How M-i
Re-opening Economy with a Privacy-Preserving Integrated Digital Solution for Covid-19

A Response to
HHS-NIH-NCI-RFI-COVID19-01

Submitted Jointly By
How, LLC
599 BRANCHVILLE RD
RIDGEFIELD CT 06877

&

Case Western Reserve University
10900 Euclid Avenue
Cleveland, OH 44106

Please send all inquiries to:
Moreton Binn
Direct: 203-431-7933
Cell: 646-662-7696
Moreton@Binn-Investments.com

1. Introduction

We represent **a strategic partnership between a team of interdisciplinary scholars and a private enterprise with a single shared goal of opening the global economy safely** using the most advanced digital tools. Ours is the only tool in development that preserves the privacy and civil liberties of individual users while allowing data portability with users' control. The research team consists of scholars in digital innovation, public health, cybersecurity and privacy, artificial intelligence, the market economy, and law from ***Case Western Reserve University, Cleveland Clinic, Cleveland State University,*** and ***HAT-LAB, UK***. The private enterprise partner, How LLC., includes executives from transportation, trade, commerce and public health.

Our solution is designed to alleviate two major pressure points in our economy due to Covid-19: mobility within local economies and transportation. **We have a strong growing public partnership including a mid-size city and a county in Ohio. We are also in discussion with four major international airports in the nation.**

Our team of scholars, public health experts, and business leaders are designing, implementing, and validating a scalable integrated solution building on a set of advanced digital tools that offers a balanced approach for (a) preserving data privacy while offering data portability, (b) promoting public health while protecting individual civil liberties, and (c) allowing economic activities while minimizing the risk from Covid-19. We recognize this is a difficult set of goals with inherent tensions. Our solution is based on our collective research on technology, innovations, public health, law, and ethics. We plan to validate our solution through citizen science projects and a large-scale regional pilot. We plan to rapidly scale our solution through a nation-wide network of local business leaders who are ready to join the effort. **We do all of this without compromising the privacy of individual users.**

At its core, our integrated solution is based on an open-source project, ShareTrace (http://www.sharetrace.org/), initiated by Case Western Reserve University and its partners that offers a personalized Covid-19 risk assessment to individual users. **Our solution extends ShareTrace with a set of proprietary features including additional data integrations, analytics, dashboards, and procedures. We are getting ready to begin a pilot in Ohio as early as mid-July.** We have a plan to scale it both in geographic markets and with additional features and data sources.

Our plan offers a bold strategic plan based on the combined strengths of academia and private sector to help all sectors of our society and economy to open again.

2. Challenge: Public Health and Transportation

In 2005, 196 countries agreed to establish the International Health Regulations (IHR) to help decrease the risk of spreading emerging communicable diseases through international travel, trade and commerce. The IHR became effective in 2007 and since then we have seen them used to contain global public health threats. Today, COVID-19 is one of those public health threats. One of the most important core aims of the IHR is to have countries strengthen their surveillance at the local and national level as well as international ports of entry, airports and ground crossings[1].

From Tuberculosis to H1N1, core public health tools and strategies -- surveillance, contact tracing, mitigation and response -- have been essential to maintaining social and economic order. Today our major pandemic is COVID-19. The future will hold other pandemics and our system can address those as well. The identification of individuals at higher risk for having COVID-19 is of paramount

[1] International Health Regulations, 2nd Edition, 2005 Author World Health Organization

importance if we are to open our country for business. Interrupted travel due to COVID-19 has far-reaching and devastating effects on our local, state and national economy. From disruption of business travel, to loss of technical support to reduction of clinical trials, COVID-19 travel restrictions have negatively impacted our economies.

In 2005 when the IHR was created, the public, in general, didn't have access to portable devices of communication as we have today. Presently most of the world has access to smartphones and portable technologies that can be of transformational value to protecting users and enabling the transportation ecosystem to be healthy and thrive again. This is precisely the opportunity that our team is trying to address.

3. Overview of Our Solution

Our proposed solution will offer:

- A privacy-preserving contact tracing capability with a user-friendly design that offers accurate and early risk assessment for individuals based on symptoms and contact history using a unique anonymized network model;
- Tight integration with commercial rapid Covid-19 test results for those who have high-risk scores;
- A scalable privacy-preserving decentralized data layer architecture using Personal Data Accounts (PDAs) that meets the federal data privacy regulations including HIPAA and CCPA;
- An ability to include any number of user-generated, machine-generated, and third-party provided (via APIs) personal data relevant to Covid-19 or future pandemics into PDAs;
- Data portability to allow individuals to share their risk status with other individuals, employers, businesses, schools, and government agencies to open society safely;
- Data portability under full control by the users to help healthcare organizations to provide necessary care safely to patients including mental health needs;
- Data portability under full control by the users to enable individuals to share data with public health agencies and scholars to identify dynamic patterns of Covid-19 transmission;
- Ability to integrate decentralized algorithms at the edge to offer necessary insights to the users and authorized individuals and organizations based on personal data stored in PDAs; and
- Machine learning algorithms that predict the virus spread based on physical interactions, symptoms, and test results.

While the benefits of digital risk tracking are clear (Raskar et al. 2020, Troncoso et al. 2020, PEPP-PT, PACT, Google and Apple, Chan et al. 2020), the potential deployment of ubiquitous surveillance tools by state authorities, or even by private firms, raises serious concerns of privacy and civil liberties. Recognizing these concerns, several decentralized approaches are being proposed, most notably by the joint efforts between Apple and Google. Several academic institutions have also introduced similar solutions. One common feature in these privacy-preserving contact-tracing solutions is the use of anonymized contact lists for collecting Bluetooth radio signals on a user's device. While more efficient and scalable than traditional manual contact tracing, these proximity-based decentralized contact-tracing solutions suffer potential shortfalls both in their effectiveness and privacy protections. Particularly, the data portability of the proximity-based decentralized contact tracing is severely limited by the inherent architectural design choice that these solutions use to protect user privacy, which limits their usefulness beyond assisting manual contact tracing. Also, as these approaches rely only on direct contact history, they can be too slow in a highly transmissible epidemic like COVID-19.

ShareTrace offers an alternative architecture that provides more effective and timely solutions while providing better protection of user privacy. ShareTrace utilizes a distributed architecture that constitutes a network of anonymized digital twins of users using decentralized Personal Data Accounts (PDAs). PDAs are implemented using [the HAT Microserver] in the cloud. Using the HAT Microserver, ShareTrace computes hyperlocal interaction graphs using anonymized digital twins. The use of hyperlocal interaction graphs offers ShareTrace several advantages over other proximity-based solutions:

- ShareTrace provides much quicker and more effective notifications to individual users of exposure to potentially infected contacts compared to other proximity-based solutions.
- ShareTrace's distributed PDA architecture better protects privacy by eliminating the need to broadcast even anonymized user IDs and related information, which can be used to re-identify individual users in some circumstances.
- By using hyperlocal networks, ShareTrace allows users to "roam" to different locations, and immediately receive appropriate guidance even when traveling.
- By using PDAs, ShareTrace provides a *personalized* risk assessment for each user that is based on multiple data sources, not only potential contact with infected individuals.
- N-degree of interaction information is available to users more promptly, so that they can alter their behaviors days earlier.

ShareTrace offers the dual goals of privacy protection and data portability through **our "privacy by architectural design" approach**. It calculates individual risks using (a) symptom logs and (b) interactions with other users. ShareTrace uses Personal Data Accounts (PDAs), where all individual personal data is stored, managed, and owned by individual users, using HAT Microserver architecture. In its current version, ShareTrace takes user-generated symptom logs. It also generates hyper-local physical interaction graphs, using Bluetooth Low Energy (BLE) technology. Together, they form the bases of calculating individual users' risks. Figure 1 is a schematic representation of ShareTrace's architecture.

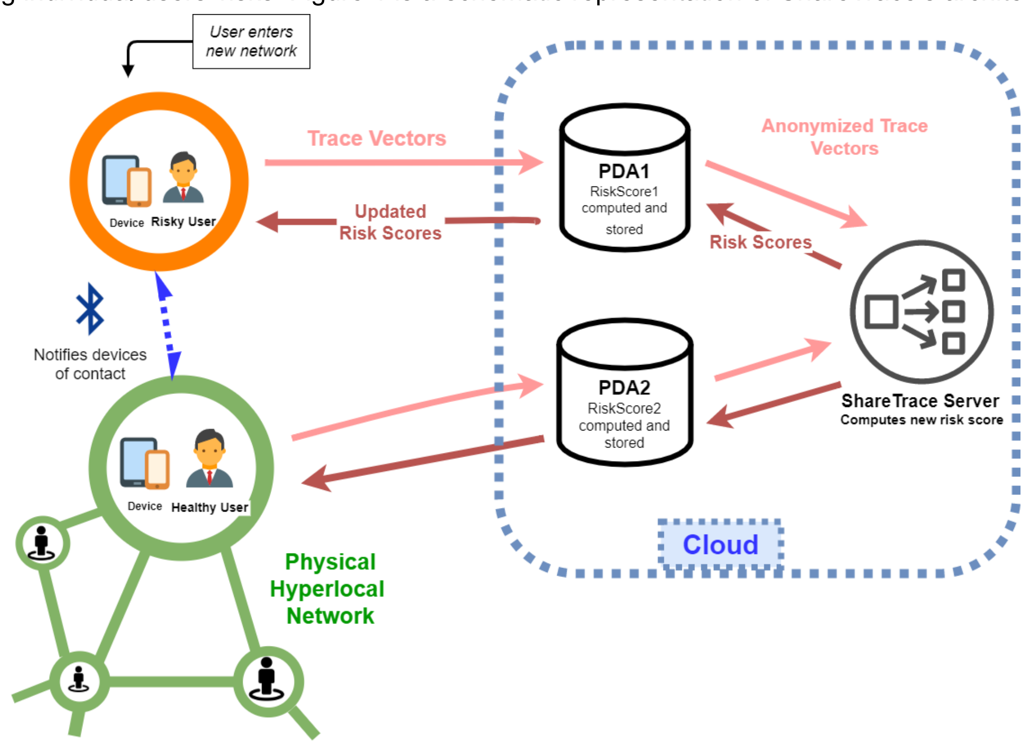

Figure 1. A schematic architecture of ShareTrace with Digital Twins and PDAs.

ShareTrace offers significant advantages compared to other existing privacy-preserving apps designed to assist in contact tracing. Currently, most applications rely primarily on two different models: (1) the Apple/Google Bluetooth-based API model that creates a decentralized list of anonymized contacts generated and stored in the user's smartphone; and (2) models similar to the MIT-developed SafePaths model, which permits users to store GPS-based location data on their smartphones, which can be de-identified and aggregated into a centralized database that users can access to self-identify potential exposure to infected individuals.

Both models send warnings to individual users who may have come into close contact with confirmed infected patients so that they can seek testing or self-isolate. This approach is retroactive and relies on a single data point: potential exposure to an infected individual. Therefore, both models are only partially effective in quickly and efficiently identifying individuals at high risk of infection, particularly with highly viral epidemic situations, where many carriers of a virus are asymptomatic. In an illustrative example shown in Figure 2, a contact tracing app alerting users to potential exposure and with the availability of testing within the same day results in the entire community being infected by day 3. These models also risk a high rate of false positive and negative notifications because they rely on technologies that are imprecise and prone to significant errors to identify potential exposure ([Leith & Farrell (2020)](#)).

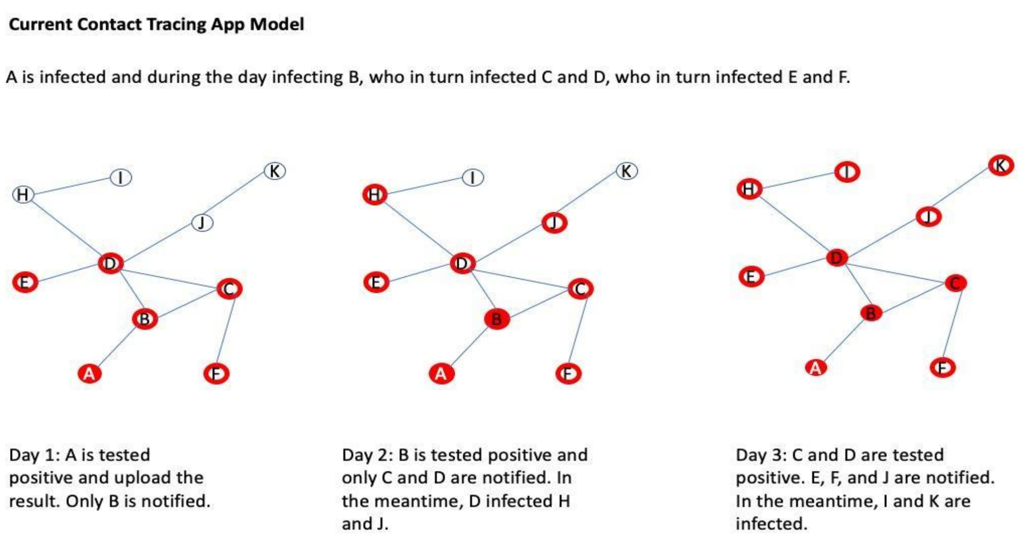

Figure 2. An Illustrative Example of Contact Tracing with Proximity-based Approach.

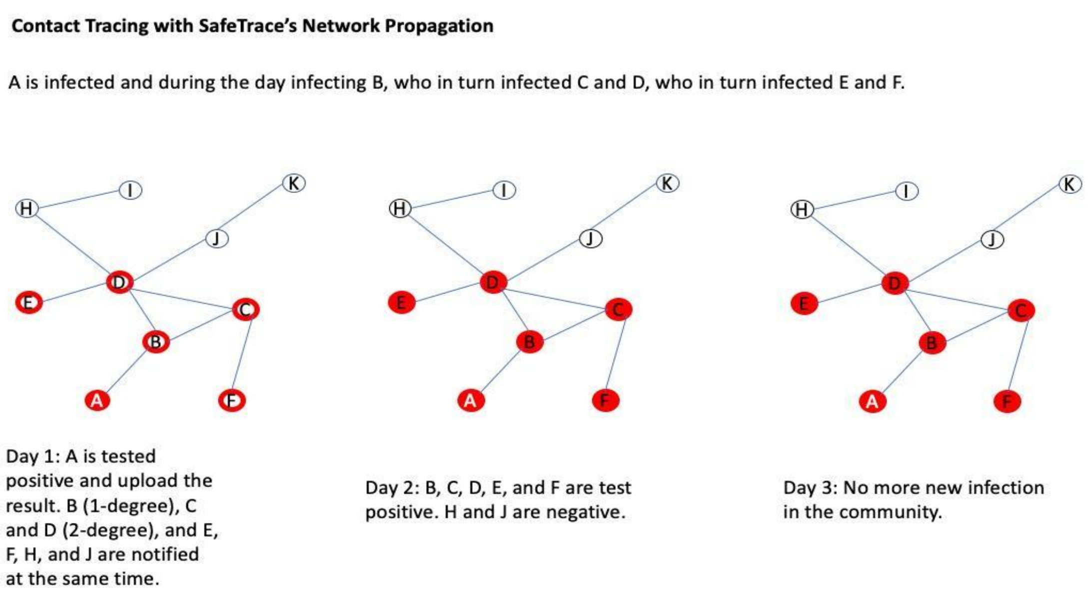

Figure 3. An Illustrative Example of Contact Tracing with an Interaction Graph.

By contrast, ShareTrace uses a hyperlocal interaction graph to capture direct and indirect physical interactions among users. ShareTrace combines this information with other data, including self-reported user symptoms, to create a nuanced risk score for each user. This is essential, as many users carry the virus asymptomatically from earlier exposures to virus carriers. The system is able to pick up early warning signals based on the combination of interactions with others and symptoms. Figure 3 shows the same illustrative example with a contact tracing solution using an interaction graph. In this example, a virus flare-up is contained by day 2.

User Experience

ShareTrace provides an easy-to-use intuitive mobile-first user experience. Our system and unique algorithms enable the user to identify his or her risk of having the COVID-19 infection in a simple three-color scheme and provide for better decision making for themselves (see Figure 4). That first step in their own assessment of their risk for the virus will help open the local economy and support the transportation ecosystem in our country and borders to mitigate our risk of exposure while traveling.

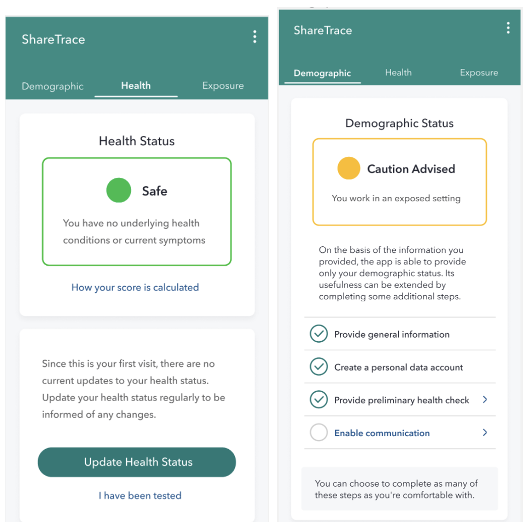

Figure 4. Examples of User Experience design of ShareTrace

Data Integration and Dashboard

We are building a set of proprietary APIs and a service layer to provide actionable information to organizations. Leveraging the unique architectural design of PDA where individual users have complete control and ownership of their personal data, individuals can choose to share certain data with chosen organizations. This enables local organizations to make necessary decisions for each individual user dynamically, such as whether to permit them to come to work that day as the condition of the user changes.

In the domain of transportation, the individualized risk assessment will help and support the transportation ecosystem in our country and borders to mitigate our risk of exposure while traveling. This public health principle of mitigation of communicable diseases helps create a more efficient way of moving a large number of passengers by air, sea and land transit. Our integrated solution will use the risk profile of individual users to quickly triage to determine who need to be further tested and who can continue on the journey. The sharing of the risk profile will be controlled by the users and will not include any detail private information on health and movement. From airports to subways, from seaports to trucking companies, our system will help expedite the movement of goods and people while providing guidance on their risk and safe-guarding and protecting the privacy of the user. Our solution will be complementary to other systems and or procedures put forward by the Transportation Security Agency (TSA) as well as U.S. Customs. As an example, presently, TSA has consolidated its screening operations as the number of passengers and flights has been reduced. Our application will help TSA expand its processes as more prospective passengers use our application to make more educated decisions on travel and TSA will then help facilitate their security in a safer environment.

Our Approach to Public Health and Health Disparities

Our technology solution coupled with our unique algorithm provides an urgently needed ability to reduce the unprecedented threat to health equity posed by COVID-19. The tight collaboration among academia, researchers, public health experts, technology teams and industry experts in our project enables our solution to confront COVID-19's public health challenges in a more efficient, effective, and scalable way. The technology enables the user to maintain their privacy as well as obtain information to mitigate their risks. As we bring information in a two-way channel it allows aggregated data to provide better quality of data to the health ecosystems using it. It provides communication to users to make better decisions on how to mitigate risk of exposure to COVID-19 and provide guidance to access their healthcare and public healthcare systems. Medicaid and Medicare, Veteran Health Administration and Indian Health Services could use our solution to better guide their members and thus help provide more equity and mitigate disparities based on social determinants of health.

The public health elements of our approach will advance in phases. First, we will refine our solution and unique algorithm by testing the tool in a limited setting with employees in one setting. Second, we will deploy the solution in settings where individuals have lower levels of access to the digital tools and trust in government and health care institutions. They include but are not limited to the elderly, racial and ethnic minorities, non-native English speakers, and people living with disabilities.

Our Approach to Interoperability

While we believe our solution is superior to others entering the market, we nonetheless see value in ensuring interoperability among these apps. Such interoperability is essential for ensuring that collectively, contact tracing apps achieve the level of population coverage needed for any of these apps to be effective. In order to offer interoperability, we need to employ two cross-platform standards. First, all contact tracing apps must use the same Bluetooth ID framework to generate contact vectors needed to produce the local contact list[2]. Second, all contact tracing apps must agree to exchange keys of the Bluetooth IDs of infected users with each other. Such exchange of Bluetooth IDs can be done with minimum exposure to security threats via API calls between servers. At the moment, there are no such standard protocols being developed and with our ability to scale our solution, we will lead such standardization efforts.

ShareTrace is designed to provide such interoperability with other contact tracing apps. When a cross-platform Bluetooth ID broadcasting framework emerges, ShareTrace users (in-network users) can collect Bluetooth IDs of other app users (out-of-network users), and vice versa. Unlike other apps, ShareTrace will store the list of other users' Bluetooth ID, along with other relevant user data, in their

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[2] Currently, Apple and Google are developing a cross-platform framework to provide such a standard. Unfortunately, Apple and Google have put severe restrictions on data portability, severely limiting the ability of individual users to share data, even with their full consent, beyond a simple contact tracing.

PDAs, not on their local devices. ShareTrace server is designed so that it can exchange keys of the Bluetooth IDs of confirmed test positive users. In the future versions, ShareTrace will provide APIs for out-of-network users.

In the near term, in the absence of cross-platform standards, ShareTrace can utilize the warnings provided by other apps (from out-of-network users) for our in-network users (assuming that our in-network user also has the other apps on their device). When an in-network user receives a warning from another app, it means that the user had contact with a diagnosed individual (that uses the other app). This is something we cannot detect since, here, the diagnosed user does not use our app. However, using the received warning, we update the risk of our in-network user accordingly and propagate that updated risk to all of our other in-network users.

4. Privacy Analysis of Our Solution

ShareTrace provides a unique structure that protects user privacy as well or better than the two other models proposed by Apple/Google and MIT SafePaths, while at the same time offering substantially more data portability and user control, which are absent in other models.

To start, ShareTrace uses privacy-protective protocol similar to that of the Apple/Google model that permits users to consent to broadcast, rotating, anonymized Bluetooth IDs at prescribed intervals and collect those same anonymous identifiers from other users to identify potential contact that could lead to exposure without identifying themselves or other users. ShareTrace differs from the Apple/Google model by using PDAs to store that information as well as self-reported symptoms, and potentially other useful information using the HAT Microserver architecture. A PDA differs from standard cloud-based file storage (such as Google Drive or Dropbox) or an AWS/Firebase backend as it decentralizes user data storage and computation to the "edge". A PDA is, therefore, cloud-based technology for data rights, privacy protection, portability, and control for individuals.

Using PDAs, ShareTrace creates anonymized digital twins for each user. A user's PDA acts as a proxy between the real identity of the user and the node of an interaction graph on the ShareTrace server. Since the user has full control of her PDA, the user's PDA behaves as a trusted entity on behalf of the user on the ShareTrace server.

Individual users can store any number of Covid-19 or other related personal data (user-generated, machine-generated, or third-party provided) into their own PDA securely and privately. Individual users maintain complete control over the data stored in the PDA and can elect to selectively permit health authorities or other applications permission to access any part of their information and also to add new information into their own specific app folders in the PDA. PDAs also enable individuals to install pre-trained tools (supplied by organizations or data scientists) to generate "edge" analytics and private AI insights, where the output data is returned back into the PDA and websites and apps can ask their users to share those insights with their websites and applications. Therefore, PDAs replace the need for websites and apps to have centralized databases where they hold users' personal and private information.

5. Our Team

Our team presents a unique combination of interdisciplinary scholars with a strong track record and a strong private commercial partner with a robust business network that will enable a rapid scaling of the project. Below we provide their names, titles, and relevant experiences.

<u>Academic Team</u>

- Youngjin Yoo, Elizabeth M. and William C. Treuhaft Professor in Entrepreneurship, Weatherhead School of Management, Case Western Reserve University; Faculty Director, xLab; Former Innovation Architect, University Hospitals of Cleveland; a global leader in digital innovation working with several major global companies.
- Erman Ayday, Assistant Professor, Case Engineering School, Case Western Reserve University; an expert on cyber security and privacy.
- Amy Sheon, Research Scientist, Case Western Reserve University School of Medicine; An expert on public health and combatting digital health disparities.
- Brian Ray, Alan Miles and Judge Betty Willis Ruben Professor of Law, Director, Center for Cybersecurity and Privacy Protection, Cleveland State University; An expert on privacy law and cyber security; A member of Cyber Ohio.
- Taehyun Hwang, Assistant Staff, Lerner Research Institute, Cleveland Clinic Foundation; An expert on machine learning and AI algorithms.
- Irene Ng, Founder and CEO, Dataswift; Director, HAT-LAB; Professor, University of Warwick, UK; creator of the personal data accounts and the architect and co-inventor of personal data account infrastructure; an expert in market design economics.
- Todd Schwarzinger, Chief Commercialization Officer, Veale Institute for Entrepreneurship, Case Western Reserve University
- Daniel Ducoff, Vice President for Strategic Initiatives and Global Principal Gifts, Case Western Reserve University
- James Kingston, Deputy Director, HAT-LAB

Business Team: How

- Moreton Binn, Chairman and CEO; Former CEO, Atwood Richards; Former Chairman, XpressSpa; Founder, CEO, and Chairman of multiple international firms.
- Marisol Binn, COO; Founder, XpressSpa; Founder, Fernandes Soda Company; An executive and board member in multiple global enterprises.
- Admiral Joxel Garcia, EVP, Medical and Environmental Principal; Retired Four-Star Admiral in the US Public Health Service Commissioned Corps; Former Assistant Secretary for Health, USA
- Jeff Dudan, CDO; CEO, Dudan Brands; a franchise executive with 25 years of experience scaling complex national franchise companies.
- Nick Neonakis, EVP, Licensing; CEO, The FCC; CEO, The Great American Franchise Expo; Publisher, The Franchise Journal.
- David Sterling, CFO; CEO, Sterling Risk; Vice President and Past President of the Nassau County Police Reserves; the Treasurer of the American Friends of Rambam Hospital; a National Board Member for The American Israel Public Affairs Committee.
- Alain Maca, Advisor; Former CEO, JFK Terminal 4; COO, Schiphol Airport; former executive, KLM Airline.
- Les Cappetta, Advisor; Former CEO, SSP America; Former Chairman, Airports Council International.

6. Our Track Record

Our academic team includes leading scholars with a strong track record of complex large-scale federally funded research projects in digital innovation, machine learning, public health and cyber security. Yoo has led the entire digital health innovation strategy at one of the largest teaching hospitals in the country, tightly coordinating joint research agreements between University Hospitals and Samsung Research America. Hwang has used machine learning and AI algorithms for biomarker discovery and immunotherapy. Shon has led significant public health research initiatives in Michigan and is a national leader in public health innovation and in digital inclusion for health.

The business team is business leaders who created and scaled complex public and private-sector solutions to address pressing societal needs. They collectively have unparalleled experience and networks to create and scale complex solutions globally. Binn has founded and grown significant international enterprises. Admiral Garcia is one of the leading authorities on public health worldwide, having led the global fight against HIV/AIDS, pandemic influenza planning, vaccine preventable diseases, among others. Maca was CEO of JFK Terminal 4 during 9/11 and led the efforts to create new safety procedures post-9/11. Dudan and Neonakis have launched dozens of successful startups and are experts in rapidly scaling national businesses that require local fulfillment.

Our solution is built on HAT Microserver architecture, developed with over £10m of public and private funding and through a research partnership among 9 UK Universities (including Warwick, Cambridge, and UCL) and, most recently, Case Western Reserve University. The research spun out via [Dataswift Ltd](), a commercial organization, and the [HAT Community Foundation](), it's governing body.

7. Our Pilot Plan

We will pilot our solution in two phases; regional and then national. Phase One will be rolling out our solution in Ohio, beginning with an international airport and a mid-size city in Northeast Ohio. We will quickly expand our pilot in other cities, businesses, public health authorities, and schools in Ohio. The plan for the initial proof of concept stage is well underway. We have already started working with the mayor's office of the city to closely coordinating a plan to introduce the concept of personal data privacy and ownership, the implications of surveillance capitalism, and potential benefits of privacy-preserving contact tracing tools like ShareTrace. We will deploy ShareTrace to city employees, two corporate employers in the city, and employees at a youth summer camp. We will coordinate with the public health department of the city and county to provide Covid-19 testing to validate and continue to improve the model. The outcome of the proof of concept with the city will become our model of deploying our solution with our public partners.

For the proof of concept study at the airport, we are designing an integrated system that involves a proprietary version of ShareTrace with a proprietary machine learning algorithm to triage passengers to be tested, an airport dashboard for rapid check-in process, and a network of national laboratories to perform Covid-19 tests for passengers with suspected infections. The 4 candidate airports are in negotiations for the pilot scheduled in mid-July. The outcome of the airport proof of concept will be the model that we will use to deploy our solution in the private sector.

By the end of the first phase of the pilot, we will introduce our solution throughout Ohio covering all major sectors of its economy. By the end of the first phase of the pilot in Ohio, we will develop a plan for nation-wide roll out. The plan will include how to work with different sectors of economy including major airports, state and local governments, schools and universities. We will also have a fully tested ShareTrace tools with enhanced algorithms. We will have a fully developed business model that offers universal access to our solution to all Americans.

Phase Two of the pilot is to implement the nation-wide roll-out plan by working with 50 states, based on the model developed from the first phase of the pilot. By the end of the second phase, we will be ready to operate nation-wide.

8. Beyond Pilot

Our scaling plan beyond the two phases of pilot has three key elements that are important for most digital innovations: (a) user-based network effect; (b) learning effect; and (c) data-network effect.

User-based Network Effect

Like any other digital innovations, the value of ShareTrace will grow as its installed user base grows. Upon the successful completion of the two pilot studies, our business team will mobilize their nation-wide network to scale the system to the nation's top 50 airports and tens of thousands of franchised small businesses" by the end of the year. Additionally, we have already started our discussion with one of the largest counties in Ohio to deploy ShareTrace for the county's contact tracing efforts. We plan to expand our pilots in other public health contexts, such as universities and religious organizations. We believe that we will be able to create a massive nation-wide network effect through our business team's nation-wide network.

Learning Effect

Our plan includes creating a closed-loop of Covid-19 testing through a national network of laboratories. ShareTrace will provide a secure API to directly acquire the test results of individual users into their PDAs. The availability of ground truth, together with a large volume of user- and machine-generated data, used to infer the spread of viruses through networks in communities, will allow us to apply the latest machine learning algorithms to continue to improve our models. In turn, these data can be made available for other public health agencies. The unique distributed architectural design of HAT Microservers allow us to deploy select algorithms at the edge so that individuals can realize full benefit of these models, while assured of their personal data privacy.

Data-based Network Effect

Data-based network effects can be created when a multiplicity of data can be combined to gain novel insights that are not available when only a single source of data is available. Scientific communities' ability to model and predict the behavior and impact of Covid-19 is still very limited. However, what is clear is that the unprecedented speed and scope of the infection of the viruses requires us to explore not only clinical, but also biological, social, behavioral, and psychological data. In the current dominant model of personal data, gaining access to such a diverse set of data is impossible. ShareTrace, with its use of PDAs, makes it possible, particularly as we gain traction with users who learn about the privacy-preserving benefits of PDAs. As users are in full control of their own personal data, scholars and digital health service providers can ask individual users to permit them to deploy pre-trained algorithms into their PDAs for the delivery of crucial insights which mitigate personal and public health risks. We already have several of those data sources identified in our roadmap.