BIOTAGGING AND ADVANCED TRACEABILITY

TRACING THE PROPAGATION OF AEROSOL WITH BIOTAGGING

REPLY [MTA, STAR: REY] specialises in the design and implementation of solutions based on new communication channels and digital media. Through its network of specialist companies, Reply supports some of Europe's leading industrial groups in Telco & Media, Industry & Services, Banks & Insurance, and Public Administration to define and develop business models, suited to the new paradigms of Artificial Intelligence & Machine Learning, Big Data, Cloud Computing, Digital Media and the Internet of Things. Reply services include: Consulting, System Integration and Digital Services.

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Reply's experiment based on Advanced Traceability simulates the spread dynamics of COVID-19's main transmission vehicle in enclosed spaces.

TRACING THE PROPAGATION
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A GAME CHANGER IN AIRFLOW TRACING

The term **BioTagging** refers to DNA-based markers (and other chemicals) which are applied to products to guarantee their traceability.

An **Advanced Traceability** solution that fits perfectly into what is known as the Deep Tech ecosystem: a set of innovative technologies based on scientific research (Deep Science), designed not only to generate a profit, but also to help achieve truly significant progress for humanity and for the planet, based on collaborative logic. A market that, in 2020 alone, raised an impressive $60 billion in investments.

Biotags consist of distilled water, food-grade, watersoluble ingredients, and DNA. The FDA confirmed Generally Recognized as Safe (GRAS) status for this technology, which uses short, non-coding, non-living DNA sequences. Such DNAtagged particles can safely mimic the mobility of airborne pathogens by simulating the chemical composition of human saliva and aerosols. It is possible to use such tags to simulates transmission of airborne pathogens via a spraying action that approximates human coughing and sneezing and an air sampling action that approximates human inhalation. Each spray creates a distribution of tracer particle sizes consistent within human respiratory droplet and aerosol range. Meanwhile, veriDART™ employs an air sampler with a vacuum flow rate similar to breathing that pulls airborne particles on to a filter specialized for small aerosols.

It is now well known, and confirmed by bodies such as the WHO and the Italian National Institute of Health, that **saliva droplets are the main transmission vehicle of SARS-CoV-2**: the droplets can be directly inhaled by people after they aerosolize, or they can settle on different surfaces, such as hands or other objects, and, through contact, facilitate the spread of the virus.

In fact, it is sufficient for a person infected with SARS-CoV-2 to speak, cough, sneeze or blow their nose to cause the formation and diffusion of **aerosols** (liquid micro-droplets or solid micro-particles nebulized in the air) containing a **viral load** (virus concentration per volume unit).

BioTagging is the first technology capable of simulating the flow and mobility of aerosols, and thus the only tool that safely enables an understanding of how pathogens move within an enclosed and shared space such as an office, school, manufacturing plant or hospital.

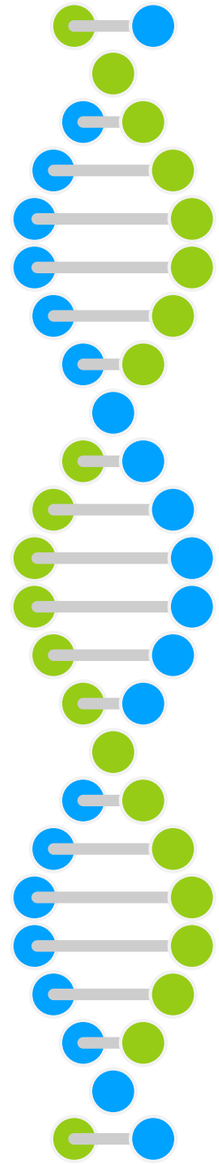
While it is virtually impossible to completely neutralize the average viral load of an environment where one or more sick individuals are present, current recommendations and guidelines for the prevention of contagion in enclosed spaces are based on the general assumption that **ventilation** is the most effective measure to dilute the potential viral load when sick individuals are present.

Ventilation can primarily take place:

- Through natural **aeration** of the space, by opening windows (external air only).
- Through a **mechanical ventilation** process, thus introducing a mixture of external air and internal air recirculated through the air conditioning and/or the ventilation systems. The use of air that is already present in the building generally leads to a significant reduction in energy use because the air will – at least in part – already be at the correct temperature, namely warm in the winter and cool in the summer.

In compliance with what is known as the A.L.A.R.A. principle (As Low As Reasonably Achievable), public authorities and competent bodies recommend introducing only air from outside and keeping the recirculation systems off.

In reality, opening windows is not an absolute guarantee as it is not possible to control the quantity of incoming air, nor its path within the shared space, and moreover, one may be sacrificing other requirements such as energy savings or comfort.



HOW DO WE DEFINE THE ACTUAL AEROSOL FLOWS OF A BUILDING-PLANT SYSTEM IN A SCENARIO CHARACTERIZED BY COMPLEXITY, HETEROGENEITY AND UNCERTAINTY?

If it is not possible to precisely calculate such variables as the emitted viral load (talking, breathing or sneezing) from an infected individual or to define, based on the specific duration and frequency, the impact of micro-events such as small movements and doors left open or the effects on the layout of offices or the degree of maintenance of the recirculation system, and so on...

SO HOW CAN WE ENSURE THAT VENTILATION THROUGH WINDOWS IS THE MOST UNIVERSALLY VALID SOLUTION TO REDUCE THE LIKELIHOOD OF CONTAGION?

As has already happened in the world of global supply chains, BioTagging has the potential to be a true revolutionary **game changer** in the fight against Coronavirus as it is the only technology capable of detecting or simulating the behavior of aerosols and is thus clearly much more effective than solutions relying on sensors or tracer gases.

Reply, in collaboration with the California-based **SafeTraces**, has not only **demonstrated the validity of BioTagging in aerosol tracking** through a series of experiments that used SafeTraces' patented technology. Reply has contributed to making this technology more mobile, creating the first testing service of aerosol flows at a European level, supporting building managers and managers of ventilation systems for air conditioning.

HEALTH AS AN INFORMATION FLOW

Reply has added a digital component to an existing DNA-based solution, veriDART™ by SafeTraces, a solution based on DNA science, technology, and analytics to provide critical information to clients and service providers on aerosol mobility and the infectious aerosol exposure risk in their buildings. veriDART's proprietary airborne tracers safely mimic the chemical composition, particle size distribution, and mobility of viral emissions from coughing and sneezing. The solution uses edible, invisible ingredients that are FDA Generally Recognized as Safe (GRAS) and are well below the OSHA- and NIOSH- safe exposure limits.

Reply's digital component **simplifies the testing process** and, therefore, the tracking of aerosol flows within a specific shared environment, in order to **help risk managers to define the most effective configuration of systems, spaces and procedures to reduce the risk of infection.**

THE EXPERIMENTATION PROCESS

REPLY'S EXPERIMENT – COMPARISON OF TWO SCENARIOS

We will illustrate here the test performed at the beginning of 2021 in the offices made available for this purpose by one of Reply's partners. The analysis focused on 8 key areas: an office, a small meeting room, a reception area, a waiting room, a bathroom, a break room, a large meeting room and a corridor.

The aim of the simulation was to compare the aerosol mobility dynamics in two different ventilation scenarios in order to identify the one with the lower risk of infection, with the additional variable of opening and closing the doors:

Recirculation ON (Doors closed / Doors open) – the first test was done with the air recirculation system turned on (with air coming both from outside and from inside the building, reintroduced after being filtered by the recirculation system);

Recirculation OFF (Doors closed / Doors open) – the second test was carried out one month after the first, with the recirculation system turned off, in other words, with air introduced exclusively from outside the building (and which therefore had to be completely heated or cooled each time).

Once the building floor was mapped, thus identifying the different rooms (with their related intended uses), the corridors and the type of ventilation system installed, the Reply Team placed **8 origin points** (aerosol emitters) in the 8 areas outlined above, in order to simulate the production of saliva droplets released by infected individuals.

The Team then placed **12 sampling points** (air samplers), selected to best identify the areas in which healthy individuals are likely to station, thus assessing their risk exposure.

Near the origin points (OPs) a water-based solution containing minute amounts of BioTags (DNA) was sprayed to simulate a cough or a sneeze.

A different biomarker was used for each dispenser in order to reconstruct the aerosol flows in both scenarios with maximum precision.

Air samplers were positioned at different sampling points (SPs), each equipped with a cotton swab. Each SP was configured to aspirate air at the same respiratory rate as a healthy person under normal conditions (expressed in litres per minute). Moreover, the swabs were used to **simulate the filtering capacity of an average pulmonary system**, **thus collecting the circulating BioTags.**

The aerosol particles, nebulised at the OPs and containing the traceable markers, were circulated for about 30 minutes, both with the recirculation system turned on (Recirculation ON scenario) and with the recirculation system turned off (Recirculation OFF scenario).

At the end of each test, an **RT-PCR** (reverse transcription polymerase chain reaction) analysis was carried out, in order to determine the quantity and origin of the BioTag particles deposited on the different cotton samples and compare the two scenarios (ON/OFF).

It is worth emphasising that **the technique used for the detection of the BioTags and the nasopharyngeal swab, the gold standard test for detecting COVID-19 infections, are both based on the same, widely used molecular analysis technique**: the polymerase chain reaction, commonly referred to as PCR.

THE FINDINGS: AT TIMES COUNTER-INTUITIVE, YET ALWAYS USEFUL

As previously described, to carry out the experiment a water-based solution was used containing minute amounts of DNA.

The solution was sprayed at the OPs and subsequently collected at the SPs to measure the percentage reduction of BioTags in terms of particles per litre on a logarithmic scale (this scale makes it possible to compare positive real numbers characterised by very wide ranges of values).

Given the starting baseline at the SPs, equal to zero, the presence, for example, of 100,000 particles per litre on the swab means that, on a logarithmic scale, there was a reduction in the order of magnitude of 1 going from 10^6 (1 million) to 10^5; a reduction in the order of magnitude of 2 (so $10^{6-2=4} > 10^4$) corresponds to 10,000, and so on ...

The experiment that was carried out provided a series of results which, on the one hand, confirmed expectations and, on the other hand, produced a number of counter-intuitive results. **In both cases, however, having this information made it possible to implement the most appropriate corrective measures, both in terms of behavioural recommendations and technical interventions.**

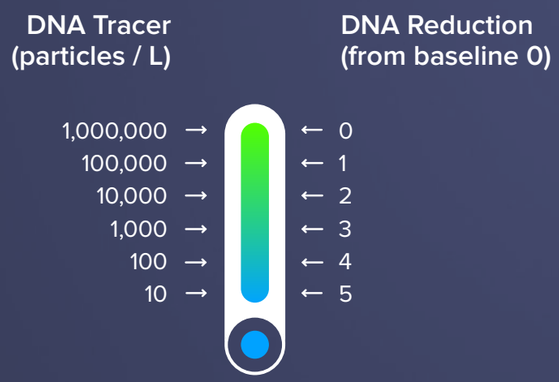
Some of the insights that emerged:

- It was possible to confirm that the areas with the doors kept tightly closed were **well isolated** with the exception of the bathroom which, acting as a sort of extractor hood, attracts aerosols from the outside without releasing any.
- The presence of a **natural airflow** was confirmed from north to south, caused by a leakage through the technical wall located on the north side. This characteristic alters the movement of air and, for this reason, the tags released on the north part of the floor were detected in the area to the south, but not vice versa. **Thanks to the experiment that was carried out, for the first time the building managers were able not only to confirm the presence of this leakage but also to clearly observe its impact.**
- **Contrary to expectations**, a reduction – albeit minimal – of BioTags was detected with the Recirculation System ON (both with the door closed and open) compared to the Recirculation OFF scenario. More precisely, **with the recirculation system turned on, it was possible to reduce the quantity of tracers inside the office**, while with the recirculation system off, the quantity of substances remained the same.

In reality, an infinite number of scenarios can be defined, which vary, for example, based on the **type of building and the system installed** (air conditioning systems with or without a ventilation function, radiant floors, fan coils, etc.), the different combinations possible in terms of opening and closing doors and windows, etc.

More importantly, the value of this experiment does not end with the timely and potentially decisive outcomes that would not otherwise have emerged. Instead, it consists in laying the foundations for a new type of analysis, enabled by technological innovation.

DATA-DRIVEN VERIFICATION



RISK DIAGNOSTIC INDICATOR

A value between 0 and 1.5 indicates a 90 to 95% reduction of BioTag particles per litre: this range is defined **high risk**.

A value between 1.5 and 2 indicates that a 99% reduction has been achieved, a result considered to be of **intermediate risk**.

From a value of 3 onwards, the reduction level is 99.9% and is considered to be a **safe range**.

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CONCLUSIONS AND RECOMMENDATIONS

AEROSOL FLOWS REQUIRE A TAILOR-MADE CONFIGURATION. WITH REPLY, THIS IS POSSIBLE.

The experiment that was carried out did not – in all cases – confirm expectations, for example showing that, in some circumstances, the use of recirculation systems can improve safety and well-being where these are properly maintained and managed.

What therefore clearly emerges is that there is no such thing as the best strategy: each case is unique and is very closely tied to the specific characteristics of the single location and of its various interdependencies.

Several software solutions capable of simulating the fluid dynamics of a building are already available on the market. However, Reply's integration with the veriDART™ solution is the first that makes it possible to determine these flows in an empirical way, thus enhancing the analysis ability of current technologies.

Being able to detect anomalies in a ventilation system with certainty makes it possible, in turn, to identify areas that are protected to a greater or lesser degree, to test suspect air movement inside a building and, more generally, to i**ncrease the knowledge and analytical skills of the building manager, who will thus be able to take more effective, accurate and targeted measures and decisions**.

With the increase in experimentation, it may be possible to partially model the various configurations, identifying compatible buildings in terms of their intended use or architectural structure (for example, a greater presence of windows and metal compared to masonry walls results in less insulation and better airflow).

FROM THE MEETING ROOM TO THE OPERATING ROOM

The veriDART™ solution delivered by Reply can map out the airflows of any enclosed environment, regardless of the type of building, placing an increasingly stronger focus on people's health.

Indeed, it would be interesting to use this technology to test the effectiveness of negative pressure within the Covid ward of a hospital, dispersing the BioTags in the ward and/or near the doors to verify whether the biological marker does not actually spread to other areas.

Or it would be possible to test the compatibility of an emergency care unit layout (between the entrance, a waiting room and a ward used for treating patients who are most at risk) and the actual trend of airflows. What if there was a draught, arriving from the outside of the building, that was able to reach the area where vulnerable patients are treated?

TECHNOLOGY-ENABLED HEALTH AND KNOWLEDGE

Reply offers its services as a technological partner to initiate and help customers manage this type of experimentation inside buildings, with the aim of improving planning processes and allowing risk managers to carry out comparative tests through the collection and display of data.

These past months have shown how knowledge of the virus and its effects, on and between people – enabled by scientific and technological progress – is absolutely crucial to ending the pandemic: the global vaccination effort currently under way constitutes an extraordinary goal but having a timely and in-depth understanding of the propagation dynamics of the main vectors characterising the Coronavirus can also prove to be a decisive factor.

Once again – as was also the case with the launch of the first Advanced Traceability trial at a European level focused on the Food sector – **Reply** has not only bet on the integration and application of different technologies in a field as unexplored as it is important but was able to transform the experiment it had carried out into a solution capable of generating insights and of creating real value (social, environmental and economic), starting from the important goal of protecting human health.

SafeTraces, a US technology company, harnesses the incredible power of DNA to deliver veriDART™, the market leading solution for verifying safe indoor airflow. By leveraging veriDART™, customers throughout commercial real estate, education, and healthcare facilities are able to target capital expenditures to the highest value opportunities and stay in control of air safety.
To learn more visit, **www.safetraces.com**