

NATO MODELLING & SIMULATION CENTER OF EXCELLENCE



ANALYSIS OF SOFTWARE AND TOOLS
TO SUPPORT CONTAINMENT AND CONTROL
OF COVID – 19 "CORONA VIRUS" THROUGH TECHNOLOGY

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BACKGROUND

The situation that we are experiencing in this historic moment is both particular and complex. It is particular because in the memory of modern mankind, the last pandemic took place in the early 1900s (Spanish influenza), something current generations have never experienced, and the only usable information about those derive from historical memoirs that if available are of value to scientists, but not to the average global population.

The situation is also complex because the cultural, technological, socio-political and all contemporary economic interrelations are far greater than those that existed in the early 1900s, being so intertwined and accelerated that the surrender of one causes the surrender of others in a sequential and exponential manner.

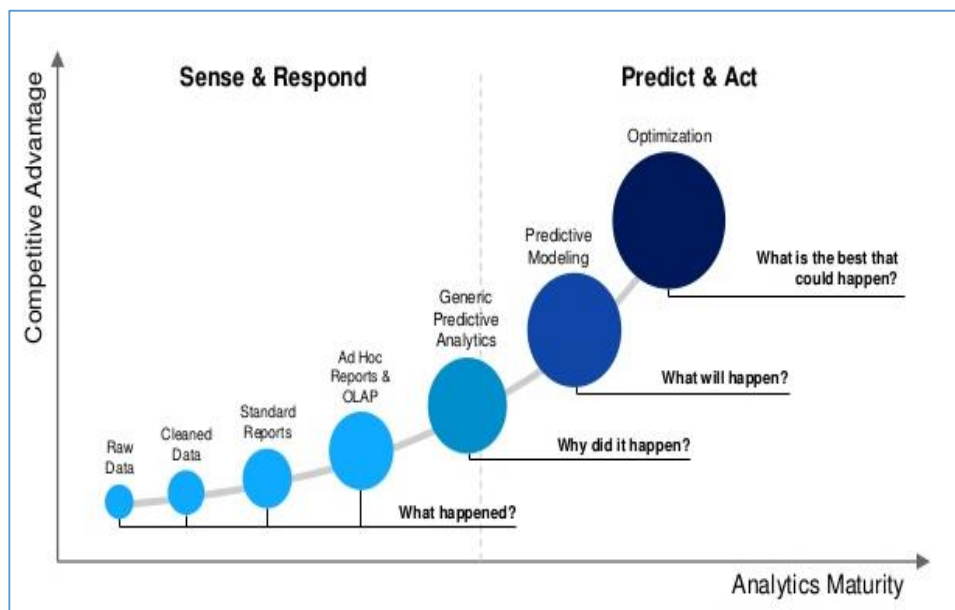
What the present day gives us to combat such situations, is a far greater ability to apply



technologies compared to the past. The evolution of techniques and the maturity of analysis capabilities, makes available today such tools as Artificial Intelligence, Modelling & Simulation, predictive and prescriptive analysis (augmented analysis) to improve decision support capabilities, optimize the use of data, etc.

Predictive analytics, which can be applied to different situations, embraces a variety of statistical techniques such as machine learning and data mining to analyze events and provide possible predictions about the future or events as cause – effect relationships with the best possible success rate. Predictive models typically investigate patterns

and structures in historical data to identify risks and opportunities. Models look for relationships between the various factors that allow risk assessments or those potentially associated with specific conditions. In this they allow better decisions to be made because "deciders" are better informed. This type of analysis, for example, helps to influence the organizational processes of government structures to optimize choices and improve the use of resources and the effectiveness of the choices themselves. These types of analyses are used in marketing, financial



services, insurance, telecommunications, retail, tourism, health, government and certainly in the military sector.

Prescriptive analysis is the last stage of the analysis process after predictive analysis. This is normally based on the robustness of previous analytical processes and tends to specify actions to achieve a specific goal or effects related to a specific decision. Using mathematical applications seeks to maximize the results of previous phases, improving decision-making processes to achieve unique goals.

IDENTIFYING SUPPORTING TECHNOLOGIES

The demand for technological support, which has come from many national and international parties, calls for the identification of ways of mutual assistance in order to overcome the critical moment we are facing. Possible responses to COVID-19 go primarily through emergency medicine and broader medical science and research, but other technologies can contribute. The NATO M&S CoE does not have any specific health expertise or M&S tools in that field, but can be a supporting partner to experts in the virology/medical field in using M&S to conduct analysis. With this perspective, we have been working with the guidance provided by NATO STO and looking in the M&S and Command and Control sectors to identify solutions that could be implemented based on these criteria:

- **Efficiency:** *Summarize techniques, protocols and approaches developed in response to the crisis that could increase the efficient use of scarce medical equipment (e.g. ventilators, masks, etc.)*
 - a. *Analysis tools, prioritization, logistics, M&S etc.*
 - b. *.....*

- **Effectiveness:** *Identify tools, equipment and analytical approaches that could be shared with allies that would address the needs in such areas as medical, logistics, forecasting, security and analysis*
 - a. *3D printing (e.g. sharing of respirator designs), M&S, etc.*
 - b. *M&S of mid to long term implications*

The aim is to improve NATO's response to the possible needs of allied nations by sharing information on innovative and quickly applicable tools to support medical or logistics distribution efforts and provide insights and advice through M&S predictive analysis to help authorities' decision-making better cope with the pandemic.

CONSIDERATIONS

Our analysis looked at some tools already on the market and therefore quickly usable. Technological innovation can offer state-of-the-art tools useful for epidemic prevention and control, with analysis techniques and algorithms that can meet the additional need for monitoring, prevention and control of COVID-19 while tuned for the principles of privacy and safety. Digital solutions available for telemedicine, and home care of patients and technologies based on innovation for "active" monitoring of contagion risk, can be coordinated to be rapidly adopted and used in order to improve the results in terms of monitoring and combating the spread of COVID-19.

The systematic use of emerging technologies (data analytics, artificial intelligence) and telemedicine (teleconsultation, tele-examination) has already proved in other situations around the world to be a very effective weapon for monitoring and containing the contagion.

AI and Deep Learning could be used for: diagnostic support; to formulate new medications; or in support of medical robotics. These technologies have investigated the synergistic union between computational modelling and high-throughput experiments to create complex biological scenarios and models of highly complex bacteria and viruses, but there remain many obstacles to overcome the difficulty. Ultimately finding a vaccine will be an outcome where technology provides leverage for the effort.

NATO M&S CoE DIRECTOR
Ph(D) Col. Michele TURI

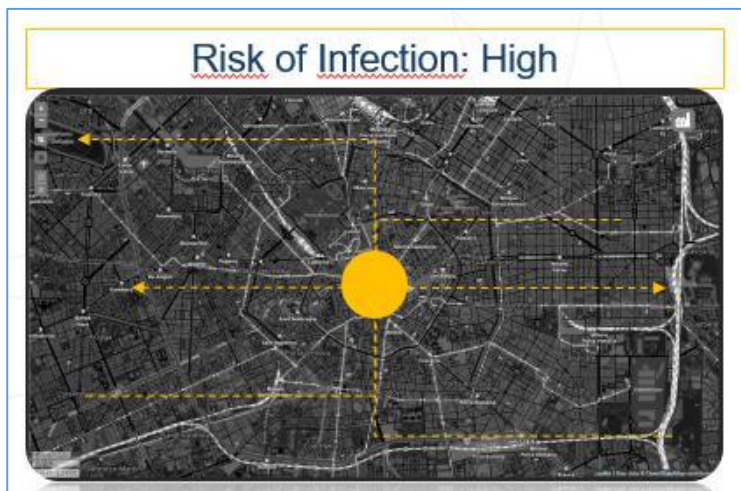
SOFTWARE AND TOOLS

1. HITS – Human Interaction Tracking System

This software is produced by CY4GATE (Electronics Group). It is a complex structured web platform that allows you to identify potential areas of infection or known outbreaks and predict unknown ones. It relies on tracking the cell phones of infected people who have been identified and treated and reconstructs the history of cell phone pathways to check where the person was and where it may have led to the infection. The tracking takes place through a free app downloadable via Google store that is installed on the individual's mobile phone after it has been treated and to which he has given this consent; the application remains automatically tracked as it happens for many cookies already present on normal websites and sends traces to a server that collects data, without violating the privacy of the person and keeping the individual anonymous.

The software then allows:

- Reconstruction of the journeys of infected patients;
- Restriction of access to hazardous areas and services with precision;
- Identification of areas at high risk of infection;
- Forecasting new areas of infection.



In addition, the App can monitor the patient's health, use phone cells and WiFi to monitor the movements of infected people and also ensure via Bluetooth suspected cases of contagion due to excess proximity to other individuals.

Areas and people are represented on detailed maps that use explanatory charts and show the progression of the situation.

The system as a whole also contains other features associated with Artificial Intelligence to ensure the "decision maker" with a high approximation also a prescriptive analysis of the moment, and the possibility of entering specific government data, data related to the number of hospitals, available beds updated automatically, 3D study of areas where to place field hospitals, storage areas for materials, evacuation areas and not least also the management of medical personnel.

In addition, the App can monitor the patient's health, use phone cells and WiFi to monitor the movements of infected people and also ensure via Bluetooth suspected cases of contagion in close proximity to other individuals.

Areas and people are represented on detailed maps that use explanatory charts and show the progression of the situation.

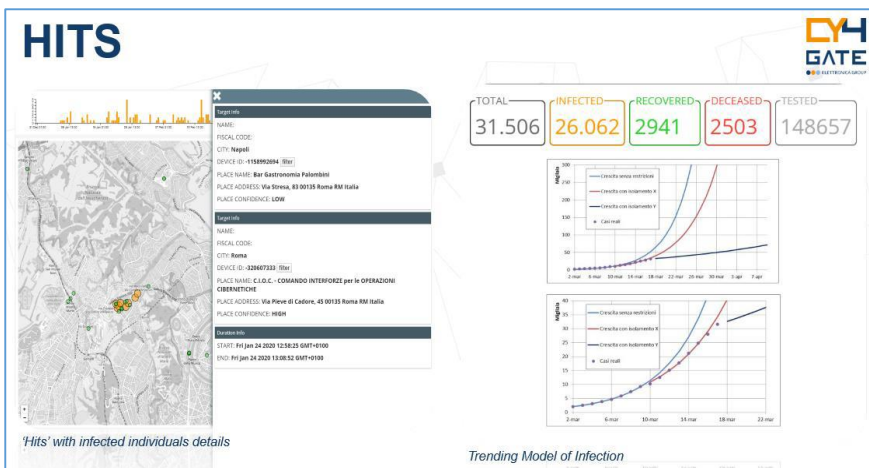
The system as a whole also contains other features associated with Artificial Intelligence to ensure the "decision maker" has with a high approximation a prescriptive analysis of the moment, and the possibility of entering specific government data; data related to the number of hospitals with available beds updated automatically; 3D study of areas to place field hospitals, storage areas for materials, evacuation areas and not least the management of medical personnel.

The combination of real data, data relating to infected people, reconstruction of journeys to detect new outbreaks and data of the infection make HITS software a very powerful tool that is not limited to a mobile application, which is only a secondary aspect, but outlines professional, modular and scalar software with large capabilities even later since it is interoperable with other SW information management , data exchange and is interfaceable with the main military C2 systems.



HITS is also optional with another software, **IGEA – Integrated Guest Easy Access**, designed for the next return to normality by efficiently managing flows of people in frequented places or gathering. The SW IGEA is designed as an integrated system, able to manage a set of sensors, algorithms and tools that can balance access constraints, the needs of speed and security of service by customers,

the logistical and security issues for queue management and the costs of any more or less invasive tests, discriminating against those with lower risk index through: collection of the anonymous identifier of the person's phone, the result of an infrared sensor that collects body temperatures. The analysis of the data through the IA calculates the

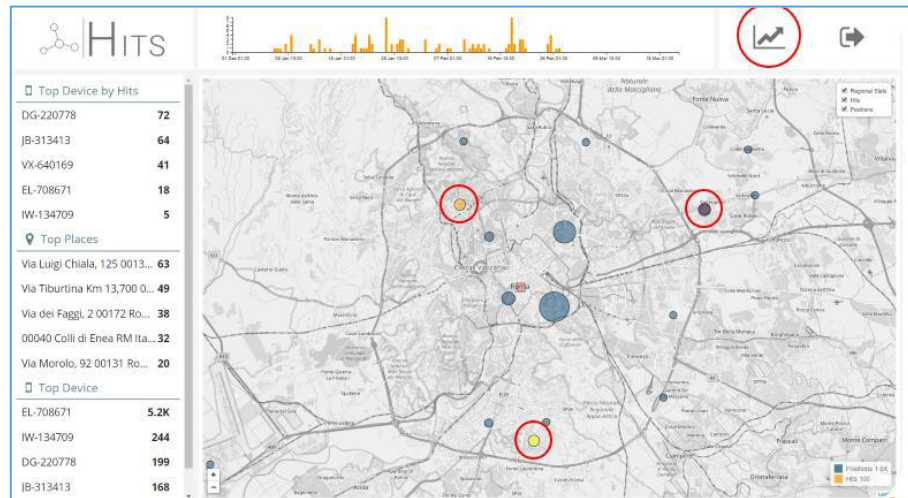


risk index by cross-checking the data collected with any historical data that may be present.

HITS software is a great example of adapting and responding to the emergency needs we are facing. It's not just an app, but it's an integrated system. The representation of SW HITS reproduces a political – strategic situation but also of public order and military control, putting together different domains and having the possibility to interface with different data bases of various nature to be able to efficiently and effectively manage resources in the infected environment of reference or the creation of a synthetic environment able to assist decision making, facilitate mission rehearsal, analyze situations and bridge the individual domains. This ensures that the leadership chain has an important capacity of SA and IS (Situational Awareness and Information Superiority) to conduct containment, restriction and responsiveness activities even through the presentation of models

considering that in a multi-technology domain, M&S support represents about 70% of systems, applications solutions and support.

The costs of SW are also appreciable considering that the full annual license for a whole system, first installation, maintenance and basic operator course is less than € 100K and the software is already available.



The power of the SW HITS and its possible future expansions, can count it

as an important tool for a number of future activities also related to the military and civil CBRN sectors, the medical containment and sickness control tool and a instrument for logistics management and first intervention for the Civil Defence during this types of situation or others (earthquake, tsunامي, immigration control, etc.).

We must consider that we are not talking about a crisis that will end tomorrow but that will have potential implications in the near future of six months, a year or more for which we will have to be able to understand and respond proactively with appropriate tools.

The common operational picture (COP), represented by SW HITS, can be integrated immediately or in the future, in a multidimensional domain with other state realities and interact to reproduce and describe the whole series of situations related to driving and controlling a containment and sanitation activity. This integrated and interoperable representation in parallel with the command and control systems, with an adequate computational capacity and a consistent data hold, will allow to provide decision makers at the various levels, the right information at the right time, to conduct better situational analysis and make the most accurate decisions.

2. SOFTWARE SOLUTIONS FROM GENOVA UNIVERSITY

Software based on Simulation, Modeling, AI and Intelligent Agents that address issues related to CBRN with special attention to Pandemics and Global Crisis.

Agostino Bruzzone, Simulation Team, SIM4Future & Genoa University

VESTIGE: Virus Epidemics Simulation in Towns & Regions for Infection Governance during Emergencies, Year 2020 - Italy in Joint Cooperation with other Countries

The proposed Technological Solution is applied to Pandemics and it based on the innovative Strategic Engineering to address pandemics, the proposed approach integrates Simulation, Artificial Intelligence and Data Analytics in closed loop to support decisions based on scenario evolution and human behavior and population modeling. The current approach has been already demonstrated in relevance to Smart Government and several applications, including PONTUS & Decision Theatre, have been already employed in Operations and Strategic Planning as part of Smart City Project.

Therefore, the conceptual models and simulation experimentations on pandemics have been carried out by Scientists of Genoa University and Senior Partners of SIM4Future since over 10 years with specific attention to Pandemics, Epidemics and CBRN (Chemical, Biological, Radiological and Nuclear). The very innovative aspect of this solution relies on its capability to reproduce human behavior of population and interest groups, coupled by Intelligent Agents and reproducing individuals & social networks considering Age, Gender, Health Status, Social level, Education, Ethnics, Religion, Political Preferences and other attributes, including psychological modifiers (e.g. fear, stress, fatigue, aggressiveness). By this approach it turns possible to evaluate different courses of Actions and to keep forecasts about effectiveness of applied measures aligned with data collected on field and media.

<http://www.liophant.org/projects/vestige.html>

Agostino Bruzzone, Simulation Team, SIM4Future & Genoa University

TOPRO: Town Protection, Years 2020 - Italy in Joint Cooperation with Other Countries

TOPRO is devoted to support the operations related to protecting a Town or a Region during a epidemics and contamination crisis. The System reproduce People Behaviors, Units and Entities as well as activities related to Protection, Cordoning of Areas and Cities to protect them from Contaminations and Epidemics as well as planning of decontaminations and treatments and resource allocation. Entities include law enforcements, military units, health care resources, sensor networks, social media info. TOPRO allows to Identify the Critical Areas and Part of a Town at Risk, as well key points and sectors to control in case of detection of infected people and it provides support for tracking them. TOPRO is a Decision Support System able to be used for training, education as well as operational planning and operation support, Check Points Organizer and Management Tool during Pandemics and CBRN crises. TOPRO aims to support also training and operational planning for isolation and containment of epidemics.

<http://www.liophant.org/projects/topro.html>

Agostino Bruzzone, Simulation Team, Genoa University & SIM4Future

T-REX: Threat network simulation for REactive eXperience, Years 2014-2020 - Italy and Cooperation with Other Countries and in NATO

T-REX (Threat network simulation for REactive eXperience) is a MS2G (Modeling, interoperable Simulation & Serious Game) devoted to reproduce Hybrid Warfare and to be federated with other elements to evaluate the impact of these actions. T-REX reproduces urban, as well as extra urban contexts over multiple domains including land, air, sea, space and cyberspace. The models allows to consider media communications and possibility to use different assets and to experiment virtually the different decisions in terms of COAs (Courses of Actions). The T-REX was presented and demonstrated during NATO MSG ET-43 "Hybrid Warfare.

<http://www.liophant.org/projects/t-rex.html>

Agostino Bruzzone, Simulation Team, Genoa University and SIM4Future

PANDORA: PANdemic Dynamic Objects Reactive Agents, Year 2010 - Joint Cooperation Simulation Team, Genoa University Italy, CRiCS Charles Sturt University Australia, Dartmouth College, NH USA, Australia, Europe, North America

PANDORA addresses the dynamics of the spreading of a Pandemic and experiments are on-going on H1N1 influenza A virus by a joint simulation project involving USA, European and Australian R&D Centers (MISS DIPTeM, Dartmouth College, CRiCS). PANDORA proposes to use an evidence-based approach whereby statistical data (census) and ethnographic surveys are source for the model and integrated with Human Factors representing the psychological and social parameters impact on people behaviors and their reaction to containment measures and policies. PANDORA evaluates the efficacy and cost benefit of various mitigation strategies such as school closures, target anti-viral prophylaxis and other mitigation measures, level of absenteeism, and its impact on commerce, industry, economy and functioning of society as well as population attack rate, risks related to specific groups and on flows across State borders.

<http://www.liophant.org/projects/solutions/pandora.html>

Agostino Bruzzone, Simulation Team, SIM4Future & Genoa University

MINOTAUR: Multipurpose Industrial New Operator & Transport system based on Autonomous Unmanned Robot, Years 2020 - Italy and Cooperation with France, Czech Rep., USA

MINOTAUR represents an innovative concept of UGV (Unmanned Ground Vehicle) derived from the experiences made by different partners in Industry and in the Defense and Homeland Security sector also thanks to common contacts in NATO and MESAS Initiative.

The partnership involves DIME, SIM4Future Spin Off UNIGE, Prolexia (French Company) as well as University of Defense (Czech Republic), Dartmouth College for the development of innovative Autonomous Vehicles and Robotic Systems that combine arm robots, sensors, speakers and microphones for indoor industrial use / outdoor, operations and inspections in risk areas, reducing staff exposure. There are different configurations of MINOTAUR, on wheels and on tracks that have been made for different purposes (e.g. asbestos removal) and that can be quickly customized thanks to the digital twin built that allow simulating their operation. In the current case, it is assumed to take an adequate configuration to move in the wards of hospitals or areas where infected patients

are housed and use MINOTAUR to keep medical personnel at a distance and interact and monitor both them and supervise the equipment/equipment through the arm/camera and various sensors.

MINOTAUR is currently conducting tests to perform cleaning operations that could be adapted to act as cleaning of infected areas and/or decontamination. It would also be possible to use it to provide doctors with support also for interventions on infected patients outside the hospital and at home. It could also be used at check points or in support of first responders.

<http://www.liophant.org/projects/minotaur.html>

Agostino Bruzzone, Simulation Team, Genoa University & SIM4Future
CIPROS VIS: (Simulation Team Civil Protection Simulator) VIS (Virtual Interoperable Commander),
Simulation Team Civil Protection Simulator - Virtual Interoperable Simulation, Year 2014-2018 - Italy
& Other European Countries

CIPROS

is a MS2G (Modeling, interoperable Simulation and Serious Game) project for supporting Commander and Staff in addressing a Crisis within a Civil Protection Scenario. ST_CIPROS provides an HLA interoperable immersive framework for the supporting critical decision making over a complex situation respect different kinds of crisis (e.g. flooding, hazardous material spill, CBRN, fires). ST_CIPROS includes models of Population and Human Behaviors developed by Simulation Team based on IA-CGF. ST_CIPROS supports training and operates in multiple modes from stand alone to federated in HLA with other simulators.

The system is integrated with CRISOM Simulator and it has been demonstrated in NATO MSG-147 "Support to Crisis Disaster Management Processes and Climate Change Implications".

http://www.liophant.org/projects/st_ciprosvis.html

Agostino Bruzzone, Simulation Team, Genoa University & SIM4Future
ST_CRISOM: Simulation Team Crisis Simulation, Organization and Management, Year 2014-2018 -
Italy & Other European Countries

ST_CRISOM (Simulation Team Crisis Simulation, Organization and Management) reproduces the dynamics of a complex scenario where a crisis evolves. CRISOM considers the human behavior of the population in terms of evacuations, reactions due to the emergency as well as to human factors such as fear, stress, fatigue and aggressiveness. CRISOM uses the IA-CGF (Intelligent Agent Computer Generated Forces) to reproduce both civilian Populations as well as First Responders and Military units, Health Care, Civil Protection Agents & Public Infrastructures. CRISOM acts as a NCF (Non Conventional Framework) for IA-CGF and allows to reproduce Flooding Scenario over regional areas and impact on Town, Industrial Facilities and Critical Infrastructures. CRISOM could be federated in HLA with other Simulators. The system is integrated with CRISOM Simulator and it has been demonstrated in NATO MSG-147 "Support to Crisis Disaster Management Processes and Climate Change Implications".

http://www.liophant.org/projects/st_crisom.html

Agostino Bruzzone, Simulation Team, SIM4Future & Genoa University

PONTUS: POpulation behavior, social Networks, Transportation, infrastructures and industrial Urban Simulation, Year 2014-2020 – Italy

PONTUS supports decision makers in the management of critical events such through simulation and different models addressing Population behavior, social networks, transport and urban simulation PONTUS operates based on concept MSaaS (Modeling & Simulation as a Service) and it adopts the MS2G Paradigm (Modeling, interoperable Simulation and Serious Games) by using Intelligent Agents to reproduce behavior of individuals as well as social networks. PONTUS supports Strategic Planning, Operational Planning and Simulation of Operational Activities, emergencies and containment measures, crisis management, development of decision support systems. It has been applied to cases dealing with Urban Strategic Planning, Crisis Management due to Floods as well as CBRN Threats and Hazardous Material Spills in Air and Rivers.

<http://www.liophant.org/projects/pontus.html>

Agostino Bruzzone, Simulation Team, Genoa University & SIM4Future

ALACRES2 : Years 2019-2021 - Interreg Maritime 2020, Italy & France, High Tyrrhenum

The aim of the ALACRES2 Project is to activate a Permanent Virtual Laboratory able to identify, test and validate integrated emergency management procedures in the case of accidents, crises or significant accidents occurring during the loading and unloading of goods and dangerous substances. The threats include explosions, CBRN and joint crisis going across Ports, Cruise Ship Terminals, Cargo Activities, Transportations, Industrial and Urban Areas and including Media and Cyber Layers.

http://www.itim.unige.it/projects/alacres2/index_e.html

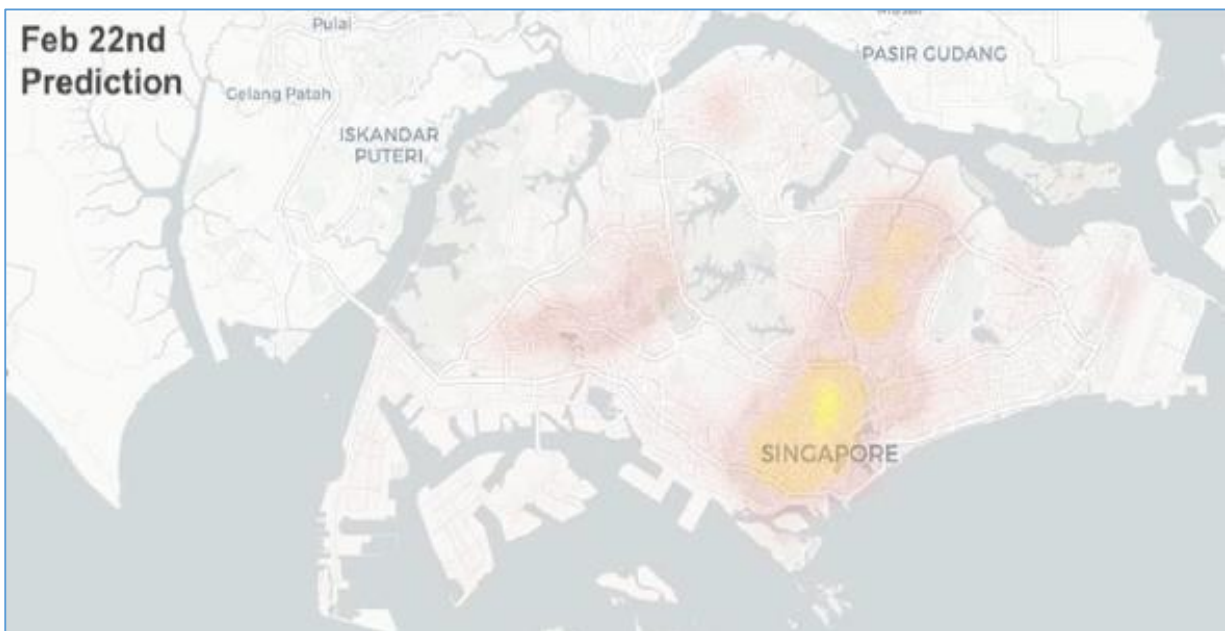
3. SPARKBEYOND AI

This Software is proposed by the SparkBeyond company. It can deliver a tactical response to virus using Artificial Intelligence. It can be used to inform social distance measures, prioritize resource deployment, adapt to change dynamics and map areas with risk of infection to help government and healthcare.

Software can generate automatic maps and insight view to monitor movement and collect data for diagnoses from individuals. It can help to predict risk at building level and help to decide how to reallocate medical personnel and resources.

By combining data on known COVID-19, carriers with global footfall data, socio-demographic data, and millions of points-of-interest, SparkBeyond's AI platform generates a dynamic heatmap that predicts hotspots of risk at the granularity of a building.

The dynamic heatmap will highlights predicted infection zones to inform government on which areas have to be closed and determine when to ramp up sanitizing efforts so the authorities can deploy resources more efficiently to areas with greater need.



4. CURRENT STUDIES AT TRENTO UNIVERSITY

At the University of Trento, Faculty of Electronic Engineering, Simulation and AI, a joint activity is underway between various research groups, to develop a fast triage system based on ultrasound. It is an automatic capture and inference system that can also be used by unskilled personnel (and therefore also in peripheral centres) to detect COVID-specific lung-level abnormalities on the basis of an ultrasound (essentially a diagnostic model). Preliminary results look good and an international network has already been formed to experiment with this technology.