exposure Notification (EN)	Google Maps History	Paper diary Existing phone calendar	Rippl – POC	CTIP	https://www.wired.com/brandlab/2018/06/whos-sniffing-public-access-wi-fi/	NIghtingale	NZ COVID Tracer	Ventures – population density/flow	Under investigation by MoH

Draft

Understanding what Bluetooth data looks like

A Bluetooth digital model collects information about what other devices are nearby and for how long. It uses signal strength to estimate distance. This has some risks and issues associated with the fact that Bluetooth was designed to make connections and transfer data, not measure distance. Google and Apple have developed an ENF model that is available on smart phones to share these connections between devices, but a wearable can be used instead as Bluetooth is an open specification and the chipsets are openly available. A model like this has been implemented in Singapore where they supplement data from their Trace Together app with a custom built dongle.



From Google ENF Documentation – Proximity Estimate

- Lower attenuations indicate stronger Bluetooth signals
- **Very low values** indicate short distances
- **Larger values** can be caused by:
- Type of phone cover
- How it is being held
- Device in a pocket or bag
- Longer distances
- Other factors

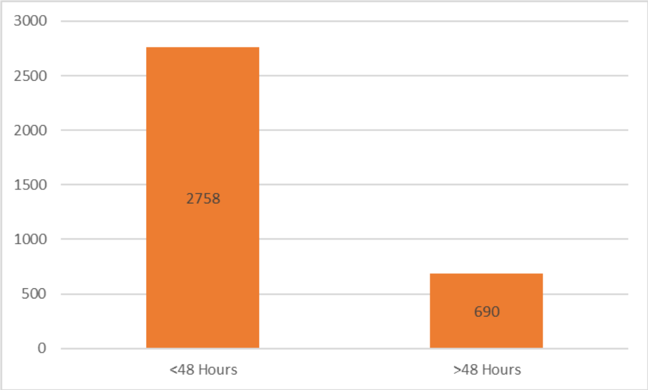
Background Papers on the use of Bluetooth to measure distance – all suggest significant uncertainty

https://www.scss.tcd.ie/Doug.Leith/pubs/bluetooth_rssi_study.pdf
https://github.com/admin-ch/PT-System-Documents/blob/master/SwissCovid-ExposureScore.pdf
https://github.com/corona-warn-app/cwa-documentation/blob/master/2020_06_24_Corona_API_measurements.pdf
https://bluetrace.io/static/bluetrace_whitepaper-938063656596c104632def383eb33b3c.pdf

Draft

Understanding how coverage affects digital methods

Our current contact tracing system is designed to find close contacts within 48 hours. In the Auckland outbreak, shown in the graph below, this meant 2,758 close contacts needed to be found within 48 hours to reduce the R0 below 1.

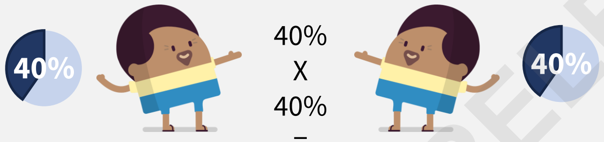


This means, we need to consider how a digital technology will create two benefits:

1. Speed up the finding of all close contacts – reducing time from identification to self-isolation.
2. Finding those who can't be found easily – this is likely to be a small percentage of those identified when surveillance testing is considered.

High coverage of a digital solutions can help us improve performance in both of these problem domains.

A model for considering how likely it is to find contacts using digital sources is a simple quadratic equation. For example with 40% coverage, each party to the interaction has a 40% chance of interacting.



16% likelihood of an interaction

This suggests growing coverage increases the likelihood of interaction, with small increases above 50% coverage growing interaction likelihood much more than coverage below 50%. This simple model discounts two key considerations:

1. The use of digital tools is lumpy due to distribution of the population and cultural/social groups being subject to clustering through consensus bias (ie. people tend to spend time with people they agree with).
2. That there is already a contact tracing model, that finds individuals to get them to self-isolate.

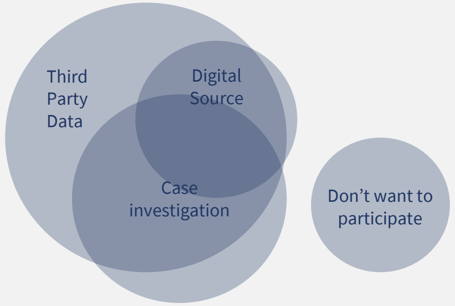
There is some evidence that this effect is already being seen in other jurisdictions with low coverage (Swiss reporting on outcomes). **

In order to understand the impact of coverage on contact tracing, we need to consider the two benefits. The first as described is the impact of finding those who otherwise weren't found.
If we assume that a case investigation can find 80% of people (the target), there are 20% of people who will be need to be found using other means. There are probably has two root causes to why contacts aren't found:

1. They didn't know they were at risk;
2. They don't want to be found.

If we discount the second group (could be up to 10%), the first best option is to alert people that they might be at risk using digital tools (we already publicise places of high risk).

If coverage at 40% is assumed (with the caveats described), the maximum we would add with digital methods is 1.6% - assuming there isn't any overlap with those already identified. This doesn't consider those who would also be found using third party data sources (under investigation by the Ministry).



** https://github.com/digitalepidemiologylab/swisscovid_efficacy/blob/master/SwissCovid_efficacy_MS.pdf
https://www.technologyreview.com/2020/06/05/1002775/covid-apps-effective-at-less-than-60-percent-download/
https://www.technologyreview.com/2020/09/02/1007947/coronavirus-contact-tracing-apps-save-lives-low-15-percent-adoption-rates/

Understanding time to notification of close contacts

The second impact of digital contact tracing would be on the speed to notify those of interest to the case investigation. Currently, this involves a largely sequential process where each close contact is called, and then asked to take specific actions based on their risk of exposure.

As described in previous pages, the time from exposure to starting contact tracing means that a number of transmissions has already occurred, and the intent of the contact tracing process is to catch up to the virus and ring-fence those affected.

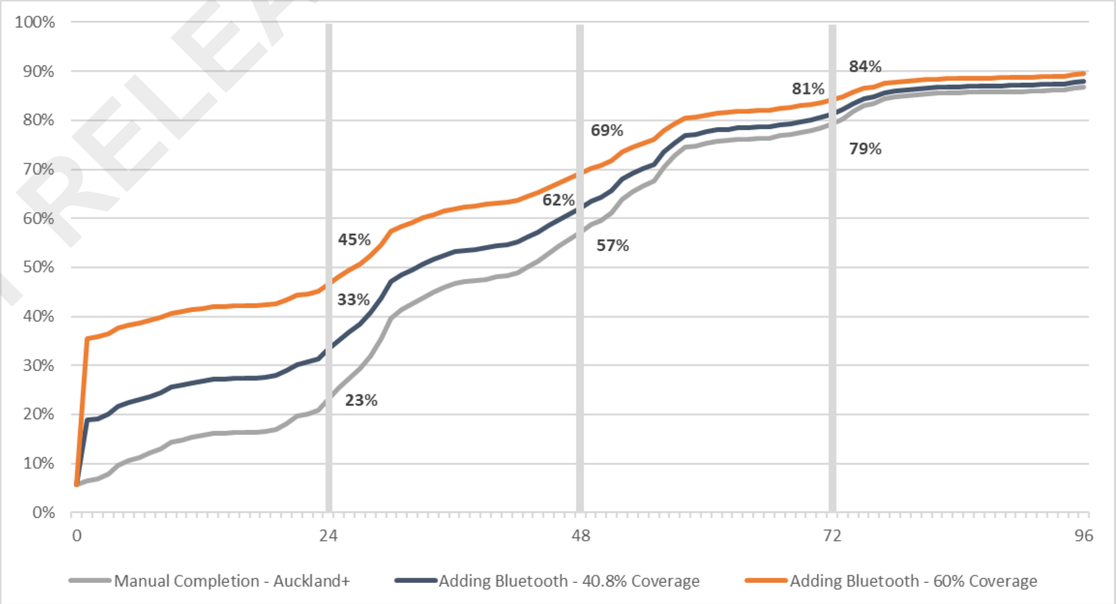
Reducing the time taken to notify close contacts is an opportunity to improve the contact tracing process, due to the need to stop continued infection of people in the community in an outbreak.

As described on the previous page, this is very sensitive to coverage and this can be seen in the profile change to the close contact call timelines seen in the Auckland outbreak.

From the original profile, we have identified two scenarios, consistent with the notification model identified further in the document, with coverage at 41% and with coverage at 60%.

This increases performance in the first 24 hours significantly by approximately 10%. This is reduced to a 5% benefit after 24 hours and a 2% benefit at 72 hours.

Number of Close Contacts Reached by Hour



Note while this appears similar to operational performance reporting, there are a number of key differences between these datasets:

1. This includes

Draft

Understanding notification volumes - conceptual

Singapore

- 1100 contacts in 21 days in Singapore on average
- At the time population coverage was at 25%
- Current Population density is 8358 km^2

NZ Model for Notifications

- Our density is significantly lower and much more variable between places
- Our current uptake is much higher (44%)
- There is further behavioural consideration in terms of likelihood of movement etc.
- There is little variability in settings by different countries with ENF.

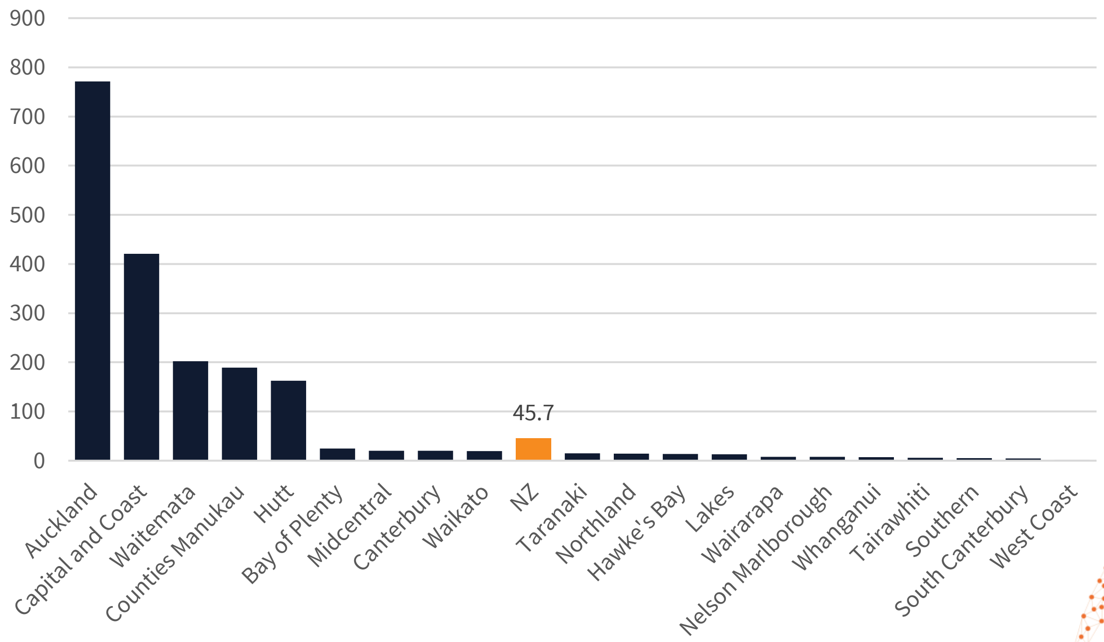
Actions

- Understand the impact on the variables on controlling the numbers notified
- Understand some more about the average number of contacts and variability from Singapore
- Utilise data from our open trial

ENF – signal thresholds by country

Country	Immediate	Near	Medium
German	55	63	70
Swiss	55	63	
Ireland	56	62	70

Population Density NZ - 2018



Draft

Understanding digital data types/elements

This shows the different types of data that is available in different models (centralised and decentralised) for Digital Contact Tracing and includes location data (GLN bound) and proximity data from Bluetooth.

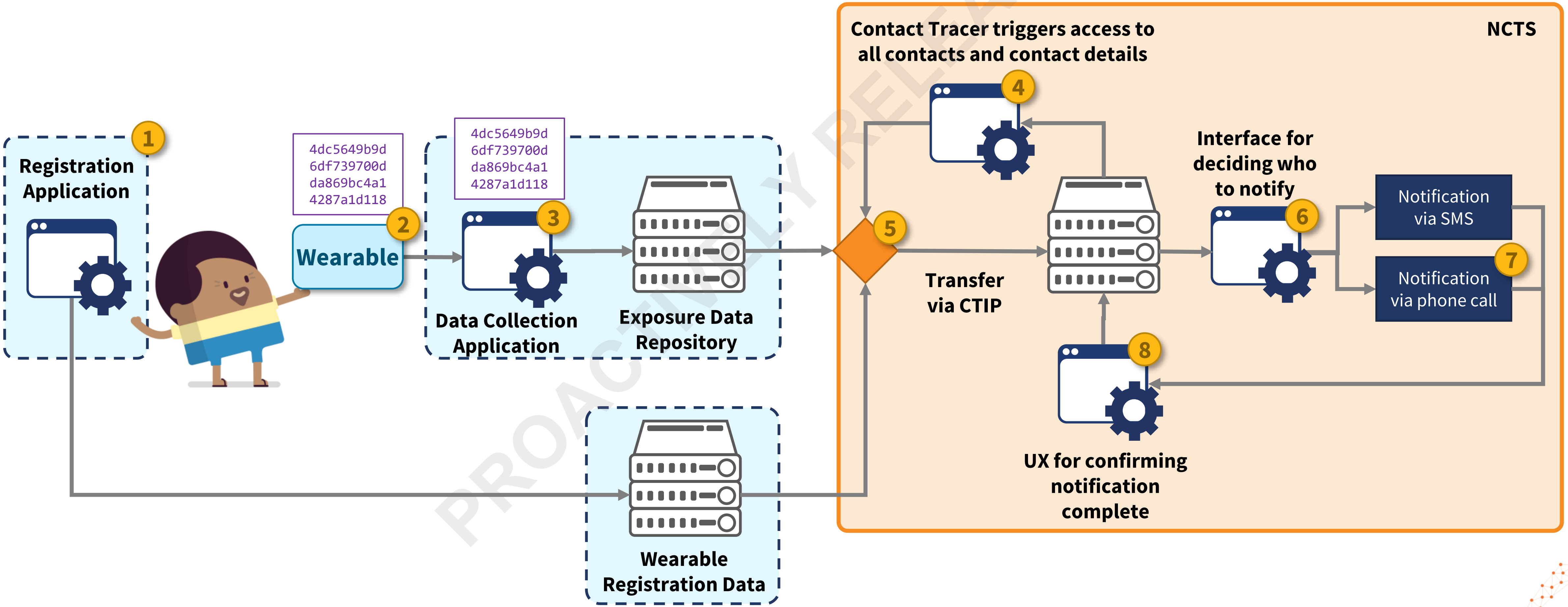
Data Item	Description	Centralised Wearable model	ENF (v1.6)	ENF Wearable (v1.6)
Daily/Proximity Keys	Represents the case on the given period and this is what is used to derive what it shared with other people	Get the keys of contacts	Get the keys from the case	Get the keys from the case
Daily Key Weighting	Allows infectious period to be weighted higher	Calculated from symptom onset	Calculated from symptom onset	Calculated from symptom onset
Length of Contact	Measuring how long the case and contact were together	We collect this from Case – is a summary	Blind – held by contact	Blind – held by contact
Proximity Estimate	Signal strength between case and contact	We collect this from Case – is a summary	Blind – held by contact (average and minimum)	Blind – held by contact (average and minimum)
Proximity Weighing	Categorisation of proximity based on signal thresholds	Set by us	Set by us	Set by us
Calibration Confidence	Used to account for differences in antenna and source signal strength between different device types	Not required (all devices are the same)	Provided by Google/Apple based on the phone	Provided by Google/Apple based on the wearable
Continuity of Contacts*	A sampling and smoothing method to increase confidence in measuring actual distance	Would be post-hoc	Could be provided on the phone	Could be provided on the linked phone
Location of Interest	A GLN that represents the location, is embedded in a QR code at present	N/A	N/A	N/A
Time Period of Interest	The time a person was at a location	N/A	Could be linked to Bluetooth risk score	Could be linked to Bluetooth risk score

* Source: https://www.turing.ac.uk/blog/updates-algorithm-underlying-nhs-covid-19-app

Draft

A simplified application architecture – Centralised

This shows how the application components come together in a centralised digital contact tracing model.



Owner and development would need to be identified if this model proceeds to production

A community user story - Centralised

This describes the story for a user with a centralised system and how this works in real life. The story is similar to the Centralised Model with the differences between the models identified in the story.

Jack and his Whanau
Jack has organised a set of wearables for his whanau. They don't all have phones (particularly some of the tamariki and his nana). His whanau take them when the kids go to the Kura Kaupapa and when they go to the shops or to the marae. Jack scans the QR codes because he knows he has to remember where he been, not just who he has been near.

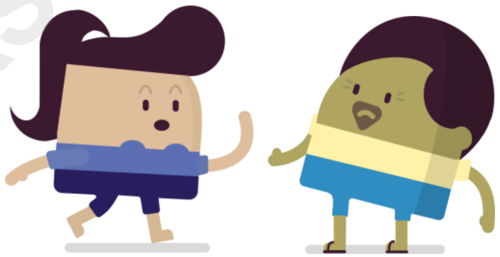
Jack doesn't feel well
Jack gets tested for COVID and uploads his data from his app and his wearable just in case he tests positive.

Jack has COVID-19
Jack gets a call from his doctor that confirms his test has come back positive. His doctor tells him that the Contact Tracers will be ringing him soon.

The Contact Tracer rings Jack
It is great that Jack has been scanning where he has been and has wearables for his whanau.

He tells the Contact Tracer Jill that his wife had been away for a work trip when he was most infectious, and she is able to stay away from home because she is pregnant.

The data from his wearable has been matched to all the people his wearable has seen and they can see his close contacts (his whanau) match those from his recollection.



The Contact Tracer finishes their investigation
Jill helps Jack remember seeing a number of extended whanau members who have a different wearable that didn't show up in his records. They also identified a number of people from work who use their phones rather than a wearable.

Jill notices in the data from his wearable that his wife's wearable was in close contact with him when she was on her work trip. The Contact Tracer suggests that maybe she forgot it when she went away, but Jack is sure she didn't.

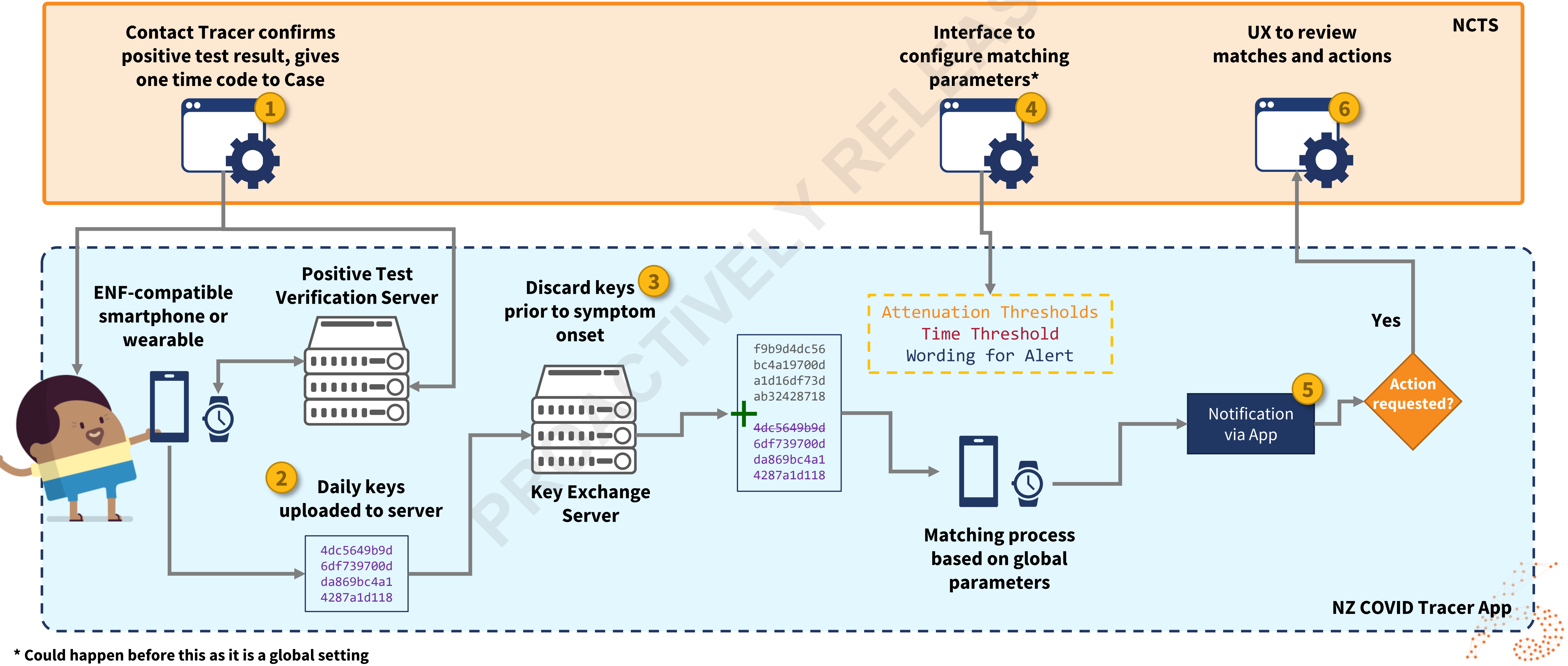
Jack remembers that after telling his wife to remember her one he forgot his one day she was away. He wants to know what she was doing home that day. He gets angry at his wife because there shouldn't have been a reason for her to be home and not have told him, and she is reluctant to tell him why she was there.

It turns out she was there talking to a party planner. Jack is 40 next week and they were planning a big surprise for him.

Draft

A simplified application architecture – Decentralised

This shows how the application components come together in a decentralised digital contact tracing model.



* Could happen before this as it is a global setting

Draft

A community user story - Decentralised

This describes the story for a user with a decentralised system and how this works in real life. The story is similar to the Centralised Model with the differences between the models identified in the story.

Jack and his Whanau
Jack has organised a set of wearables for his whanau. They don't all have phones (particularly some of the tamariki and his nana), he registers them on his phone.
His whanau take them when the kids go to the Kura Kaupapa and when they go to the shops or to the marae. Jack scans the QR codes because he knows he has to remember where he been, not just who he has been near.

Jack doesn't feel well
Jack gets tested for COVID.

Jack has COVID-19
Jack gets a call from his doctor that confirms his test has come back positive. His doctor tells him that the Contact Tracers will be ringing him soon.

The Contact Tracer rings Jack
It is great that Jack has been scanning where he has been and has wearables for his whanau.

He tells the Contact Tracer Jill that his wife had been away for a work trip when he was most infectious.

Jill decides that Jack has been near a number of people recently and, can't remember all of them, and she isn't sure how many there are. She collects the handshakes from his phone and broadcasts them out to all the compatible wearables.

The Contact Tracer finishes their investigation
Jill helps Jack remember seeing a number of extended whanau members, these people get a notification on their phones. The notification also identifies a number of people from work who use their phones rather than a wearable. They are asked to call the Contact Tracing team.

Jacks wife gets a notification on her phone because she was home organising Jacks 40th birthday party. She was supposed to be away for work but was meeting a birthday planner at home. She remembers see his wearable next to the bed while she was home and realises that while he wasn't there she would have been pinged.

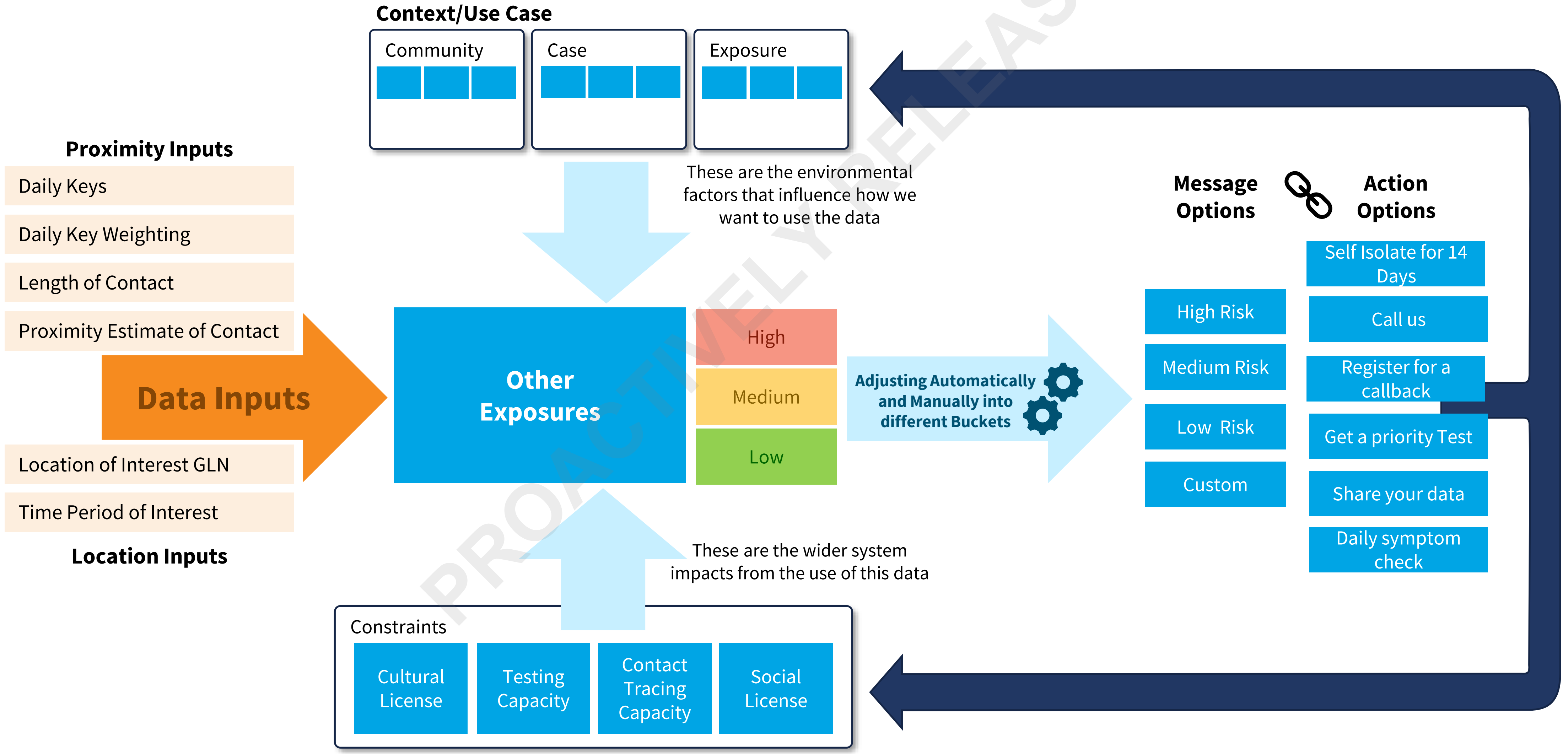
She doesn't tell Jack or the contact tracer as she doesn't think there was any risk (he wasn't there when she was).

The surprise birthday is great for Jack who is just starting to feel better after his illness.

Draft

Digital Contact Tracing Framework v1.3

This shows conceptually how the data flows and is used within a digital contact tracing model. Key parts include the context, the risk model, the message and call to action, and the system constraints. Data Inputs are shown on the following page.



Draft

Model for understanding digital contact tracing data

MINISTRY OF HEALTH
MANATŪ HAUORA

Draft

Context

We have developed a model that begins to consider the numbers of people likely to be notified with digital data from Bluetooth. This is a point estimate model, with no accounting for statistical variance. A model that incorporates this will provide more understanding of the likely effect, and will only be possible as we gather data from our trial in Rotorua and through the use of the system.

A model for using digital data for notification therefore needs to start with the performance of these solutions in other jurisdictions in a real-world situation. We have been able to access data from Singapore, Ireland and Switzerland. The quality of this data is reasonable, but there are some potential limitations.

There are a partially known set of confounders that influence the number of people notified with a system like this. We have identified a number of features that influence this, but given the unknown nature of some of these and their relationships it is difficult to be confident in the accuracy of our approach.

Fundamentally, other jurisdictions use signal strength and time to identify individuals to notify. These are not linear relationships and given the lack of data from decentralised systems (and a lack of access to data from centralised systems) our ability to reflect these relationships is likely to limit our understanding.

The model includes a simple sensitivity analysis where assumptions and base data to create a “high” scenario. This scenario helps understand the uncertainty in the model. This is used to provide assurance around the risks with using the notification system. It is expected that data from the trial in Rotorua would provided additional insights into the likely accuracy of the model.

Further detail about the model is included in the Appendix.

Draft

Key Limitations/Assumptions

In designing the model there are some assumptions/limitations that exist that mean we should be cautious in our initial use of the system and look to validate our assumptions. These have been considered in the sensitivity analysis completed where possible.

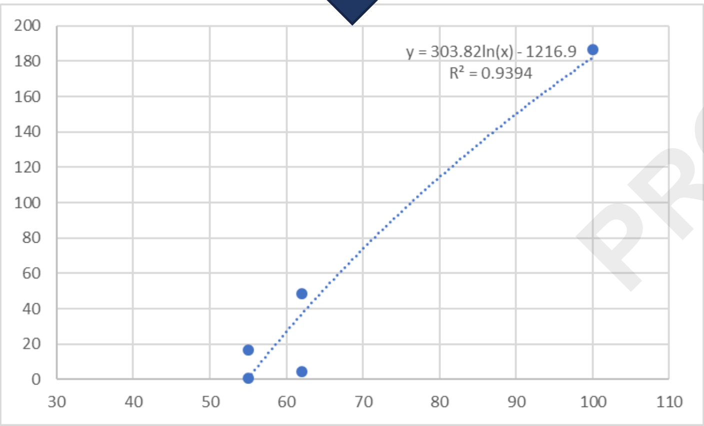
	Limitation/Assumption	Effect	Mitigation
1	All the people notified were all of those eligible for notification (some people may have turned notifications off).	Under-estimate	In conversations with Ireland and from the Swiss analysis – they are reasonably confident that people who are using the system have also enabled notifications
2	Population density is variable between centres in New Zealand	Increased uncertainty	Ability to use urban population estimates provides an alternative model (currently using DHB)
3	Social interaction is represented by number of steps taken	Increased uncertainty	There is the possibility that there may be other social interaction models we could use – it is unclear how reliable these would be
4	That effective coverage is a simple quadratic equation	Under-estimate	We know that due to cluster effects a simple quadratic equation is likely to underestimate the number of users that interact. It isn't clear how large this effect is.
5	Point estimates don't evaluate uncertainty and the associated statistical variance inherent in a model such as this	Increased uncertainty	Data from using our system is the best mechanism to understand this. There are sensitivity analyses that can be used to understand the risk of uncertainty in this in the immedicate term
6	Differences in the settings used by different countries	Increased uncertainty	Given the different signal thresholds used and the different time thresholds standardising to this model has been simplified.
7	Coverage - we are not clear the coverage of the systems is entirely accurate.	Over-estimate	There is a difference between downloads and active users – and it is difficult to know the number compliant phones. This means using "downloads" and assuming all phones are compliant will result in an over-estimate of interactions.
8	There may be increased contacts for different community groups - from the Auckland data – although these related more to the cluster than the case	Under-estimate	Considering differences in social interaction between communities is something that should be considered as this would affect volumes of notifications.

Draft

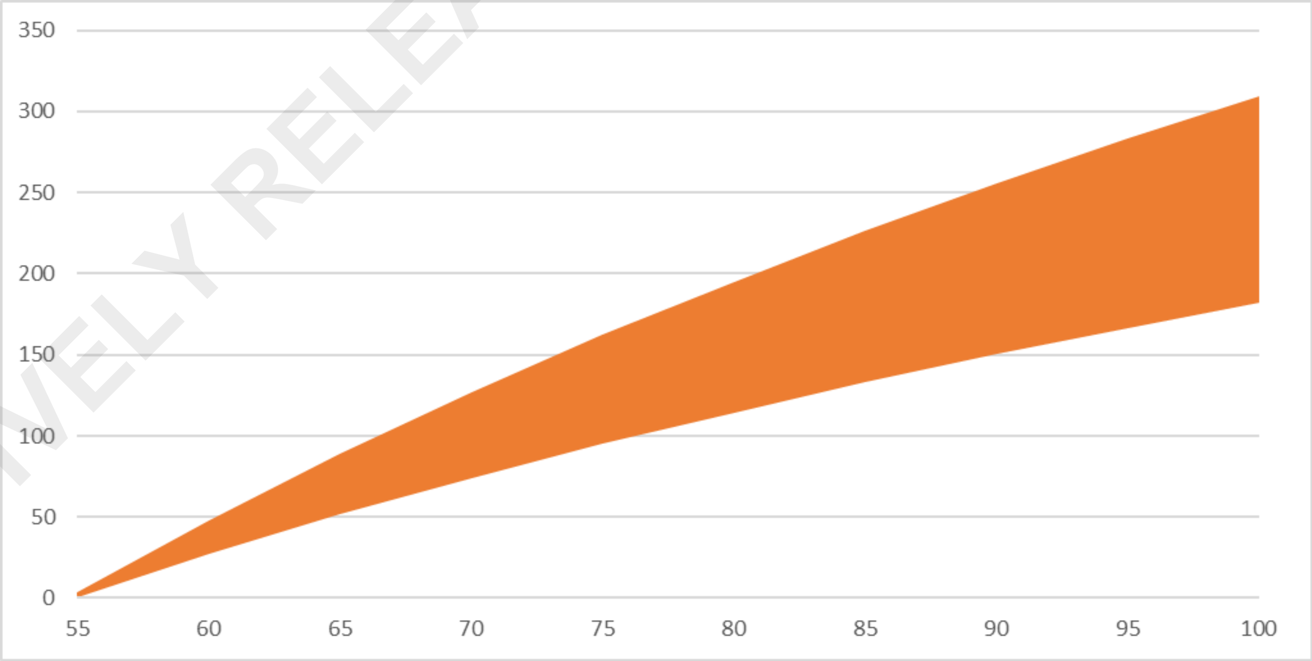
Creating a Model for Use (Auckland DHB Density)

This shows how the data from the international examples were used to create a model that fits the New environment. A sensitivity analysis increases the number of people identified in an Auckland context by approximately 70%.

Data Source	Threshold	NZ Numbers Identified
Swiss Immediate	55	0.92
Ireland Near	70	4.62
Singapore Total Contacts	100	186.38
Singapore Model Close (October) - 2m 30mins	55	16.86
Singapore Model Casual (October) – 5m 30mins	62	48.59



Numbers of Contacts Identified at different signal thresholds – High and Realistic Scenarios



Input Values and assumptions adjusted to create High Scenario

- Contact per Case – updated in Singapore to use upper range provided
- Social interaction model – adjusted down 50% of New Zealand estimate
- Singapore 30 minute timings – adjusted to account for likely decay model
- Coverage in New Zealand increased to 60%
- Population Density increased to reflect average urban density in NZ

Draft

Applying the Model to the Auckland Outbreak

This shows how the model could have been applied to the Auckland outbreak. If all people were notified from all signal strengths, we would have notified between 30-54,000 users. When constraining this to similar weightings from other jurisdictions – eg. Swiss, Irish, Singapore, the volumes drop to between 3-8,000.

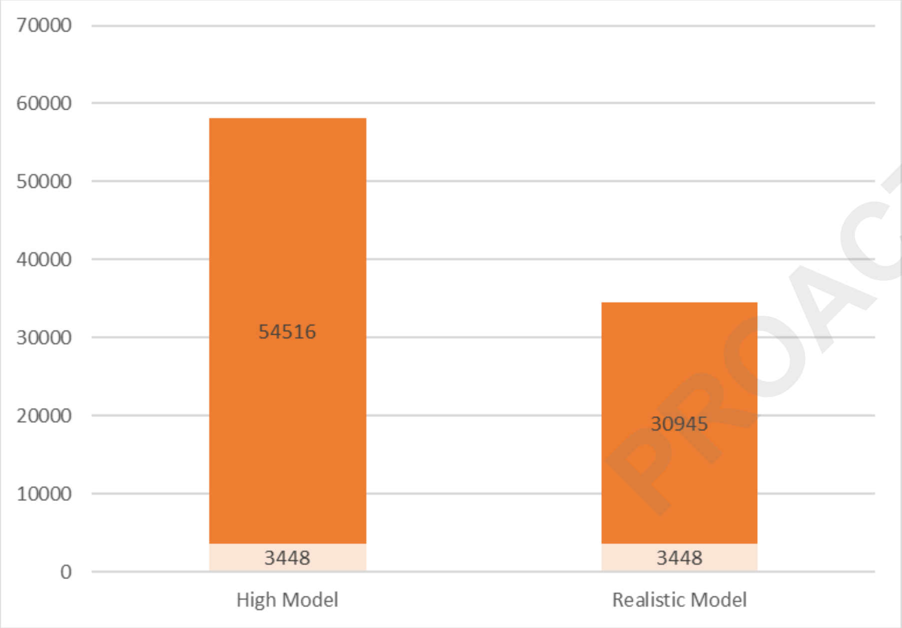
Key Point

Weighting and **thresholds** provide us the ability to constrain notification volumes

	Calculation	Immediate	Near	Medium	Other	Total
A) Weighting		100%	100%	100%	100%	
B) Signal Threshold		56	65	70	100	
C) Number	C=model(B)	6.1	45.3	22.5	108.4	182.2
D) Weighted Number	D=C*A	6.1	45.3	22.5	108.4	182.2

These are key variables that need to be considered

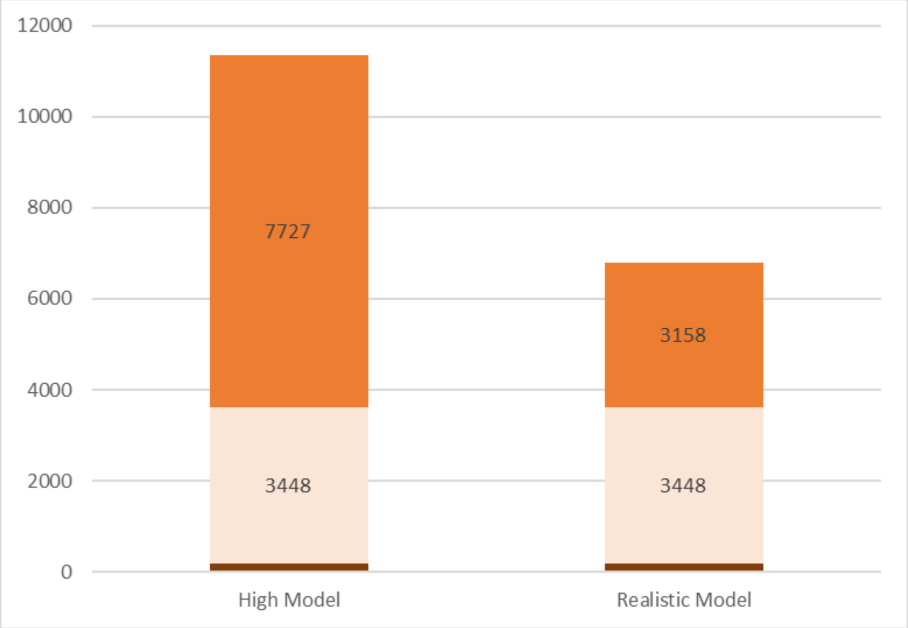
Number of People Notified – High and Realistic Scenarios



Adjust Weightings to:

Immediate: 100%
Near: 50%
Medium 0%
Other 0%

Number of People Notified – High and Realistic Scenarios



Additional found with Bluetooth Notification
Close Contacts in Auckland Outbreak
Cases in Auckland Outbreak

Draft

Draft Business Processes (Contact Tracing)

MINISTRY OF HEALTH
MANATŪ HAUORA

Draft

Approach to implementation

This shows the principles by which an operational service has been developed and will be delivered should it be approved. This also identifies key risks for consideration when implementing this service.

Principles

1. **Active Learning Approach**
   Need to make use of the feedback loop

2. Manual → More Automated

3. More conservative settings → More aggressive settings

Risks

- We underestimate the impact of our use of this data and damage trust or overwhelm the system
- We fail to use the system because the process for using it is too onerous
- A lack of cases mean that we don't get the system tuned quickly and effectively

Operational Governance Process

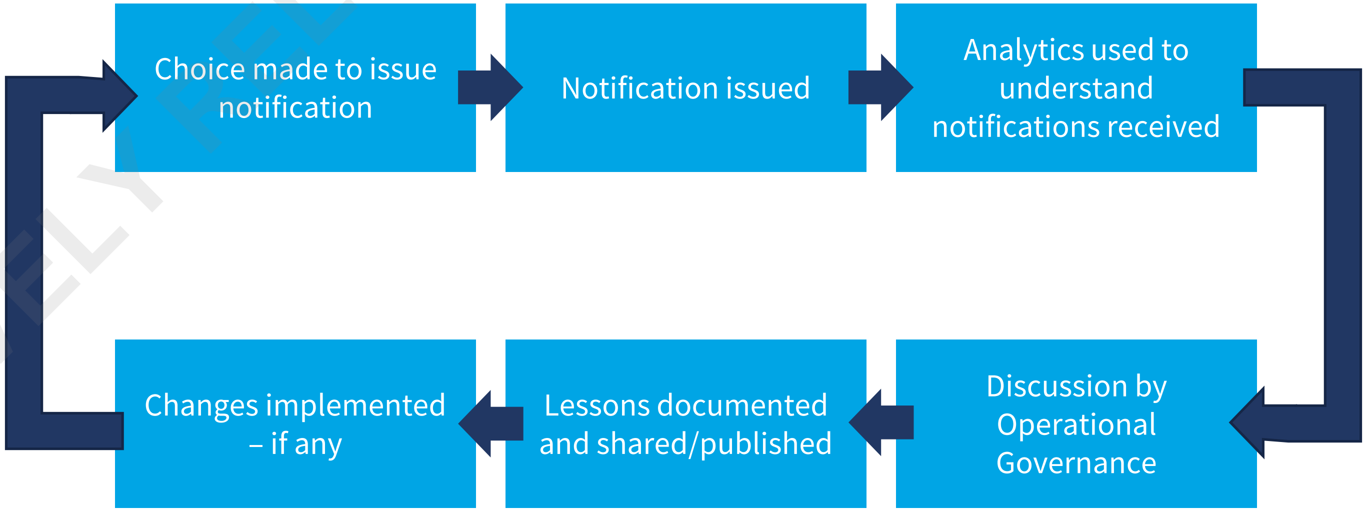
In order to make the most of the new data and the approach, there is a need to utilise the learnings from the process.

This shows how the process will work in order to use the notification process and learn from it. The Operational Governance group will meet once a notification is issued and the analytics are available.

This conversation will include considering all the different components of the Digital Contact Tracing Framework. Key components include:

1. Context the notifications were issued in including:
    1. Features of the outbreak
    2. Features of the case
    3. Features of the exposure event of interest
2. The settings in use with the system at the time (including text of notification and Next Best Action Requested).
3. The number of people notified
4. The impact of the notification on our key constraints if known.

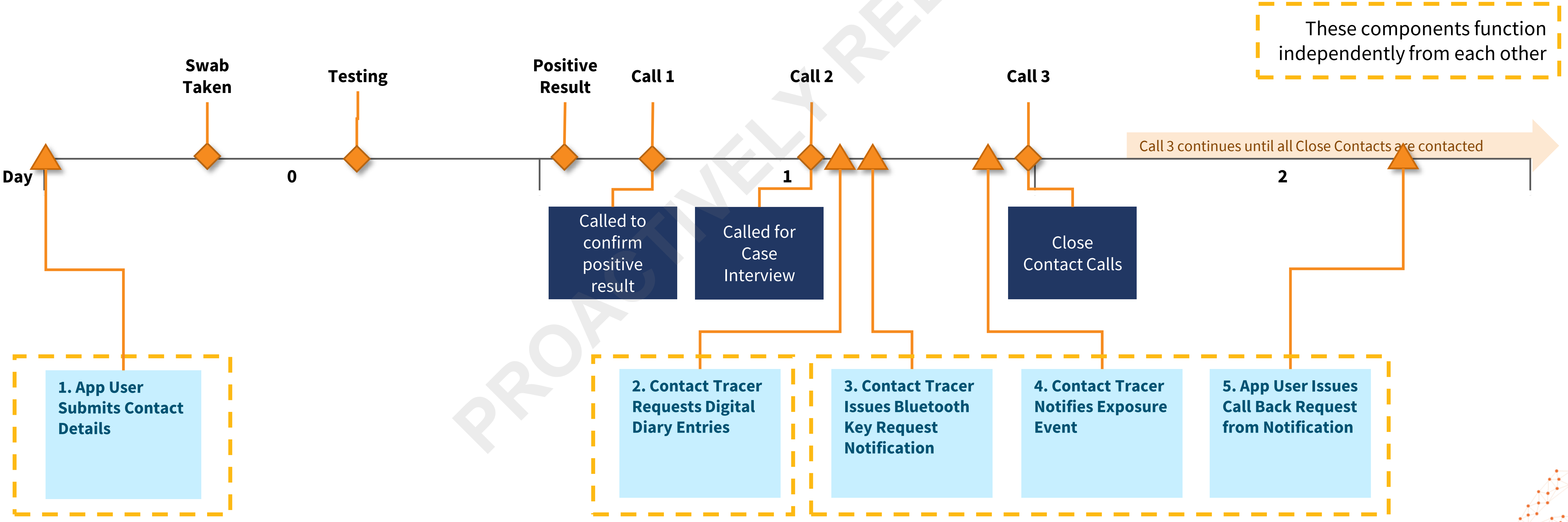
Timeliness is important, however impacts on our constraints may either compound over time (and not be immediately observable) or may occur in PHUs rather than centrally.



Draft

How digital processes fit with Contact Tracing

This shows how the processes for integrating with NCTS and the Contact Tracing process connect. These begin with Step 1 - App user submitting contact details. This can happen at any time before the contact tracing process starts, and isn't bound to a positive case occurring. Step 2 – a contact tracer requests digital diary entries – happens as a part of the case interview along with Step 3 – these aren't compulsory steps. This is then followed by an operational process (Step 4) to determine whether to make a notification, if agreed this is then completed. From here Step 5 – App users issue a call back request to contact tracers.



Draft

1. App User Submits Contact Details

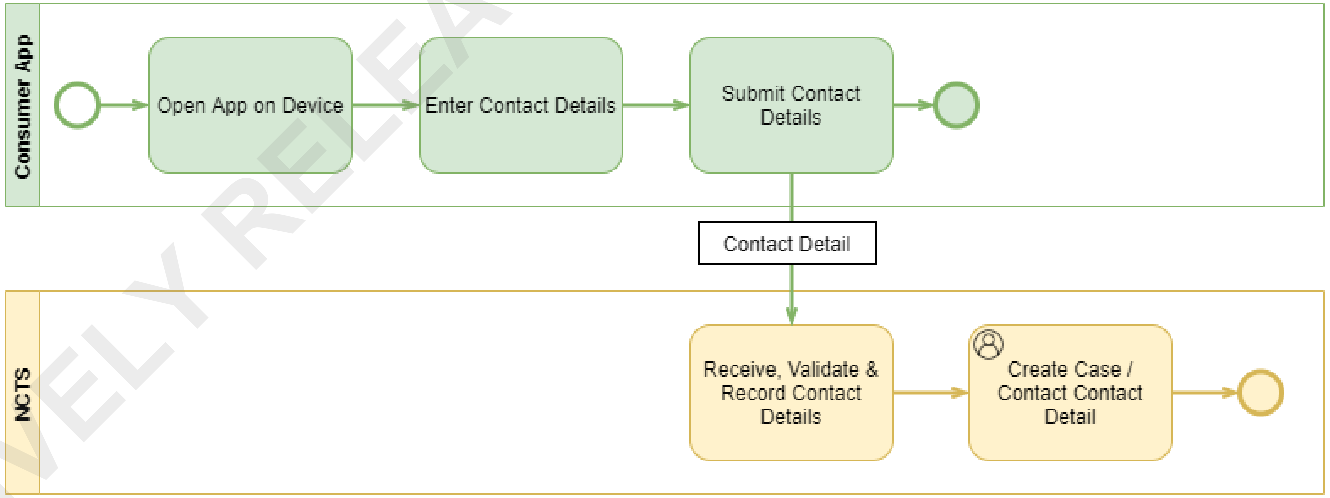
App Users are able to submit their contact details to the NCTS.

The submitted contact details are stored within the NCTS system boundary and are available to support contact tracing activities, including finding services.

The contact details can be queries by an NCTS user and where that can chose to create a contact detail record on the Person, Case or Contact objects within the NCTS.

App users can submit the following information:

- Name
- Date of Birth
- Gender
- Email
- Phone number
- Address



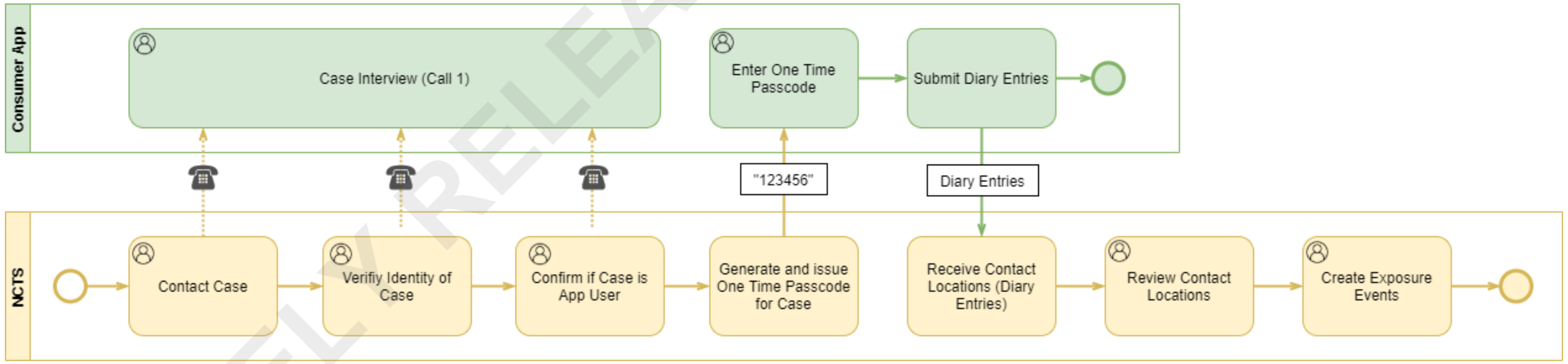
Preconditions	Post Conditions	Alternative Outcomes
1. App User has App Downloaded and wishes to submit updated contact details via the consumer App.	1. Contact Details submitted by the App user are recorded in the NCTS and available to support contact tracing activities. 2. The source of the contact details is recorded on the Contact Details record in the NCTS.	1. Submitted data is invalid and cannot be recorded in the NCTS 2. Submitted data is a duplicate of previously submitted data

Draft

2. Contact Tracer Requests Digital Diary Entries

During the Case interview contact tracers, and where the Case is identified as an App user the case investigator can provide a One Time Pass Code to the Case to enter into their App that will allow their Digital Diary Entries to be submitted to the NCTS.

Once submitted the Diary entries are recorded as Contact Locations within the NCTS. These Contact Locations can be further investigated and Exposure Events relating to those Contact Locations can be created by the Case Investigator.



Preconditions	Post Conditions	Alternative Outcomes
1. COVID-19 case created in the NCTS	1. Digital Diary for the App is available in the NCTS as Contact Locations to support the contact tracing process. 2. Case investigator is able to create Exposure Events for the Case directly from the Contact Location information.	1. Case is not an App user 2. Case has not maintained a digital diary

Draft

3. Contact Tracer Issues Bluetooth Key Request Notification

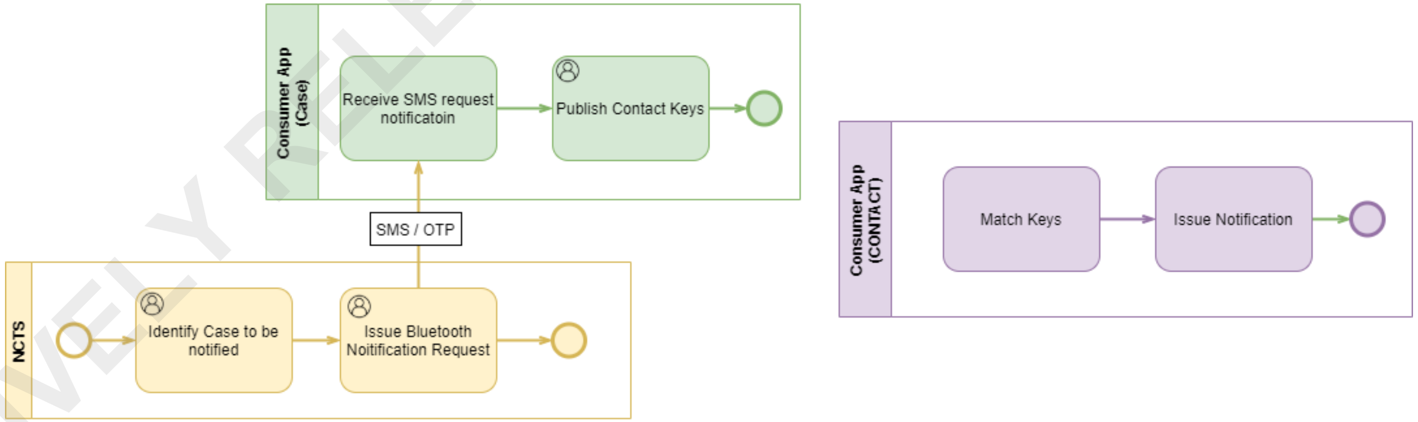
At any point through the contact tracing process and investigator may identify the need, based on risk, to issue a Bluetooth notification for a case.

The Investigator will define the parameters necessary to inform the notification, including proximity thresholds which can be used to provide different notifications based on the risk level estimate of the contact.

The notification request will be sent to the App User (Case) via and SMS message.

The Consumer App user (Case) will receive the notification and submit their contact keys for matching.

Consumer App users (Contacts) device will poll the central repository of published keys. Where a match is identified they will be notified with a message. Messages can vary depending on the risk of their contact based on proximity signal thresholds.



Preconditions	Post Conditions	Alternative Outcomes
1. COVID-19 case exists in the NCTS 2. Contact details for the case have been verified (through investigative interview) 3. Case confirmed as App user with Bluetooth enabled (through the investigative interview)	1. Bluetooth notification issued from NCTS. 2. SMS Notification issued to App user 3. App User confirms / accepts the requests and published their contact keys form their device. 4. App users that are identified as contacts through the matching process will be notified.	1. Case is not a App User / as deleted the app / has Bluetooth disabled in the App. 2. User does not confirm / accept the request and does not publish their keys.

Draft

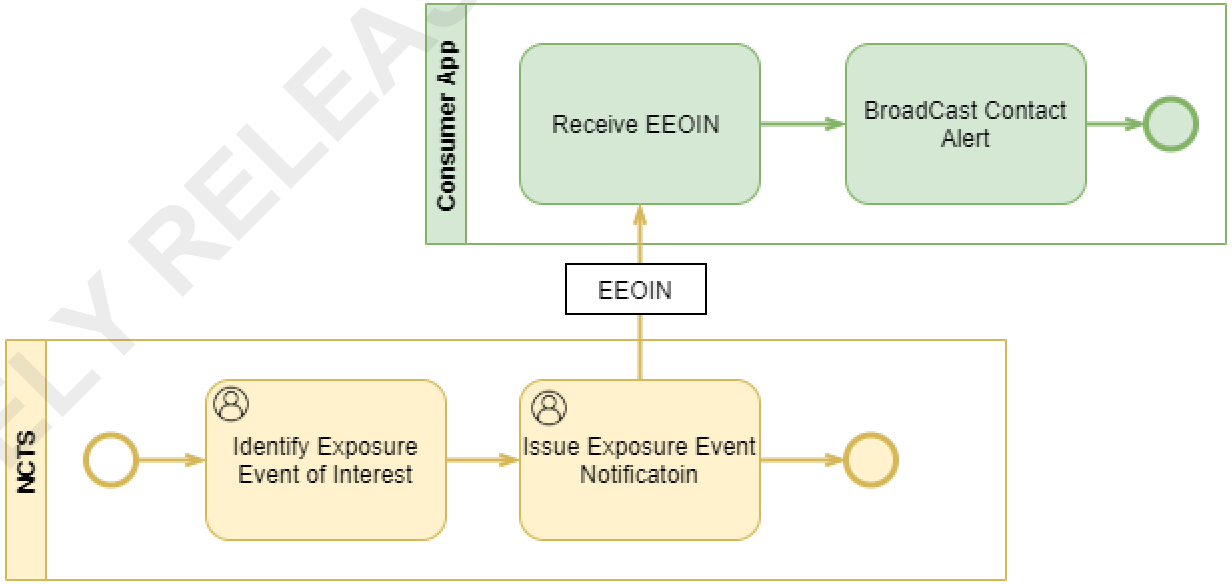
4. Contact Tracer Notifies Exposure Event

During or after the initial case investigation a decision may be made to issue notifications for one or many Exposure Events. Exposure Events of Interest (EEOI) are identified by the investigator in the NCTS and a parameters set for the Exposure Event of Interest Notification (EEOIN).

Once submitted to the Consumer App, the app will receive the EEOIN and create a Contact Alert which will be broadcast to the App instances running on peoples devices.

The App instance on peoples devices periodically polls for Contact Alerts, where one exists the App instance for a person will attempt to match the Contact Alert against the persons Digital Diary.

Where a match exists the person will receive a notification on their device with a message / interactions that is specific to that Exposure Event of Interest Notification.



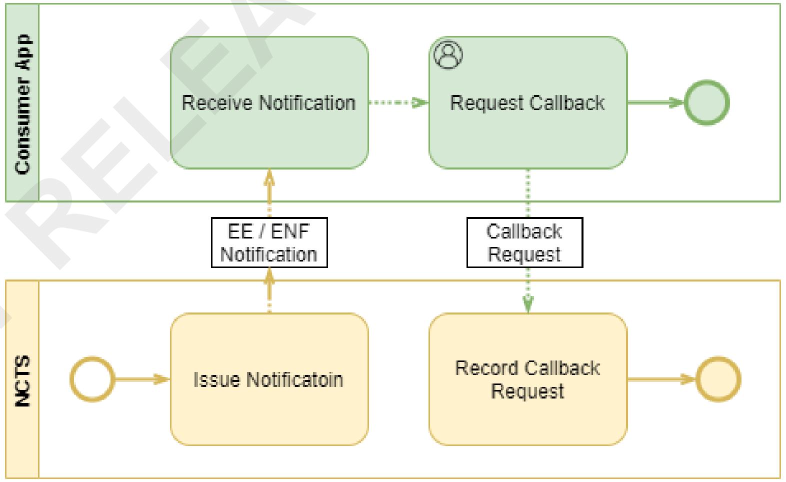
Preconditions	Post Conditions	Alternative Outcomes
1. COVID-19 case exists in the NCTS 2. Exposure Event for case has been created in the NCTS for the case.	1. Consumer App receives EEOIN, including details of messaging to be provided to App user where match exists. 2. Contact Alert notification broadcast and available for matching by User App instances on their devices 3. App users with matching	None

Draft

5. App User Issues Call Back Request from Notification

Following either a Exposure Event Notification or a Bluetooth notification a Consumer App will be able to

Users will only be able to issue a call back request where a notification from the app has been issued. The ability to issue a call back request will be time bound (say 96 hours after the notification was issued).



Preconditions	Post Conditions	Alternative Outcomes
1. A Exposure Event notification has been issued to an Consumer App user, or 2. A ENF(Bluetooth) notification has been issued to a consumer App user	1. A call back request has been recorded within the NCTS.	None

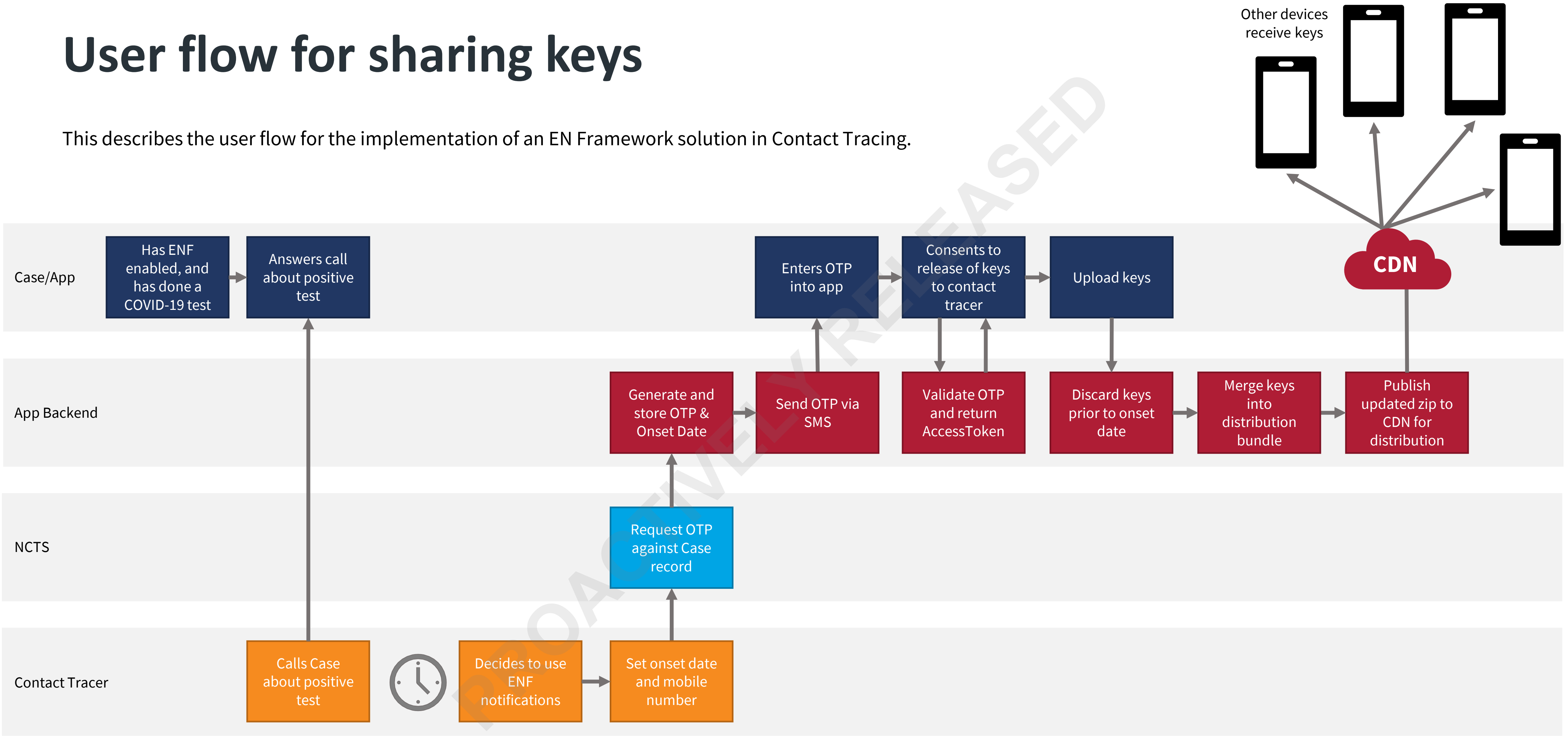
What this would mean with an Exposure Notification Implementation

MINISTRY OF HEALTH
MANATŪ HAUORA

Draft

User flow for sharing keys

This describes the user flow for the implementation of an EN Framework solution in Contact Tracing.

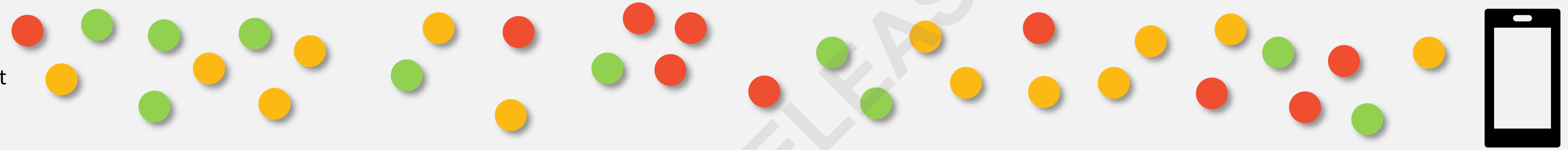


Draft

How the notification threshold is calculated with EN

This shows how the notification threshold is triggered with the decentralised EN Model. The minutes at each threshold are weighted and then added together. This total is then compared to the threshold. Generally this is 15 minutes internationally and this would be consistent with our case definition.

Recorded exposures to positive cases on a device over the last 14 days. Different signal strengths and length of exposure (in minutes)



Take all the different exposures and put them into buckets

How close were the phones? → For each match between phones (up to 30mins duration)

	Immediate		Near		Medium
Count up all the minutes of exposure in each of those buckets	Summed Minutes at "Attenuation"	$> t^1 >$	Summed Minutes at "Attenuation"	$> t^2 >$	Summed Minutes at "Attenuation"

Weight those buckets relative to how much we care about exposures at that attenuation. Higher attenuation = more risk

$$a \times w^1 + b \times w^2 + c \times w^3 = \text{“Minutes Exposed”}$$

Add those all together, and if the total minutes exceeds the threshold, show an alert to the user

$$5 \times 1 + 15 \times 1 + 5 \times 0 = 20$$

→ Is this above our threshold?

Configuration Parameters

This shows the parameters required to be set for an EN compatible service.

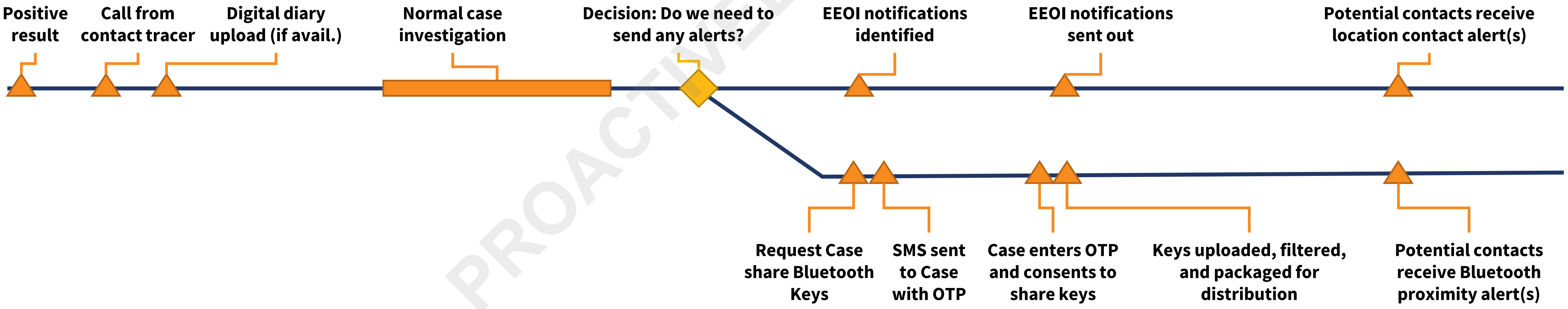
Parameter	Example	Purpose
durationAtAttenuationThresholds (t^1 ,t^2)	[56, 62]	Configures three different buckets (immediate, near, and medium) that all the individual exposures get sorted into. The two values are signal attenuations (in dB) where: • immediate > t^1 • t^1 > medium > t^2 • t^2 > near
thresholdWeightings (w^1, w^2, w^3)	[1, 1, 0]	A multiplier for each bucket to weight how important exposures in that bucket are to us in the calculation of whether to show an alert. By setting it to 0 it would mean that any exposures in that bucket are not counted in the final score
timeThreshold	15	After the calculation if the number of minutes exceeds this threshold, an alert is shown to the user.

Draft

Proposed flow for using both diary and EN notifications

This shows how an EN service would be used from a systems and business process.

Key points:
- Digital diary is collected up front if its available to support a normal case investigation process
- Near the end of the investigation, (or earlier if feasible/necessary) a decision is made about whether an EN alert, or a location contact alert, would benefit the investigation to notify people of possible exposure (i.e. are there likely people we have not notified through the normal investigation process?).
- If yes, contact tracers can initiate the EN key sharing process via the NCTS. An OTP is sent to the Case requesting they share their keys.
- The existing process for sending a location-based contact alert also can take place.



Draft

Alignment to MoH Algorithm Use Guidance

The Ministry has developed a set of guidelines for health organisations to consider when implementing an algorithm. These cover the domains below and describes how the approach described conforms to this guidance.

Domain	How this has been considered
Governance	• Person driven control mechanism for use is in place with the process • There will be operational governance in place to assess the use of the system as part of the active learning approach. • The key to the governance model being effective is ensuring that there is a mix of skills and perspectives providing oversight of this.
Operationalising	• There is a recognition that there is risk in using the system • Roll out of the system includes a review after every use to understand how the system is performing and whether it is performing in a manner that is expected (Active Learning) • The system is initially going to be manually activated and conservative settings are being used • There is wide global use of the Apple/Google ENF framework, and descriptions on how the technology works • Publish plain English description and diagrams about how it works • Limitations and uses for data are documented and understood • Data collection, transmission, and redistribution are documented and understood
Bias	• There are significant risks that the service includes bias as a result of access to the service, settings used, the notification message and call to action. These potential risks will be considered as a part of the Active Learning approach.
Assurance	• As a part of the Active Learning approach, we will be collecting data and have the ability to collect feedback on the use of the system. This should be used to ensure that the service is working as expected. • Solution architectures and system design limits data collection, and maintains privacy in line with Google/Apple restrictions • Apple/Google developer agreements limit app functionality where ENF is implemented, and review of apps before public release • Independent security audits of the solution prior to public releases • Adoption of the COVID Green Open Source project to implement ENF

Source: https://www.health.govt.nz/system/files/documents/pages/introductory_guidance_-_algorithms_v0.4_-_web.pdf

Draft

Alignment to Algorithm Charter for Aotearoa NZ

The Government has developed an Algorithm Charter that the Ministry of Health has signed up to. This describes how an EN implementation would be considered against the commitments in the charter.

Commitments	Considerations and actions towards commitment
Transparency	• There is wide global use of the Apple/Google ENF framework, and descriptions on how the technology works • Adoption of the COVID Green Open Source project to implement ENF • Publish plain English description and diagrams about how it works
Partnership	• Community engagement for Digital Contact Tracing technologies, including COVIDCard Trial • Engagement with Te Arawa Iwi in Rotorua
People	• Engagements with OPC, GCPO, NITC, Apple, Google, HSE Ireland (and others) • Colmar Brunton research into consumer digital contact tracing • Community engagement for Digital Contact Tracing technologies, including COVIDCard Trial
Data	• Limitations and uses for data are documented and understood • Data collection, transmission, and redistribution are documented and understood
Privacy, Ethics, and Human Rights	• Solution architectures and system design limits data collection, and maintains privacy in line with Google/Apple restrictions • Apple/Google developer agreements limit app functionality where ENF is implemented, and review of apps before public release • Independent security audits of the solution prior to public releases • Open source app code for public verification and transparency • Engagements with OPC/GCPO about privacy implications
Human Oversight	• Human control points for data capture and use. Requires invitation to share data, and consent from end user • Active Learning from Operational Governance will assure the use of the service • Media team briefings on how algorithms work, and comms strategy • Documentation on operational processes for end-to-end process

Draft

Open questions for resolution

	Question	Answer
1	What does the messaging show for a user who receives both a location-based contact alert and an EN alert?	
2	How do we ensure consistency of message for people who receive an digital alert before/after being spoken to via the current manual process? It's likely that close contacts of Cases who upload their keys will be notified of this exposure, even though they may have already spoken to a contact tracer prior?	
3	How can we reduce the lead time for the notification decision, to maximise the benefit of early alerts being sent?	
4	What are the settings that we would use initially?	
5	What is the make up of the Active Learning Operational Governance Group?	
6	Does issuance of notifications rest with PHUs or the national team?	

Draft

Appendix

MINISTRY OF HEALTH
MANATŪ HAUORA

Draft

Context / Use Cases

These are externalities that would influence how you place contacts into risk categories based on the particulars relating to the case or society at the time that the process is being undertaken.

Key Context Considerations

Community

- How big is the outbreak?
- When in the outbreak are we?
- What is the community this is in?
- What is the tolerance of infection in the community?
- What is the population density?
- What is the freedom of movement?
- Targeting testing or self-isolation?
- Health literacy in the community
- Has coverage and/or participation changed?

Case

- How reliable is the case?
- How social is the case?
- Number of close contacts

Exposure

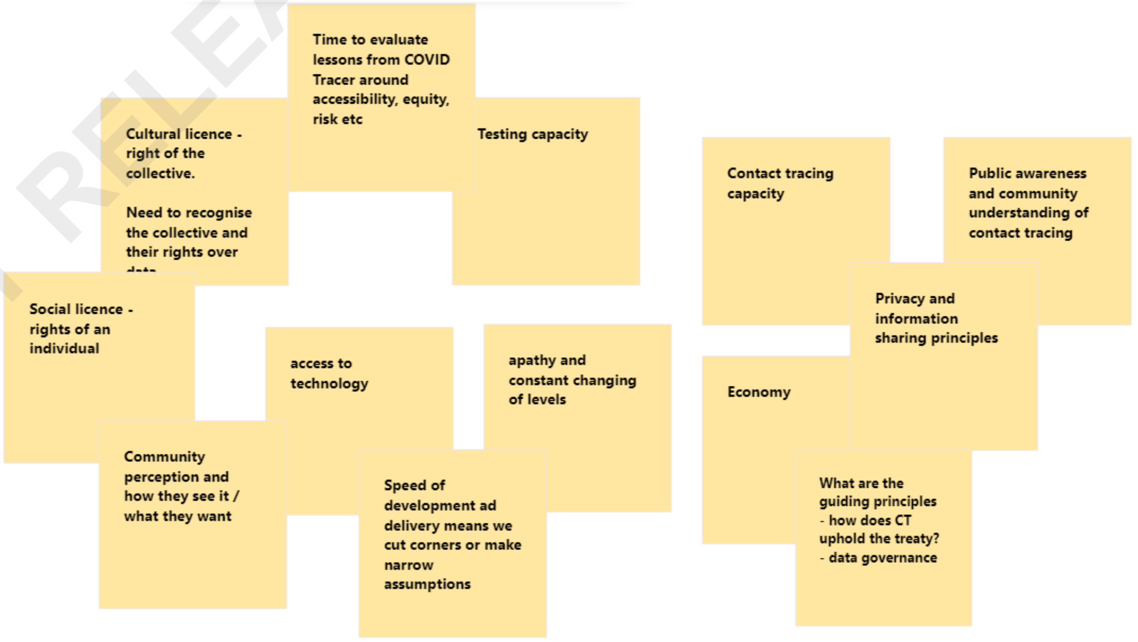
- What type of exposure event is it?
- How formal is the participation in the event?

Constraints

We think that these are the constraints that both the health system, people and population would put on our ability to use this system.

Key Constraints for consideration

Economic Effects	Testing Capacity	Contact Tracing Capacity	Social License	Cultural Licence

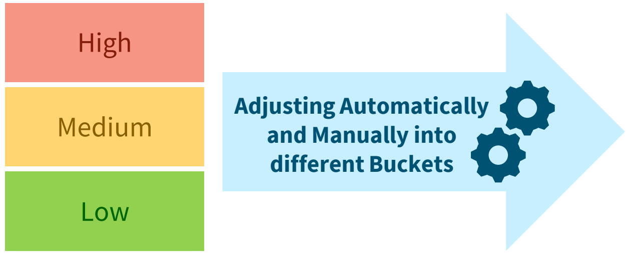


We think that these are the contraints that both the health system, people and population would put on our ability to use this system.

Questions for discussion

- What other key constraints may there be (how would we measure them)?
- Under what conditions would you use the data?
- How much would these influence the weighting and the messages/actions?

Process for confirming these buckets – Group A



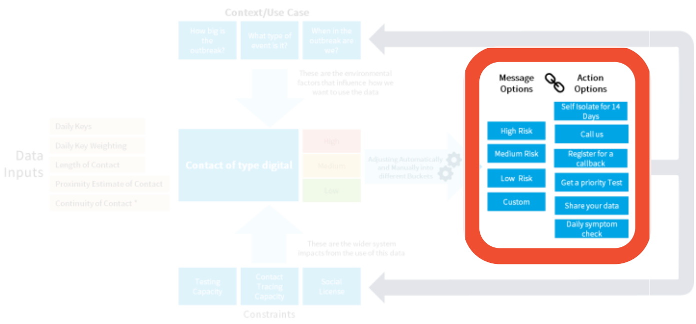
This is the process of stratifying the contacts into different risk categories, this can be done based on manual or an automatic approach – and can also have both manual and automatic checks before proceeding

Questions for discussion

1. This needs to be considered alongside our location based alerts (do we do both, do they look the same)
2. How automated is the decision making – keys and other weighting variables
3. How much oversight/accountability is required of this (does the approach vary per case)?
4. What review process exists to learn from each time?
5. Should we assume we would move from a conservative to more liberal approach (is this the same as moving from a manual to more automated approach)?
6. We know that with ENF we can have a maximum of four buckets – is this too many (or not enough)?

Draft

How are message and actions linked?



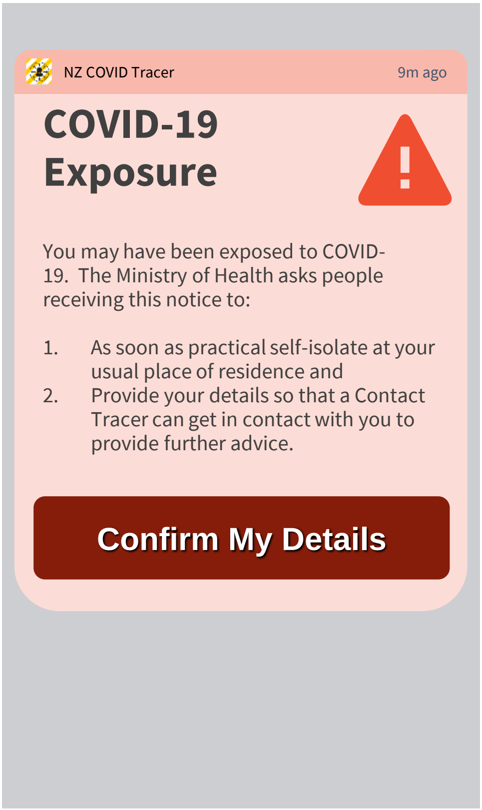
We have assumed that linking these important. The reason is that we think there are certain actions you don't want to be possible with certain message types.

Some Examples

Message Options	Action Options
	Self Isolate for 14 Days
High Risk	Call us
Medium Risk	Register for a callback
Low Risk	Get a priority Test
Custom	Share your data
	Daily symptom check

Questions for discussion

1. Can we use more conservative messaging to increase speed/automation in lower risk situations?
2. How many message categories or actions there are (and what are they)?
3. Should we have standard messages (with the ability to amend)?
4. What are the visual cues and options for high vs low risk – There is a behavioural insights component with this
5. Are some of these options only available with certain message types and risk levels (need to draw connections between the risks)?
6. This needs to be considered alongside our location based alerts (do we do both, do they look the same)



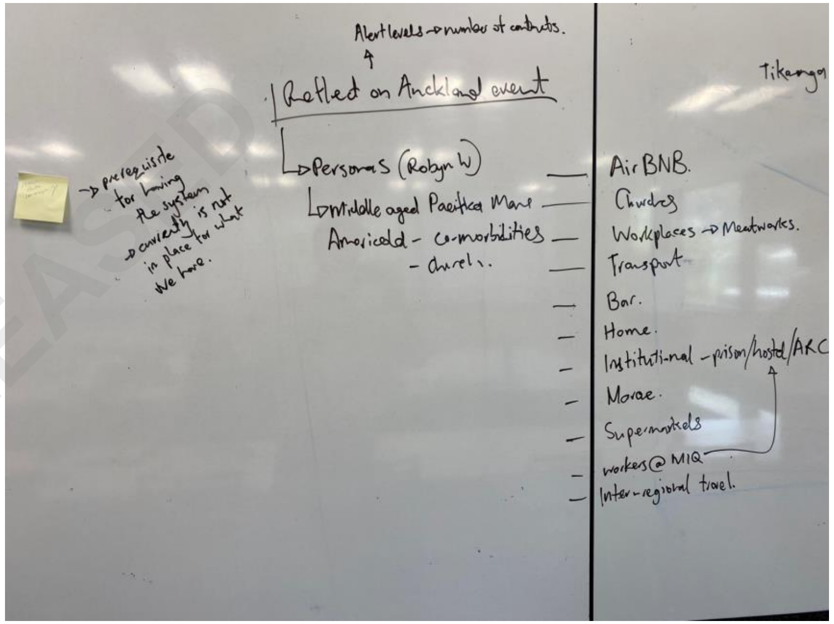
Draft

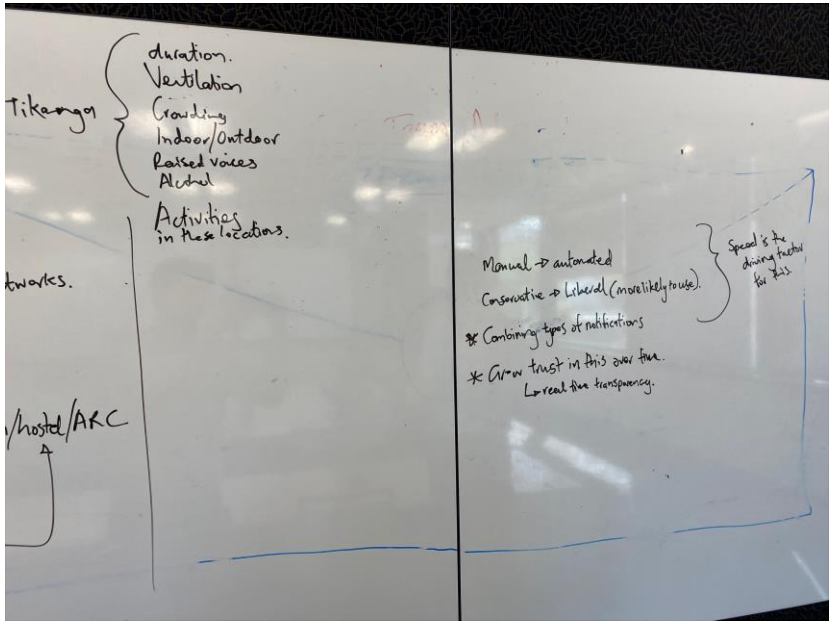
Scenario Building

Help us come up with a set of scenarios that allow us to:

1. test our system
2. operationalise our system

Consider the data and measurements we require for this to provide assurance we can use the service as expected





Draft

Definitions

Case – person with a COVID-19 diagnosis

Close Contacts – defined as those who require follow up from the Public Health Unit due to the high likelihood of transmission

Casual Contacts – may be high index of suspicion (high risk) but also may be low risk

Exposure Event – place or interaction where transmission could have occurred

Location of Interest – place where a Case has been

Case Interview – Normally face to face interview process for identifying locations of interest, exposure events and close contacts.

Draft

International Data for Creating the Model

	Formula	Swiss Model - Immediate (19 September 2020)	Irish Model (13 October 2020)	Singapore Model Total (April)	Singapore Model Close (October) - 2m 30mins	Singapore Model Casual (October)
A) Coverage (active users estimate)		19%	27%	25.0%	34%	34%
B) Effective interaction likelihood (assumes simple quadratic)	$B=A^2$	4%	7%	6.3%	11.4%	11.4%
C) Population Density		219	70	8358	8358	8358
D) Number of codes uploaded		1643	2673			
E) Number of call backs from contacts		1695	5186			
F) Number of contacts per case	F=E/D	1.0	1.9	1110	5	25
G) Found Contacts per day based on coverage	G=F/[Number of days of data collected]	0.07	0.14	52.9	0.2	1.2
H) Likely real contacts per day (adjusted for coverage)	H=G/B	2.1	2.0	845.7	2.1	10.5
I) Likelihood of meeting people (steps as a proxy)		1.1	1.1	1.1	1.1	1.1
J) Likely real contacts per day adusted for likelihood of meeting people	J=H*I	2.3	2.1	952.3	4.7	23.6
K) Ratio of contacts to Population Density	K=J/C	0.0103	0.0297	0.1139	0.0006	0.0028

Draft

Applying International Data (Auckland DHB density)

	Calculation	Swiss Immediate	Ireland Immediate	Singapore Total Contacts	Singapore Model Close (October) - 2m 30mins	Singapore Model Casual (October)
A) International Standardised Outputs		0.0103	0.0297	0.1139	0.0006	0.0057
B) Coverage (28/9/2020)		46%	46%	46%	46%	46%
C) Reduction to account for iOS Compatibility		78%	78%	78%	78%	78%
D) Eligible Coverage	D=B*C	41%	41%	41%	41%	41%
E) Effective Contacts	$E=D^2$	17%	17%	17%	17%	17%
F) Population Density		771.4	771.4	771.4	771.4	771.4
G) Real Contacts per day based on Density	G=A*F	7.9	22.9	87.9	0.4	2.2
H) Contacts per day based on coverage	H=G*F	1.32	3.82	14.64	0.07	0.36
I) Steps Per Person per Day		0.91	0.91	0.91	0.91	0.91
J) Adjusted for Social Interaction	J=H*I	1.20	3.47	13.31	0.07	0.33
K) Number of Contacts in 14 Days	K=J*14	16.86	48.59	186.38	0.92	4.62

Draft

Config File for COVID Green

#	COVID Green Config Parameter	Values	Apple APIs		Google PS Versioning	Google APIs	Apple OS Versioning	Notes
1	Minimumriskscore	1	Minimumriskscore		1	Minimumriskscore	1 (13.5)	Minimum for setting individual scores back to 0
2	Attenuationlevelvalues	[2,3,4,5,6,7,8,8]	Attenuationlevelvalues	[1,2,3,4,5,6,7,8]	1	Attenuationscores	1 (13.5)	Different buckets for attenuation
3	Attenuationweight	1	Not used	1	1	Not documented	1 (13.5)	
4	Dayssincelastexposurelevelvalues	[1,1,1,1,1,1,1,1]	Dayssincelastexposurelevelvalues		1	Dayssincelastexposurelevelvalues	1 (13.5)	Two day increments
5	Dayssincelastexposureweight	1	Not used		1	Reserved for future use	1 (13.5)	
6	Durationlevelvalues	[1,1,1,1,1,1,1,1]	Durationlevelvalues		1	Durationlevelvalues	1 (13.5)	Five minute increments
7	Durationweight	1	Not used		1	Reserved for future use	1 (13.5)	
8	Transmissionrisklevelvalues	[1,1,1,1,1,1,1,1]	Transmissionrisklevelvalues		1	transmissionriskscores	1 (13.5)	
9	Transmissionriskweight	1	Not used		1	Reserved for future use	1 (13.5)	
10	Durationofattenuationthresholds	[56,62,70]	attenuationdurationthresholds		1.5		2 (13.7)	
11	thresholdweightings	[1,1,0]	Immediatedurationweight		1.5		2 (13.7)	Four variables
12	Timethreshold	[15]			1.5		2 (13.7)	
13	Infectiousness	[1,1,1,1,1,1,1,1,1,1,1,1,1,1]			1.6			Non, Standard, High
14	Calibration Confidence	[1,1,1,1]			1.6			Lowest, Low, Medium, High

Version 2

Version 1

Intelligence from other jurisdictions

Jurisdiction	Singapore	Australia	England	Republic of Ireland	Canada	Japan/Uruguay/Spain/Brazil/Ecuador	Linux Foundation – COVID Green
Key findings	• Moderate coverage, improved with dongles but unclear on true benefits (benefits not published).	• Doesn't have large coverage and doesn't integrate to get good notification speed	• Second attempt has a key focus on building trust and participation • Combines QR codes, Bluetooth, self-isolation and test ordering	• Key focus on building trust and participation • Very similar contact tracing model to NZ, and good learnings beyond the app.	• Key focus on building trust and participation • Good marketing efforts and investment	• Interested in global interoperability for EN implementations	• A growing group of organisations participating in the collaborative
Strengths	• Open source model for software and hardware • Have considered lots of different technology options • Have a focus on data re-use and integration – are sophisticated in terms of understanding participation and impacts	• Is in the market • Good political support initially	• Is a relatively complete offering • Some further algorithm work has recently been completed that can be incorporated into other EN apps to increase accuracy • Interest in measuring specific benefits	• Is in the market • Has symptom checker • Interested in publishing the impact of the app on • Well integrated with contact tracing with call back feature	• Is in the market	• Unlikely that Apple or Google will operate this • A broker would allow apps to travel with the person as long as both countries use EN	• Opportunity to engage and gather feedback from others on a similar journey
Weaknesses	• Not compatible with global solutions or Australia • Doesn't work on iPhones • Finding difficulty contacting dongle users.	• Not compatible with global solutions or Singapore • Doesn't work on iPhones • Isn't integrated with Contact Tracing systems (state-based) • Doesn't collect information about location • Less privacy protective	• Failure in the first instance has meant slower uptake than might have occurred • Not connected to the Test and Trace process directly		• Vanilla implementation • Integration with contact tracing secondary	• Less likely people will use our app when in our country.	• A sense that having an app is the end point rather than an opportunity to join up the different elements of the response.