Issue 12, Summer 2014

# A Global Village

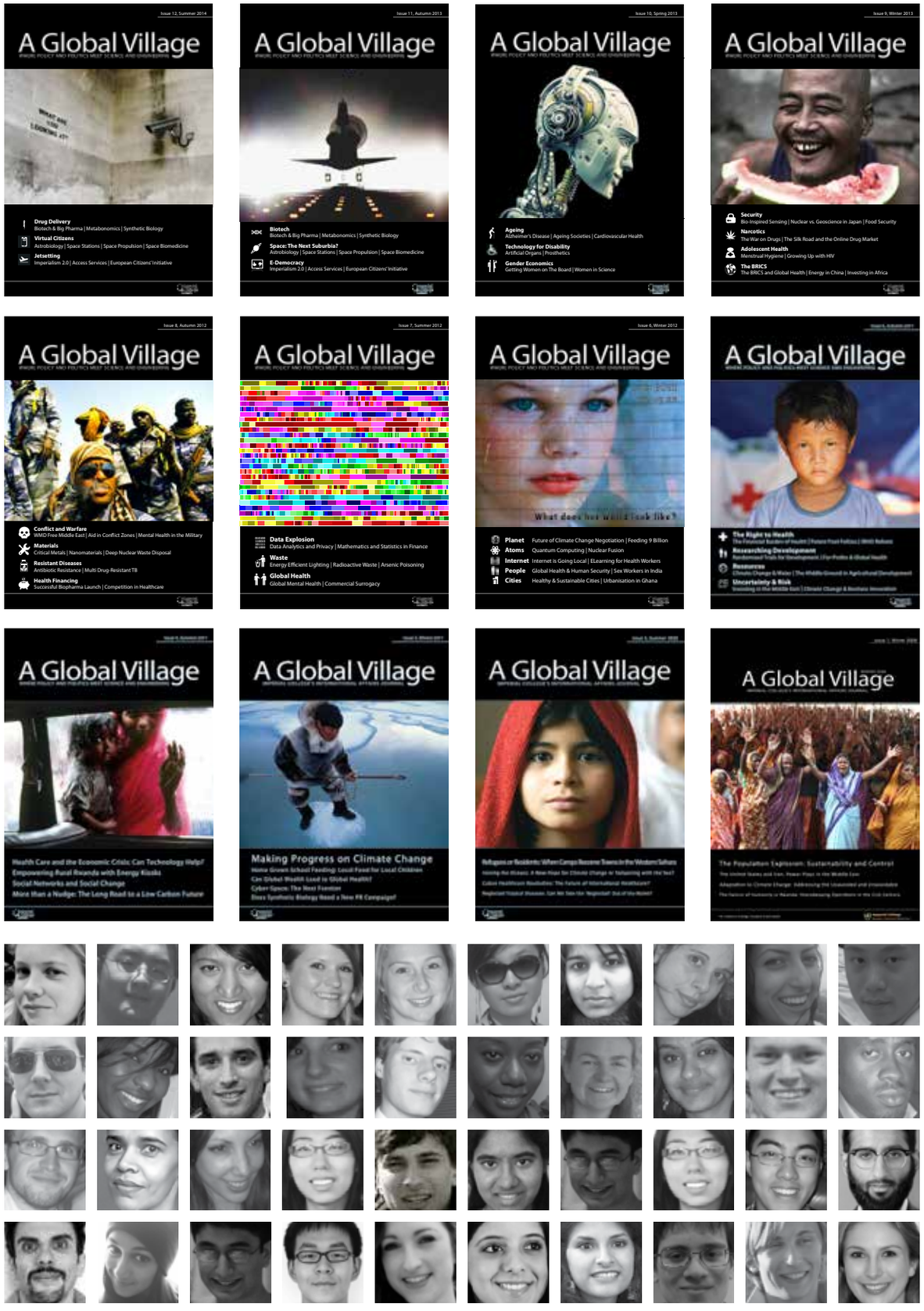
WHERE POLICY AND POLITICS MEET SCIENCE AND ENGINEERING


**Drug Delivery**
Immunogenicity | Neglected Tropical Diseases

**Virtual Citizens**
Identity | Surveillance | Health Research | Mobile Health

**Jetsetting**
Urban Traffic Flow | Virtual Drive

imperial college union




# A New Era Dawns for A Global Village

The team at *A Global Village* are excited to announce that we are entering an exciting new phase. We are currently developing a state-of-the-art interactive web platform, and will cease the print publication after this issue. Over the coming months and years we aim to use the power of the internet to cultivate a broad-based international readership, taking our niche publication to the world stage.

Established over 4 years ago at Imperial College, AGV has a long-standing commitment to working with both established and up-and-coming leaders in their field to generate high quality editorial content, with a similar focus on contemporary design and graphics. We believe that, building upon this strong foundation, AGV has the potential to contribute to the global debate on cutting-edge issues such as neglected tropical diseases, multi-drug resistance, biomedicine in space, cyber-security and climate change impact.

Since its inception, AGV has consistently focused on building a diverse range of partners including the Schistosomiasis Control Initiative, the Institute of Global Health Innovation and the Grantham Institute at Imperial College, and attract contributions from global leaders such as Chatham House. By continuing to develop strategic partnerships, in the short to medium term we aim to inform and influence the international academic and policy community. In the longer term we hope to expand to become a valuable resource for the wider public who are passionate about the most pressing global challenges in global health, nutrition, the environment and much more.

As part of this expansion phase, we are seeking new team members – so if you are a PhD candidate, or hold a PhD, based anywhere in the world and are interested in working with scientists and policy-makers who are tackling some of the world's greatest challenges, please contact us at *aglobalvillage@imperial.ac.uk*.

Neave O'Clery Editor In Chief

# From the Editors

**Drug Delivery** *Georgia Lockwood-Estrin*
With thirty thousand deaths still occurring from vaccine preventable diseases, Dr. David McIntosh discusses the issue of effective administration of vaccines and improving immune response, arguing that, from a health policy perspective, both effectiveness and possible rare negative effects need to be balanced. On the front line in global health, Prof. Alan Fenwick addresses the delivery of drugs to prevent neglected tropical diseases, which dramatically improve the quality of life of people in the poorest parts of the world. Playing a key role in the complex global process to secure finding and co-ordinate transportation and administration of donated drugs, the Schistosomiasis Control Initiative at Imperial College is leading the way towards the World Health Assembly's goal of eliminating these diseases by 2020.

**Virtual Citizen** *Mohammad Yaqub Chaudhary*
With an increasing number of real world activities being conducted in the virtual hyper-connected digital world a conception of the individual as a "virtual citizen" has been rapidly emerging. Social life has been altered in fundamental ways in less time than an individual is born and reaches maturity. The serious implications of these new relationships between individuals, governments, corporate entities and each other have already led to several unprecedented scandals, most prominently, the shocking global surveillance disclosures by Edward Snowden beginning almost exactly one year ago. This section thus addresses some of the most important issues relating to this new frontier of society and the dual nature of its citizens who simultaneously inhabit the physical and virtual world.

Authors Prof. Chris Hankin & Andrew Burton provide an overview on the theme of identity, what it means in the hyper-connected world and changing attitudes towards privacy and anonymity, especially amongst the current generation of youths that have seen online platforms traverse every stage from inception, to user bases that rival nations, to utter obscurity and death, before their own maturity. In this connection, Gerrit Beger addresses how the global youth may be empowered throughout the world by access to information and becoming digital citizens.

Richard Stallman, highlights the dangers to democracy of unlimited surveillance, provides several guidelines to ensure privacy in the design of digital systems and discusses the importance of maintaining control of computing power and data in the hands of its users and owners. Dr. Kit Huckvale addresses the emerging field of Mobile Health and Fahdah Alshaikh discusses how the internet has brought about new avenues for Health Research. Finally, Charlene Jennett and co-authors discuss how the internet is changing scientific research in general through research projects that encourage public volunteers to collaborate with professional scientists to conduct new types of scientific investigations.

**Jetsetting** *Nadia Tyler-Rubinstein*
Are we already living in the future? One thing that is often depicted in sci-fi or futuristic movies and literature is exciting progress in transport systems. Whether it is self-driving cars, vertical road systems or novel navigating technologies. Prof. Michel Ferreira discusses the future of augmented reality driving systems and how the virtual world can enhance our experience behind the wheel. The future of road transport will also have to deal with a rapidly expanding population. Dr. Andy Chow discusses smart technology to improve traffic flow in urban environments with the view that continued development of new infrastructure will not be a sustainable solution.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|---|---|---|---|
| Editor In Chief | Neave O'Clery | Design | Antonio Torrisi |
| Editors | Georgia Lockwood-Estrin | | Lars Bergemann |
| | Mohammad Yaqub Chaudhary | | Nazeeha Hasan |
| | Nadia Tyler-Rubinstein | Editorial Assistance | Mark Chen |
| Finance | Jayraj Rathod | | Sumana Chaturvedula |
| Contact | aglobalvillage@imperial.ac.uk | | Dominik Weiss |




# Foreword

**Transport: Platform for the Global Village**

Transport shapes our society, and therefore, our lives. As the ability to travel has increased, society has evolved to take advantage of the benefits this has bestowed. As a result, our patterns of life today are quite different to those of 50 and 100 years ago. We no longer live 'round the corner' from our immediate families (not necessarily a good thing), and the fresh food on our shelves – which comes from all over the world - is replenished daily. We can travel abroad on holiday for less than it costs to take a holiday in our own home country, and our decision to buy cut flowers next week may enable a worker in Africa to have a job tomorrow. Of course, not all of these things bring benefit to all, but the complex workings behind the scenes are simply a reflection of today's Global Village at work.

Cheap and efficient transport links are the foundations of this new world. Like all things, they come with good and bad attributes. It is good that we can travel safely and easily, but it is not so good that in doing so we consume energy and pollute the atmosphere. Our challenge, as always, is to build on the good and remove the bad.

The emphasis throughout the history of transport has been on the provision of faster and cheaper travel through the invention of new machines. We only have to reflect on the invention of the wheel, the age of the sea, the age of the railway, the age of the car, and the age of air transport to see how this is true. But the future holds something entirely different. We are entering the age of connection – not a transport medium in itself, but an enabling technology which has the power to transform.

The ability to exchange and process vast quantities of information on the move and in real time opens the door to another great advance in the history of transport - and not a moment too soon. Our success in creating new and better transport machines has led to consumers wanting more and more access to transport, with the result that we create vastly more consumption, pollution, and congestion. As a consequence, our roads, railways, and airspace now appear to be operating at, or near, their breaking points. This is a frightening prospect – economies that do not move do not work, and dying economies wreak social havoc.

To provide more infrastructure in response to more demand has been shown on many occasions to be self-defeating. The demand simply grows to fill the available space, and all the bad things about transport correspondingly scale up. In today's environment we need a more holistic solution. Can we enable the increased movement of people and goods without adding to the available infrastructure? Indeed, can we do this whilst, at the same time, scaling down those undesirable aspects which we all deplore?

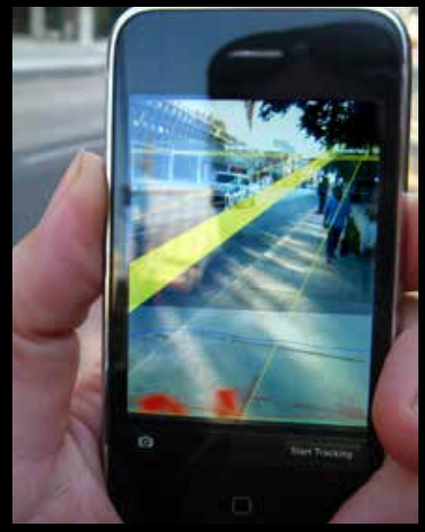
This is the goal of 'Intelligent Mobility' – a subject which looks to the new generation of 'intelligent systems' to resolve these apparent conflicts. It is a subject which has begun to receive a lot of attention recently and two articles in this issue of *A Global Village* explore some different possibilities. The changes which this approach could bring are profound, and our articles touch just a small fraction of what might be delivered in future. But this is enough to illustrate the potential and it is clearly an exciting prospect!

**Prof. John Miles**
*John Miles is the Arup/Royal Academy of Engineering Professor of Transitional Energy Strategies at the University of Cambridge. He is interested in the development of affordable, low carbon energy technologies and business models.*

# Contents









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# Improving the Immunogenicity of Vaccines

*Dr. E. David G. McIntosh AM, Imperial College London*

**It is estimated that vaccines save more than two million lives per year. However, there are still up to 30,000 deaths from potentially vaccine-preventable diseases every day. Furthermore, whilst there have been great successes in reducing vaccine-preventable diseases, a number are making a recurrence, notably, measles, poliomyelitis, pertussis (whooping cough) and tuberculosis. But, for maternal infections such as group B streptococcus and early infant infections such as respiratory syncytial virus infection, there is now hope for the development of successful vaccines, some based on adjuvants which are designed to boost weak immune response.**

Vaccines, administered globally for the prevention of illness, act by stimulating the immune system. The protection conferred by a vaccine may be short-lived or long-lived, depending on a number of factors. One of the most important is the period of time during which one is exposed to the infecting agent. A travel vaccine may need only to protect for a short time, yet other illnesses such as influenza pose a constant threat, and so one needs to be protected against this disease continuously via annual vaccination.

For reasons of immune immaturity, immune deficiency or immune senescence, an individual may not respond in an ideal way to a vaccine, and a 'boost' to the immune system would be an advantage. For this reason, adjuvants such as aluminium have been developed, and are included in a number of vaccines, for the purpose of optimising the immune response especially in younger and older members of the population, and in those with impairment of their immune systems.

**Adjuvants**

Aluminium salts are perhaps the best known adjuvants, known to increase immunity even up to a thousand fold[2], and have been in use since the 1920s. Licensed newer generation adjuvants such as MF59 and Adjuvant System 04 (AS04) are used in some influenza vaccines and one of the human papillomavirus vaccines respectively. Adjuvant System 03 (AS03), however, has been associated with the onset of narcolepsy, a rare but serious brain disorder that causes a person to suddenly fall asleep at inappropriate times, posing questions about the safety of large-scale adjuvant use.

In general, live attenuated vaccines don't 'need' adjuvants, while killed vaccines may need adjuvants and subunit vaccines benefit from adjuvants. 'Delivery system' type adjuvants, such as alum, improve antigen uptake by dendritic cells (important cells in the immune system) although their exact mechanism of action remains largely unknown[3]. It is thought that alum interacts directly with membrane lipids on the surface of dendritic cells, triggering signalling cascades that promote CD4+ T cell activation and humoral immune responses[1].


[1] Flach T. L, et al. (2011) Alum interaction with dendritic cell membrane lipids is essential for its adjuvanticity. Nature Medicine. 17: 479-487.
[2] Glenny A. T. (1930) Insoluble precipitates in diphtheria and tetanus immunization. BMJ. 16: 244-245.
[3] Mbow M. L. et al. (2011) Alum's advjuvant action: grease is the word. Nature Medicine. 17: 415-416.
[4] Miller E. et al. (2012) Risk of narcolepsy in children and young people receiving AS03 adjuvanted pandemic A/H1N1 2009 influenza vaccine: retrospective analysis. BMJ. 346: f794.
[5] Nohynek H. et al. (2012) AS03 adjuvanted AH1N1 vaccine associated with an abrupt increase in the incidence of childhood narcolepsy in Finland. PLoS One. 7(3): e33536.
[6] O'Hagan D. T. (2007) New generation vaccine adjuvants. Encyclopedia of Life Sciences.


## Glossary

| | |
|---|---|
| **Senescence** | The process of accumulative changes to molecular and cellular structures due to ageing |
| **Attenuated vaccine** | A vaccine created by rendering the pathogen harmless, but still keeping it live |
| **Killed vaccines** | Vaccines are often made from weakened or killed forms of the pathogen |
| **Subunit vaccines** | A vaccine which presents antigens to the immune system without introducing viral particles |
| **T-cell** | T-cells are a type of white blood cell that plays a central role in immunity |
| **Humoral immunity** | The aspect of immunity that is mediated by macromolecules, rather than cell-mediated immunity |
| **Squalene** | A natural carbon organic compound |
| **Surfactants** | Compounds that lower the surface tension |

Other types of adjuvants include 'immune potentiator' type adjuvants which activate dendritic cells to produce cytokines and stimulatory molecules that are integral for the immune response of the body. The optimal formulation for a subunit vaccine would be that it contains both 'delivery system' and 'immune potentiator' type adjuvants, thereby producing an effective immune response.

MF59 is an oil-in-water adjuvant composed of squalene and surfactants. In combination with trivalent influenza vaccine, for the prevention of seasonal influenza, it has been used since 1997[7]. Studied over two influenza seasons in infants and young children, the vaccine was seen to be efficacious against laboratory-confirmed influenza caused by all circulating influenza viral strains during the two study years (86% efficacy rate), with higher efficacy against vaccine-matched strains (89%)[9]. In contrast, the respective efficacy rates for (non-adjuvanted) trivalent influenza vaccine were 43% and 45%.

*Can adverse events such as narcolepsy be predicted?*

So far more than 50 million doses of MF59 adjuvanted trivalent influenza vaccine have been distributed commercially since 1997 and around 100 million doses of pandemic influenza 1 (H1N1) vaccines containing the MF59 adjuvant were distributed in 2009-2011 to all aged groups, including pregnant women, and no safety concerns were revealed[9].

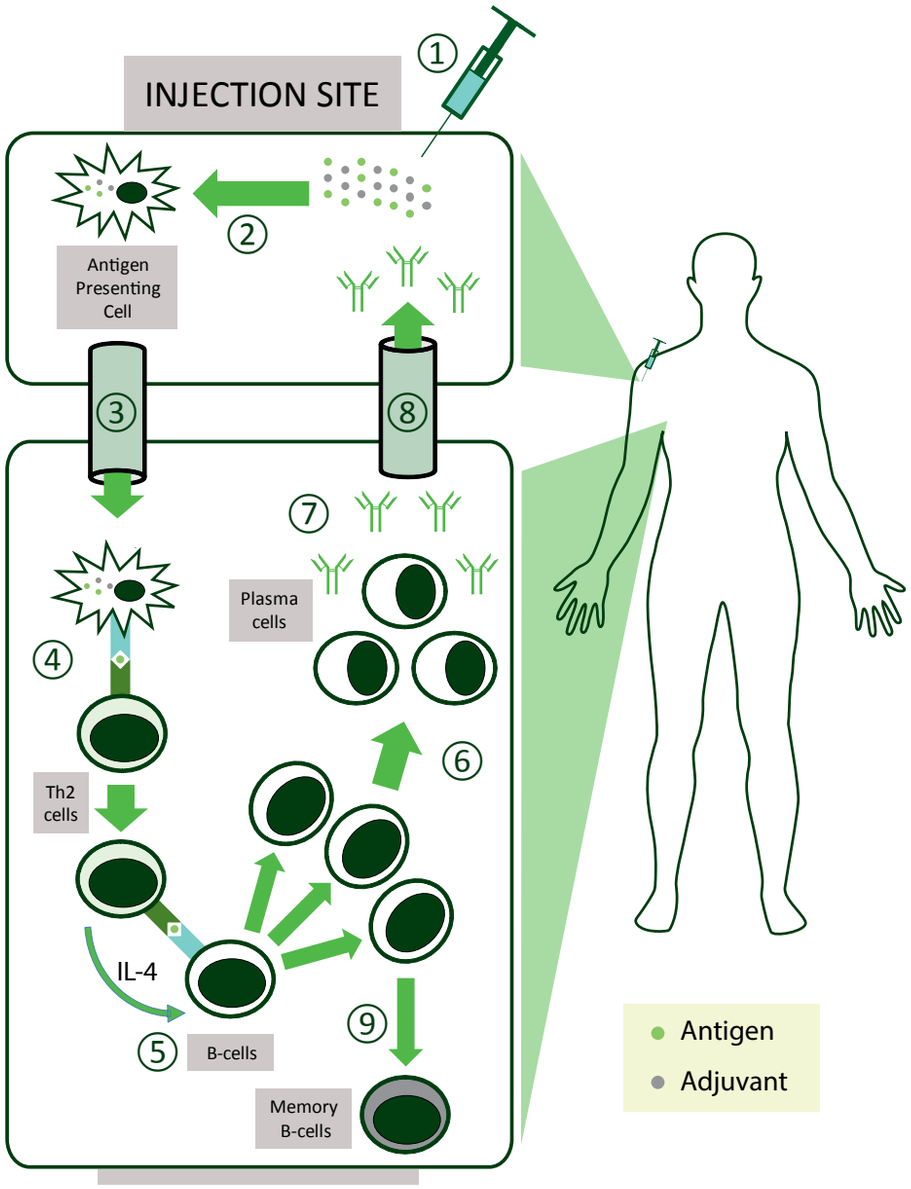
The adjuvant AS04 is used in one of the human papillomavirus (HPV) vaccines – it was approved for use in Europe in 2007 and in the USA in 2009. The AS04-adjuvanted HPV vaccine induces a high and sustained immune response against HPV and has an excellent safety profile. By contrast, the adjuvant AS03 is composed of α-tocopherol, squalene and polysorbate 80 in an oil-in-water emulsion. However, its use in an influenza A(H1N1) pandemic vaccine was associated with the onset of narcolepsy[4,5].

**Health Policy Implications**

Should concerns about narcolepsy imply that there should be a 'moratorium' on all adjuvanted influenza vaccines? Should all adjuvanted vaccines under development undergo extra safety checks to ensure that they are not associated with the onset of narcolepsy? Are the risk-benefit ratios different for public health emergencies such as an influenza pandemic when compared with a routine immunisation programme? Can adverse events such as narcolepsy be predicted? These are the type of questions facing public health experts in the field of vaccine development and delivery.

On rare occasions, adverse events including conditions such as Guillain-Barré syndrome are associated with vaccination, although there is no suggestion that adjuvants are responsible; on other occasions there is proven to be no association between vaccination and a condition – the example par excellence being MMR and the absence of association with autism.

The association between narcolepsy and AS03-adjuvanted pandemic influenza vaccine was not predicted – it was only identified after the widespread administration of the vaccine - and the exact mechanism has not yet been elucidated. It is, in fact, unusual for relatively rare conditions to be detected in even a moderately-sized clinical trial - and most influenza vaccine




*(1) Vaccine (with Antigen and Adjuvant) is delivered into the body. (2) Dendritic Cells and other Antigen Presenting Cells (APCs) take up the Antigen in the vaccine through phagocytosis. Delivery-type adjuvants improve antigen uptake here, while Immune potentiator adjuvants stimulate production of cytokines to improve the immune response. (3) APCs migrate to Lymphoid tissue through the bloodstream. (4) APCs display collected antigen on their cell surfaces. It is recognised by Helper T-cells (Th2), activating cells which recognise it strongly. (5) Activated Th2 cells stimulate specific B-cells (additionally using the cytokine interleukin-4), causing them to proliferate. (6) The B-cells differentiate into plasma cells. (7) Plasma cells begin releasing antibodies into the bloodstream. (8) The antibodies travel to the site of the vaccine, where they bind to the remaining antigen. (9) Some activated B-cells differentiate into Memory B-cells, which remain in the body and continue to provide long-term protection.*





| Antigen Delivery System | Immune Potentiators |
|---|---|
| Alum | MPL and synthetic derivatives |
| Calcium phosphate | MDP and derivatives |
| Tyrosine | CpG oligonucleotides |
| Liposomes | Alternative bacterial or viral components – flagellin, etc. |
| Virosomes | Lipopeptides |
| Emulsions | Saponins |
| Microparticles/nanoparticles | dsRNA |
| Iscoms | Small molecule immune potentiators eg Resiquimod |

clinical trials are small, short trials of long-established seasonal influenza vaccines.

Given the long track-record of MF59, a 'moratorium' on all adjuvanted influenza vaccines would appear to be unnecessary, and would deny those who benefit from the increased immunogenicity conferred by an adjuvanted influenza vaccine the opportunity to be properly protected. In this case, the preferred approach would be to ensure vigilance and safety monitoring in parallel with the use of the vaccine.

*A new era in influenza vaccination has already commenced in the UK*

Furthermore, when considering a public health emergency such as an influenza pandemic, the risk-benefit ratio need not be any different from that in a non-emergency situation. This is because pre-pandemic planning and vaccine development is an on-going and continuous process – the vaccines which will be used in the next influenza pandemic are already under intense study, albeit in their pre-pandemic form.

Indeed, a new era in influenza vaccination has already commenced in the UK with the launch of routine paediatric influenza vaccination using an inhaled cold-adapted live (non-adjuvanted) vaccine. Although this is a non-adjuvanted vaccine, some investigators are already exploring the possibility of improving the immunogenicity of such mucosal vaccines with adjuvants[8]. Current research is also focusing on both the development of adjuvants that can be linked to specific vaccines in order to optimise immune responses, and on delivery mechanisms such as inhaled and transdermal delivery systems, in the hope of overcoming the ability of organisms to evade vaccine immunity.

[7] O'Hagan D. T. (2007) MF59 is a safe and potent vaccine adjuvant that enhances protection against influenza virus infection. Expert Rev Vaccines. 6: 699-710.
[8] Okamoto S. et al. (2012) Intranasal immunization with a formalin-inactivated human influenza A virus whole-virion vaccine alone and intranasal immunization with a split-virion vaccine with mucosal adjuvants show similar levels of cross-protection. Clinical and Vaccine Immunology. 19: 979-990.
[9] Vesikari T. et al. (2011) Oil-in-water emulsion adjuvant with influenza vaccine in young children. NEJM. 365: 1406-1416.

*Dr. McIntosh* is a paediatrician, infectious disease specialist and vaccinologist. With extensive clinical experience at the Royal Alexandra Hospital for Children in Sydney and at St Mary's Hospital, and a PhD in the molecular epidemiology of hepatitis B virus, Dr McIntosh now works in the area of public health and prevention, through the development of vaccines.

# Delivering Donated Drugs Against Neglected Tropical Diseases

*Prof. Alan Fenwick, Imperial College London*

2 billion tablets of albendazole for lymphatic filariasis. Commitment to donate 400 million more.

200 million tablets/yr for intestinal worms

Over 100 million doses of azithromycin for trachoma

Mectizan for as long as needed for onchocerciasis and filariasis

2 billion tablets of DEC for LF

20 million tablets/yr of praziquantal. Mectizan for as long as needed in Africa for onchocerciasis and filariasis

Over 50 million blister packs of MDT for leprosy

**Over 1 billion people live in poverty and have less than $2 per day at their disposal. These people (one in six of the world's population) usually live in rural areas and are inevitably mired in poverty because of poor health, especially chronic diseases caused by infection with parasitic diseases now known as 'Neglected Tropical Diseases' or NTDs.**

**In 1985 a drug donation of mectizan (ivermectin) led to a mass drug administration to over 100 million people a year in Africa to protect them against river blindness. Where once 50% of people over 40 years of age were blind today they all have their sight. By 2013 several more donation commitments have been made by several pharmaceutical companies with the result that the 1 billion poor people in need of drugs can now receive them free of charge.**

**Through mass drug administration for NTDs, the Schistosomiasis Control Initiative (SCI) at Imperial College has played a leading role in reaching out to the poorest people in Africa and improving their quality of life. While many have been reached already, more support is needed. Thanks to the pharmaceutical industry the necessary drugs are available, but the challenge now is to deliver these drugs to recipients at the end of the road in developing countries.**

There are seven Neglected Tropical Diseases which are targeted for elimination by 2020 by the member states of the World Health Organisation – and all seven can be treated with safe oral drugs usually distributed annually. However the treatments do differ from disease to disease and country to country based on epidemiological data, disease distribution and in some cases intensity of infection.

The World Health Organisation has promoted the concept of 'Preventive Chemotherapy' (PCT) by which the drugs below, donated by the pharmaceutical industry, are distributed annually throughout the endemic areas in order to improve the health of those infected, reduce transmission and head towards elimination of these diseases by 2020. The WHO has made such information available to relevant Ministries of Health and supported all the efforts of the Schistosomiasis Control Initiative (SCI) at Imperial College to improve coverage against NTDs.

The SCI was established in 2002 with a grant from the Bill and Melinda Gates Foundation which was used to implement programmes in six countries: Burkina Faso, Mali, Niger, Tanzania, Uganda, and Zambia. In 2006 the SCI expanded to cover Burundi and Rwanda. In 2010 funding from the UK Aid Agency DFID allowed SCI to expand in to Cote D'Ivoire, Liberia, Malawi, and Mozambique. Additional private funding allowed SCI to assist Madagascar, Mauritania, Senegal, and Zimbabwe. Finally the World Bank called on SCI for assistance for its programme in Yemen.

SCI has been one of the strongest advocates for PCT and has assisted in raising global awareness of these diseases, raising funds for delivery of the drugs in each of 16 endemic countries, and offering technical assistance to ensure country-wide mapping to improve optimum use of the drugs, training of health personnel, teachers and community volunteers. This ensures that the necessary drugs reach the poorest people in remote areas with the greatest need. However, the mechanism for getting the donated drugs from the factory gate to the mouths of those in need is complex and requires sophisticated planning and logistical support.

**Rapid Expansion of Treatment**

As recently as 2000 there were no treatments against schistosomiasis or intestinal helminths in sub Saharan Africa, and trachoma and LF treatments were just starting. In contrast during 2013 over 700 million treatments were delivered. These programmes have expanded so much that in 2013, the World Health Assembly passed a resolution calling on all member states to move towards the elimination of Neglected Tropical Diseases by 2020. As shown above, the drugs which are needed to treat all the target populations are available on request, and so the challenge is how to reach rural communities in which the prevalence of these diseases is at the highest level.

*$2 billion might be all that is needed over the next seven years to fund the distribution of donated drugs throughout sub Saharan Africa*

Prior to 2006, the main donor for NTDs was the Bill and Melinda Gates Foundation – undoubtedly they opened the door for initial drug distributions to reach some remote rural populations infected with these diseases. Since 2006 there have been two major donors, plus a steady stream of smaller donations, to fund the delivery of these drugs from the port to the recipients. Major donations have come from the United States Agency for International Development (USAID), and from the Department for International Development (DFID) in the UK. Other donors include the World Bank, the ENDFUND (based in the philanthropic organisation Geneva Global) and from the general public in both the USA and UK, and to a lesser degree from other developed countries.

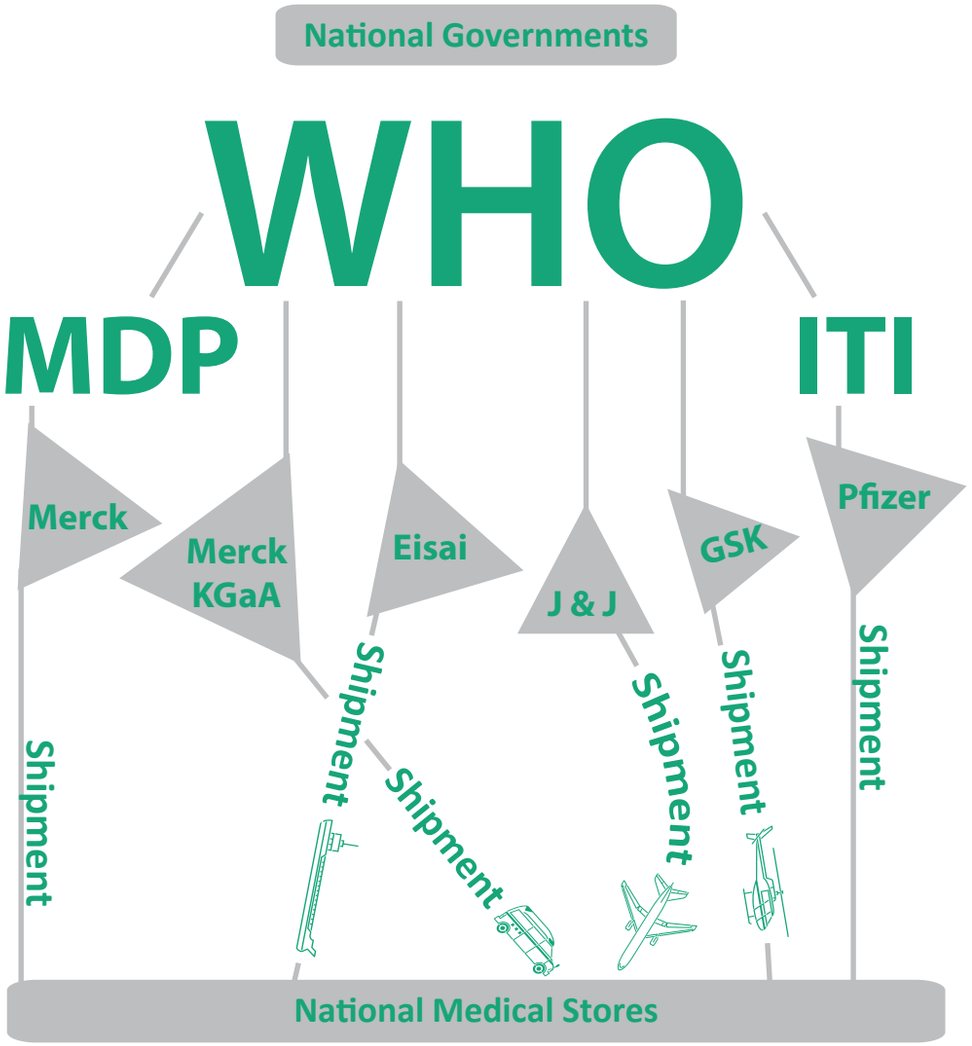
If we examine these large donations: USAID have awarded $250 million over 5 years to the Research Triangle International (RTI), who in turn use several implementers on the ground to assist Ministries of Health (MoH) to deliver the donated drugs. USAID have awarded a further $200 million to Family Health International (FHI), who in turn use implementers to assist MoHs to deliver donated drugs. RTI work in some countries and FHI are allocated other countries. The World Bank has a number of supporting initiatives helping both the Ministries of Health and Education with health system strengthening. For example, the World Bank are providing all the funding necessary to purchase and deliver drugs targeting schistosomiasis in Yemen. The budget for this one country is $25 million over 6 years, and the SCI is providing the technical assistance needed.

In addition, the SCI has been fortunate to be recognised as a "value for money" charity by UK and US charity evaluators, www.givingwhatwecan.org and www.givewell.org. Their recommendations to the public, who wish to give to a cost effective charity, have led to over £2 million in donations to SCI to help start up programmes in several countries.

Looking towards the goal of elimination by 2020, it has been estimated that perhaps $2 billion might be all that is needed over the next seven years to fund the distribution of donated drugs throughout sub Saharan Africa. Of this, about half has been pledged by the above organisations.

**Manufacturer to Mouth**

Prior to 2010, each of the drugs had to be applied for separately according to need in each individual country. Since 2010, there has been a mechanism developed to




*The World Health Organisation (WHO), the International Trachoma Initiative (ITI) and the Mectizan Donation Programme (MDP) facilitate the complex delivery of drugs to national health programmes via a range of shipment methods.*

simplify the application process as shown in the schematic above. Pfizer and Merck USA have their own separate processes for approval of donations – Pfizer operate through the 'International Trachoma Initiative' while Merck USA use the 'Mectizan Donation Programme' both based in Atlanta within the Task Force for Global Health.

However, all requests must come from individual country governments (not from NGO's) through the World Health Organisation who use a regional review panel to evaluate all requests before passing the orders on to the respective manufacturing companies.

Drugs are often imported to the recipient country with the assistance of the World Health Organisation country representative, and then delivered to the respective National Medical stores. From the stores, nationwide drug distribution is the responsibility of the Ministry of Health.

With funding from major donors, as explored in the previous section, MoHs implement drug distribution programmes with the help of Non Governmental Organisations (NGOs) which are responsible for accountability, for providing technical assistance, and for monitoring and evaluation after treatments.





So what does a Neglected Tropical Disease (NTD) implementation programme look like? There are several critical path steps for a country to implement an NTD programme aiming for elimination by 2020, and these are:

*Mapping*
- To determine the distribution of the various NTDs in the country – these diseases are not evenly distributed and we need to know where the diseases are to be found and indeed where they are not, so that we can plan treatments by district.

*Stakeholders meetings*
- To determine what resources are needed, what are available and what the resource gaps are.
- To agree a strategy for treatments by district – and from there determine the drug needs.
- Agree distribution of work and responsibility between stakeholders.

*Order drugs for each NTD*
- Determining how many drugs to order is no easy matter, and of course the lead time to delivery is at least 6 months.

*Training*
- A timetable and curriculum for all the training needs is required. Training should be directed to all levels – central scientists responsible for the programmes through to regional directors, health personnel, teachers and community drug deliverers.

*Logistics*
- Arrangements for transport of not only the drugs but also all the other equipment that is required such as microscopes, haemacue machines, dose-poles etc.

*Advocacy (sensitization)*
- Every official likely to be involved in the drug distribution needs to be fully informed to 'keep them on board'.
- The people who will actually dispense the drugs need training and to know where and when to collect their drugs.
- The target population need to be given information about the campaign and the benefits of taking the medicines offered.

*MDA (Mass drug administration)*
- The drugs are administered according to the agreed protocol to either school children through the schools, to school-aged children, which means a strategy is needed for reaching children outside school, and the whole community where appropriate. Provision must be made to deal with any adverse events.

*The seven infections which are the causal agents for disease, detailing the numbers estimated to be infected and the drugs used to treat the infections.*

| Infection (Disease) | Distribution | No. Affected (No. at Risk) | Drug (Donor) | Effect of Drug | Target and Treatment Status |
|---|---|---|---|---|---|
| **Schistosomiasis (Bilharzia)**<br>S.mansoni<br>S.haematobium<br>S.japonicum | <br>Africa & S. America<br>Africa & Middle East<br>China & Philippines | 210m (600m) | Praziquantel (Merck KGaA) | Kills adult worms | Mostly school-aged children (SAC)<br>30 m/yr rising to 100m/yr by 2016 |
| **Onchocerciasis**<br>O. volvulus (River Blindness) | Africa & S. America | 40m (100m) | Mectizan/ Ivermectin (Merck USA) | Sterilises adult worms | Endemic communities 100m |
| **Lymphatic filariasis**<br>W. bancrofti (Elephantiasis) | Globally Across Tropics | 140m (>1b) | Albendazole with Mectizan or DEC (GSK; Merck; EISAI) | Sterilises adult worms | Endemic communities 700m |
| **Trachoma (Blindness)** | Global | 30m (100m) | Zithromax (Pfizer) | Prevents infection | Endemic communities 70m |
| **Necator/ Ancylostoma (Hookworm)** | Global | 600m (>1b) | Albendazol/ Mebendazole (GSK; Johnson & Johnson) | Eliminates worms | Endemic communities and SAC<br>700m/yr during LF treatment plus 400 m SAC |
| **Ascaris (Roundworm)** | Global | 800m (>1b) | | | |
| **Trichuris (Whipworm)** | Global | 600m (>1b) | | | |

*A man carries freshwater prawns to the Senegal River as part of a re-implementation project to reduce schistosomiasis parasites. The prawns have been wiped out of the Senegal River by habitat loss, but when present, they serve as a successful biological control mechanism.*

*Monitoring and Evaluation*

- After treatment - a coverage survey is required to confirm effective drug delivery.
- Monitoring of any unwanted side effects.
- 6 month or 12 month follow up to monitor drug efficacy.

Thus, it is clear that very large drug donations is just one part of an elimination strategy - it is necessary to have in place mechanisms for reaching out to recipients and ensuring good coverage (over 75%) if the programme is to be successful.

**Towards Elimination**

With these fantastic drug donations, parasitic diseases such as schistosomiasis are en route to elimination in terms of both morbidity and transmission. Co-ordination between the Gates Foundation, WHO, USAID, The World Bank and DFID and implementers such as SCI ensures that available resources are used carefully and efficiently, and duplication of effort is avoided.

Currently the main push is to expand in the large countries of Africa such as DRC, Ethiopia, Nigeria, Tanzania and Mozambique, and when national coverage is achieved in all of them we will be well on the way to elimination. However the last mile will be reached only when water supplies are improved, sanitation is much more widespread and latrines are used.

However, by 2020 we can expect to be much nearer our goal thanks to the pharmaceutical industry, the funding agencies and implementers – but most of all because of the increased awareness and political commitment of the developing countries to eliminate these diseases.

*Prof. Alan Fenwick OBE* is Director of the Schistosomiasis Control Initiative (SCI) and professor of Tropical Parasitology at Imperial College London. The SCI was founded in 2002 with funding from the Bill and Melinda Gates Foundation and has since assisted 16 countries in overseeing the delivery of over 100 million treatments against schistososmiasis, and many more against STH.



# Identity: Who Do You Think You Are?

*Prof. Chris Hankin & Andrew Burton, Imperial College London*



**Hyper-connectivity driven by internet access is changing the way we live our lives. By 2020, it is predicted that networked devices, streaming information and connecting us globally, will exceed 50 billion. But will we be able to switch off, or maintain distinct identities in online and offline worlds?**

**A Foresight study[1] was recently commissioned by the Government Office for Science to provide policy makers with a better understanding of changing identities in the UK over the next 10 years.**

The beginning of the 21st century is characterised by near ubiquitous internet connectivity. Hyper-connectivity (otherwise known as the Internet of Things) is the use of multiple communications systems and devices to remain constantly connected to social networks and streams of information. Hyper-connectivity has several key attributes: being always on all the time and everywhere; readily accessible; information-rich beyond anyone's capacity to consume; interactive; and with virtually unlimited storage capacity. By 2010 there were more networked devices than the population of the world, a number predicted to rise by CISCO[1] to 25 billion by 2015 and 50 billion by 2020.

A recent report by the Government Office for National Statistics summarises 2013 internet access in the UK:

- 21 million households (83%) had Internet access.
- 36 million adults (73%) accessed the Internet every day, 20 million more than in 2006, when directly comparable records began.
- Access to Internet using a mobile phone more than doubled between 2010 and 2013, from 24% to 53%.
- 72% of all adults bought goods or services online, up from 53% in 2008.

There is an age-related aspect to hyper connectivity, with a greater take-up of internet-based communications by younger people than older people. Among young people in the UK aged 16 to 24, 45% said they felt happiest when they were online, with 86% feeling that new technology helps them to communicate with people. Increasing digital network coverage and higher access speeds will continue to drive this trend, while bringing new opportunities to rural communities.

**The Hyper-Connected World**

The trend towards hyper-connectivity has the potential to have a positive impact on migrant communities in maintaining social connections with family and friends. However, there is now the capacity for migrants to communicate online with people from their home country, potentially isolating them more from the host society. Over the next 10 years dispersed communities will increasingly be able to stay in close touch with events in their country of origin. This means that events which occur elsewhere in the world can have an immediate impact on identities in the UK, for example through the transmission of consumer culture and heightened awareness of political events, conflict and persecution in other countries.

With still further hyper-connectivity we could speculate that people will find it harder to disconnect themselves, switch off or maintain distinct identities in different

[1] Government Office for Science (2013) Future identities: changing identities in the UK. http://www.bis.gov.uk/foresight/our-work/policy-futures/identity
[2] Dave Evans (2011) The Internet of Things: How the Next Evolution of the Internet Is Changing Everything, Cisco Internet Business Solutions Group
[3] Office for National Statistics UK (2013) Internet Access - Households and Individuals

*Blurring the lines between man and machine: Joaquin Phoenix in 'Her' develops a relationship with his operating system.*

situations. One likely development is that the increasingly networked state of many people's lives could blur the boundaries between online and offline identities, work and social identities, and merge the different spheres of contextual identities. The advent of widespread mobile technology and email has led more people to remain identified with their work during the evenings, weekends and other leisure times, and it is possible that this breakdown in the barrier between separate fields of identity is among the most important and transformative consequences of social and technological changes.

The issues which empower Generation Y (the 'millennial' or 'digital' generation) can hence be regarded also as a burden. The pre-internet generation was defined by more physical parameters such as family, home, school, or occupation; whereas the current generation tends to collect more virtual identifiers such as on-line persona and solely cyber interactions (some would argue to the detriment of social interaction, others would argue the opposite). Manifestations of these differences may be studied in terms, for example, of the types of crime in modern society – both large/organised and small/personal scale – with old-fashioned bank robberies almost non-existent, and vastly more on-line 'crimes against the person' than the off-line variety.

Social media differs from traditional communications technologies in that, being online, social media allows users to create, share, consume and collaborate on content in new ways. The use of online social media has surged in recent years, initially spurred by young people but now used by the majority. Over 60% of internet users in the UK are members of a social network site. Over the next 10 years, the nature of online platforms can be expected to change radically. Control of online identity will become increasingly important and will highlight issues such as the ownership and use of personal content and privacy.

It is hard to predict exactly how social media might develop over the next 10 years. There may be more political activism using social media ("clicktivism"), as these networks become more influential in spreading the message and allowing instant feedback and commentary. Social media can facilitate political movements. In some cases this is very influential, for example in the revolution in Tunisia in 2011, and potentially in mobilising dissent in Egypt and Libya, or at least in raising the international profile of what is happening.

**Online Privacy**

Evidence shows that younger people between the ages of 8 and 18 are generally less concerned with their privacy than older people and are more willing to share information online, with often poor awareness of online security. The rules governing the possession of digital information are dramatically different to those of offline possession: for example, once an image has been posted online, it could be retained by the website or others could reproduce it, share, adapt or use it in ways which could be unwelcome to the original owner. An online personal history cannot be completely erased but serves as a permanent autobiography. This means that care needs to be taken when sharing personal information online, with an awareness of how that information may be retained or used by others.

Social networking sites have been associated with a loss of anonymity and a threat to privacy. People's willingness to disclose information in exchange for access to services combined with the financial value to be gained from exploiting customer data mean that people increasingly cede control over what happens to their data. Even people with no online presence may be identified online, such as through tagging in uploaded photos. People may no longer be the primary creators of their own online identity.

Social media can facilitate links between like-minded individuals to create niche communities of interest, which could be benign or malign, and may reinforce existing behaviours, normalise minority identities, and broaden choices. The persistence of digital data will also have implications as young people grow into adulthood, seek employment and progress in their careers, as information could become potentially available to unintended audiences. Social media sites can conflate work and social identities within the same online space and lead to information leaking from one sphere to another.

**The Future of Identity**

Identities will, in some ways, change significantly over the next few years, and this will have a huge impact on society and on the way people live their lives. The main drivers of change are likely to be technology and social media, data mining, hyper-connectivity and the changing nature of society, which will produce identities in flux. However, some are likely to remain reasonably impervious to change, such as religious and national identities.

Increasing numbers of people now have some online presence, and so online identities are becoming part of the many overlapping identities held by individuals. Identities can be inclusive, or act to exclude groups and individuals as identities are co-created by an individual and other people, for example by accepting someone as part of a group, or rejecting them from it. Society may become increasingly pluralised, partly as a result of overlapping and shifting identities, alongside other social, cultural, and economic drivers, which could pose challenges for policy makers. Disparities in wealth and opportunities can create resentment and social unrest, while the elite may become more distanced from mainstream society and itsconcerns.

Context is crucial in understanding identities. An individual may hold multiple identities simultaneously. At some times, in some places, one identity or another may come to the fore depending upon the context. Sometimes big events or global trends are important but more often people's sense of self and daily activities can be affected to a greater extent by local events, community, family and friends. Understanding the context and which identities are most relevant is therefore crucial to predicting behaviour.

Hyper-connectivity represents a step change. The world is now a virtual environment as well as a real place and its citizens are globally networked individuals. This means that events which happen elsewhere in the world can have a real and immediate impact at home. New communication technologies have provided ways for people to find like-minded others, and spread ideas, but equally misinformation can spread quickly. The younger generation are entirely comfortable in the digital environment, with different expectations as consumers, although there are generational differences in attitudes towards privacy, with an increasing blurring of public and private identities.

Identity is a resource that can have personal, psychological, social, and commercial value. Governments can consider identity as a resource for promoting social change, for example in policies to tackle inequality or promote social integration. Identities can also be the focus of improving relationships between the citizen and the state, for example through more targeted services and engagement in political and social discussion. The commercial value of identities through the mining of ever-increasing data sets is likely to become crucial to some private sector organisations, but also has the potential for criminal exploitation, for example through opportunities for fraud through the deliberate misrepresentation of identity.

Trust is fundamental to relationships between citizens, between people and commercial organisations, and between citizens and the state, but people are less willing to trust in authority than in the past. Research indicates that the decline in trust will continue if the line between commercial organisations and the state continue to be blurred. Ethical issues will become more complex as varying identities come into conflict, and so maintaining a balance between privacy, freedom and protection, will become a key priority as we move further into the hyper-connected online future.

*This article is based on the main findings of the Foresight Project into Future Identities, commissioned by the Government Office for Science (GO-Science), which was managed through a number of academic studies overseen by a Lead Expert Group chaired by Professor Chris Hankin. The final project report is available from the Foresight website[1].*

*Prof. Chris Hankin* is Director of the Institute for Security Science & Technology.
*Andrew Burton* is Operations Manager of the Institute for Security Science & Technology at Imperial College London.

# From London to the Arctic:
## Exploring Engagement and Learning in Citizen Cyberscience

*Charlene Jennett, Anna. L. Cox, Diana Mastracci and Cindy Regalado, University College London*

**Technology can play a role in helping people to collaborate – and increasingly participate - in areas previously inaccessible to the non-expert. For example, research projects relying on crowd-sourced data-collection by amateurs are being made feasible and accessible via mobile apps or websites. This new phenomenon, known as 'citizen cyberscience', is currently being deployed and investigated by a team at UCL.**

Citizen science is a type of crowd-sourcing, where volunteers ('citizen scientists') collaborate with professional scientists to conduct scientific research. Amateurs have been contributing to science for many years now. The Audubon Society's Christmas Bird Count, which began in 1900, involves volunteers counting birds in their local area. This population data provides valuable information for conservationists. Similarly, there is a long history of amateurs contributing to astronomy. The American Association of Variable Star Observers has been gathering data on variable stars since 1911. However, over the past decade, we have started to see citizen science projects take on a very different form to those of the past driven by a range of technological developments.

The use of mobile apps has made data recording easier, as data is digitised and sent to scientists immediately at the point of collection. For example, in Noise-Map[1], volunteers download a mobile phone app, which they use to collect and send data about levels of noise pollution in their local area. Another example of a mobile app is iSpot[2], where volunteers take a photo of a species and submit it to the project community for identification. This data is subsequently used for biodiversity research.

A further advantage of the internet is that there is potential for scientists to collaborate with volunteers from all around the world. It is also possible for scientists to ask volunteers to be involved in more complex tasks, such as data analysis. For example, Galaxy Zoo[3] is an online astronomy project. Volunteers view pictures of galaxies and it is their task to classify the galaxies, judging from the images whether a galaxy is elliptical or spherical. This data is then used by scientists to determine how different galaxies are distributed, and how galaxies are formed.

We can also see similar projects in the humanities. For example, in Transcribe Bentham[4], volunteers view digital images of unpublished manuscripts written by the philosopher Jeremy Bentham and it is their task to transcribe the manuscripts. By digitizing Bentham's manuscripts, this widens accessibility to Bentham's papers and ensures that they will be preserved for future generations.

**Extreme Citizen Science**

Depending on the nature of the research project, some citizen science projects take a public engagement approach as a way to expand scientific endeavours of tremendous spatial and temporal magnitude requiring volunteer involvement. In these cases, the problem and questions are pre-defined, the data collection is crowd-sourced, and for the most part, the analysis and results are in the domain of the leading professional scientists. The UCL Extreme Citizen Science research group (ExCiteS) – led jointly by Prof Muki Haklay, Dr Jerome Lewis and Dr Claire Ellul – take a different approach. Their purpose is to develop methodologies, tools and platforms to support communities anywhere to participate and take a lead in scientifically valid data collection and analysis. The team at ExCiteS defines their practice as taking into account local needs and culture, as well as working with broad networks of people to design and build new devices and knowledge creation processes that can transform the world. Two of the recent projects at ExCiteS include a London community project and an Arctic community project.

The community project in London focuses on engagement in Do-It-Yourself (DIY) practices that link knowledge to action in scientific research initiated by the public. The aim is to identify and explore how groups and individuals engage in the creation and mediation of knowledge to address issues that are of concern to them, and how they translate this into publicly-led actions that bring about change. The DIY approach emphasises that technology is something anyone can develop – the ExCiteS approach in this initiative is to make scientific research something anyone can do well. Two initiatives have been undertaken: the first, at the Mildmay Community Centre (MCC) and the second, still ongoing, activities with Citizens without Borders using tools from the Public Laboratory for Open Technology and Science. The latter involves co-developing prototypes and methodologies grounded in participant's interest's and which further develop and hone their skills.

A DIY citizen science approach to research is important because it allows for research to reflect the context and perspective of the local community. In addition, it provides community members the opportunity to engage in first-hand exploration of their potential for investigation, as well as access to tools and skills for research, which facilitate an enhanced understanding of their local environment. The outcomes of this project are expected to help support the acknowledgement of publicly-initiated research as valid ways conducting research, and thus foster the democratisation of the practice of science. The Touch|Play|Learn DIY mini-expo at the MCC enabled people to touch and explore DIY tools for environmental sensing, play with them and try them out, and by doing so, connect with ways they can learn about themselves and their surrounding environment[5]. One of the Public Lab workshops at Citizens without Borders workshops involved Kite-mapping[6], a fully DIY and transferable technique working together to make kites from repurposed materials, flying them with cameras attached and then stitching the aerial photos to create their own maps using the Mapknitter.org open-source platform.

The community pilot project in coastal Arctic Alaska will involve the development of an application for mobile phones for use by indigenous subsistence hunters, which will enable them to map the changing condition of the sea-ice on which they must hunt. Due to climate change, indigenous sea ice users are experiencing problems in forecasting the weather. The technology will allow subsistence hunters to capture the risks associated with travelling on sea-ice according to their knowledge, take photos and audio stories, and access information on current local conditions, reflecting the hunters' ways of hunting, learning and knowing[7]. Over time, the data collected could reveal spatio-temporal patterns that could help in the understanding of broader issues of interest to both the climate change and geophysical communities. Such interests include the validation of remote sensing data and models, as well as understanding of marine mammals

[1] Noise-Map. http://www.noisemap.org/
[2] iSpot. http://www.ispotnature.org/
[3] Galaxy Zoo. http://www.galaxyzoo.org/
[4] Transcribe Bentham. http://blogs.ucl.ac.uk/transcribe-bentham/
[5] Regalado, C. (2012). Touch.Play.Learn: make the invisible visible! Extreme Citizen Science blog. [online] Available at <http://uclexcites.wordpress.com/2012/09/26/touchplaylearn-make-the-invisible-visible/> [Accessed 31 March 2014].
[6] Regalado, C. 2013. Doing it Yourself: Kite-mapping… an activity for the 'privileged'? Extreme Citizen Science blog. [online] Available at <http://uclexcites.wordpress.com/2013/04/10/doing-it-yourself-kite-mapping-an-activity-for-the-privileged/> [Accessed 31 March 2014].
[7] Mastracci, D. (2012). "IF WE DON'T KNOW OUR LAND, WE'LL FREEZE!". Extreme Citizen Science blog. [online] Available at <https://uclexcites.wordpress.com/2012/06/14/if-we-dont-know-our-land-well-freeze/> [Accessed 31 March 2014].

behaviour in relation to local sea-ice use. Lastly, the design of the technology and use process could facilitate and improve intercultural and inter-generational exchanges, highlighting the importance of co-developing technologies that support local and traditional practices.

**Engagement, Learning and Creativity**

In both typical citizen cyberscience projects and extreme citizen science projects, researchers that run the projects desire for their volunteers to have a positive experience. Questions that they may ask include: How can we attract more volunteers? What motivates volunteers to take part in a project? Are volunteers learning when they take part in our project – and what are they learning? Why do some people volunteer for a long time, and others only volunteer briefly? By using evaluation methods such as interviews, surveys and behavioural observations, we can investigate what it is like for volunteers who take part in projects.

In previous research exploring volunteers' experiences in web-based citizen cyberscience projects, we found that gaming elements (points, leaderboards) and communication tools (forum, chat) were important for sustaining volunteers' engagement in citizen cyberscience projects[8]. Feedback from the scientific team helped volunteers to feel that their contributions mattered[9]. It was also important to recognise which volunteers were most active in the project community and to give them an opportunity to take on more responsibility by 'promoting' them to more senior positions, e.g. forum moderators[10]. Some volunteers took it upon themselves to suggest ideas or create innovative ways to solve project problems[10]. Volunteers were also found to experience several different kinds of learning, including on-topic content knowledge (related to the task) and off-topic knowledge and skills (related to their interactions with other volunteers)[11].

This year we will start to evaluate volunteers' experiences in the ExCiteS projects. We suspect that the volunteers' experiences in the ExCiteS projects will be very different to the 'typical' volunteer experience. There will be a lot of face-to-face interaction between scientists and volunteers in the ExCiteS projects. The ExCiteS volunteers have a say in what the research question will be, so they are likely to have a stronger motivation to participate. Also the ExCiteS volunteers are from different cultural backgrounds compared to 'typical' volunteers (who tend to be Western, middle class), so it is likely that their design needs will be quite different.

Another key question we aim to answer is 'what do volunteers learn as a result of participating in the projects?' The ExCiteS researchers primarily conduct their research to help communities pursue their own research questions; however, just by interacting with scientists, it is likely that volunteers will also learn something about science in the process. It will be interesting to explore what exactly it is that they learn, and also whether this experience encourages any of them to pursue science in the future.

Overall we hope that by studying volunteers' experiences in these 'extreme' contexts and by comparing these to more typical kinds of citizen cyberscience projects, we will be able to uncover how different roles – co-design versus participation – affect a person's experience of volunteering. This work will help us to develop a set of best practice guidelines for researchers designing their own citizen cyberscience projects, providing them with useful tips and insights into different ways to encourage engagement, learning and creativity for volunteers.

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*Dr Charlene Jennett* is a research associate at UCL. She is interested in digital leisure and her research includes exploring users' motivations for participating in games and citizen cyberscience.
*Dr Anna L. Cox* is deputy director of UCL. She works on a range of research projects, exploring the ways in which digital practices may affect wellbeing.
*Cindy Regalado* is a PhD student at UCL ExCiteS. She is interested in engagement in DIY practices that link knowledge to action in publicly initiated scientific research.
*Diana Mastracci* is a PhD student at UCL ExCiteS and currently a visiting student at the NASA's Jet Propulsion Lab. She is interested in indigenous issues, subsistence hunting and participatory research.

[8] Iacovides, I., Jennett, C., Cornish-Trestrail, C., and Cox, A.L. (2013). Do games attract or sustain engagement in citizen science?: A study of volunteer motivations. CHI '13 Extended Abstracts on Human Factors in Computing Systems, ACM Press, pp. 1101–1106.
[9] Jennett, C. I., Kloetzer, L., Gold, M. and Cox, A. L. (2013). Sociability in virtual citizen science. CHI'13 'Designing and Evaluating Sociability in Video Games' workshop. 28th April 2013, Paris, France.
[10] Jennett, C., Eveleigh, A., Mathieu, K., Ajani, Z. & Cox, A.L. (2013) Creativity in citizen cyberscience: All for one and one for all. ACM WebSci13, 'Creativity and Attention in the Age of the Web' workshop. 1st May 2013, Paris.
[11] Kloetzer, L., Schneider, D., Jennett, C., Iacovides, I., Eveleigh, A., Cox, A.L. and Gold, M. (2013). Learning by volunteer computing, thinking and gaming: What and how are volunteers learning by participating in Virtual Citizen Science? ESREA Conference, Berlin, September 3-6th 2013.



# How Much Surveillance Can Democracy Withstand?

*Richard Stallman, Free Software Foundation*

**Thanks to Edward Snowden's disclosures, we know that the current level of general surveillance in society is incompatible with human rights. The repeated harassment and prosecution of dissidents, sources, and journalists in the US and elsewhere provides confirmation. We need to reduce the level of general surveillance, but how far? Where exactly is the maximum tolerable level of surveillance, which we must ensure is not exceeded? It is the level beyond which surveillance starts to interfere with the functioning of democracy, in that whistle-blowers (such as Snowden) are likely to be caught.**

Faced with government secrecy, we the people depend on whistle-blowers to tell us what the state is doing. However, today's surveillance intimidates potential whistle-blowers, which means it is too much. To recover our democratic control over the state, we must reduce surveillance to the point where whistle-blowers know they are safe.

Bipartisan legislation to "curtail the domestic surveillance powers"[1] in the U.S. is being drawn up, but it relies on limiting the government's use of our virtual dossiers. That won't suffice to protect whistle-blowers if 'catching the whistle-blower' is grounds for access sufficient to identify him or her. We need to go further.

**The Upper Limit on Surveillance in a Democracy**

If whistle-blowers don't dare reveal crimes and lies, we lose the last shred of effective control over our government and institutions. That's why surveillance that enables the state to find out who has talked with a reporter is too much surveillance – too much for democracy to endure.

An unnamed U.S. government official ominously told journalists in 2011 that the U.S. would not subpoena reporters because "We know who you're talking to."[2] Sometimes journalists' phone call records are subpoenaed to find this out, but Snowden has shown us that in effect they subpoena all the phone call records of everyone in the U.S., all the time, from Verizon and from other companies.[3]

Opposition and dissident activities need to keep secrets from states that are willing to play dirty tricks on them. The American Civil Liberties Union (ACLU) has demonstrated the U.S. government's systematic practice of infiltrating peaceful dissident groups[4] on the pretext that there might be terrorists among them. The point at which surveillance is too much is the point at which the state can find who spoke to a known journalist or a known dissident.

**Information, Once Collected, Will Be Misused**

When people recognize that the level of general surveillance is too high, the first response is to propose limits on access to the accumulated data. That sounds nice, but it won't fix the problem, not even slightly, even supposing that the government obeys the rules. (The NSA has misled the FISA court, which said it was unable to effectively hold the NSA accountable.[5]) Suspicion of a crime will be grounds for access, so once a whistleblower is accused of 'espionage', finding the 'spy' will provide an excuse to access the accumulated material.

The state's surveillance staff will misuse the data for personal reasons too. Some NSA agents used U.S. surveillance systems to track their lovers[6] – past, present, or wished-for – in a practice called 'LOVEINT'. The NSA says it has caught and punished this a few times; we don't know how many other times it wasn't caught. But these events shouldn't surprise us, because police have long used their access to driver's license records to track down someone attractive, a practice known as 'running a plate for a date'.[7]

*The state's surveillance staff will misuse the data for personal reasons too. Some NSA agents used U.S. surveillance systems to track their lovers*

Surveillance data will always be used for other purposes, even if this is prohibited. Once the data has been accumulated and the state has the possibility of access to it, it can misuse that data in dreadful ways, as shown by examples from Europe and the US, such as in the case of Japanese-American internment in 1942.

Total surveillance plus vague law provides an opening for a massive fishing expedition against any desired target. To make journalism and democracy safe, we must limit the accumulation of data that is easily accessible to the state.

**Robust Protection for Privacy Must Be Technical**

The Electronic Frontier Foundation and other organizations propose a set of legal principles designed to prevent the abuses of massive surveillance. These principles include, crucially, explicit legal protection for whistleblowers; as a consequence, they would be adequate for protecting democratic freedoms – if adopted completely and enforced without exception forever.

However, such legal protections are precarious: as recent history shows, they can be repealed (as in the FISA Amendments Act), suspended, or ignored.

Meanwhile, demagogues will cite the usual excuses as grounds for total surveillance; any terrorist attack, even one that kills a handful of people, will give them an opportunity.

If limits on access to such data are set aside, it will be as if they had never existed: years worth of dossiers would suddenly become available for misuse by the state and its agents and, if collected by companies, for their private misuse as well. If, however, we stop the collection of dossiers on everyone, those dossiers won't exist, and there will be no way to compile them retroactively. A new illiberal regime would have to implement surveillance afresh, and it would only collect data starting at that date. As for suspending or momentarily ignoring this law, the idea would hardly make sense.

**First, Don't Be Foolish**

To have privacy, you must not throw it away: the first one who has to protect your privacy is you. Don't tell a company such as Facebook anything about you that you hesitate to publish in a newspaper. Don't tell a company such as Facebook anything about your friends that they might not wish to publish in a newspaper. Better yet, don't be one of Facebook's users at all.

Never give any web site your entire list of email or phone contacts. Keep your own data; don't store your data in a company's 'convenient' server. It's safe, however, to entrust a data backup to a commercial service, provided you encrypted the data, including the file names, with free software on your own computer before uploading it.

You should also avoid services that do jobs that you could do, essentially, in your own computer. These are known as a software substitute; as well as giving others control of your computing, it requires you to deliver all the pertinent data to their server.

**Insist on Free/Libre Software**

Data in your own computer may still be vulnerable. To prevent the NSA (or anyone else) from spying on you through your own software, you must insist on using only free software: software that respects your freedom. (It is often referred to as 'open source' by those who'd rather downplay its ethical and political consequences)

[1] http://www.theguardian.com/world/2013/oct/10/nsa-surveillance-patriot-act-author-bill
[2] http://www.rcfp.org/browse-media-law-resources/news-media-law/news-media-and-law-summer-2011/lessons-wye-river
[3] http://www.marketwatch.com/story/nsa-data-mining-digs-into-networks-beyond-verizon-2013-06-07
[4] http://www.aclu.org/files/assets/Spyfiles_2_0.pdf
[5] http://www.wired.com/threatlevel/2013/09/nsa-violations/
[6] http://www.theguardian.com/world/2013/aug/24/nsa-analysts-abused-surveillance-systems
[7] http://www.sweetliberty.org/issues/privacy/lein1.htm

*Banksy at work near GCHQ?*

Specifically, there are four essential freedoms:

0. The freedom to run the program as you wish, for whatever purpose.
1. The freedom to study the program's source code, and change it, so the program does your computing as you wish.
2. The freedom to make and distribute exact copies, when you wish.
3. The freedom to make and distribute copies of your modified versions, when you wish.

The first two freedoms mean each user can exercise individual control over the program. With the other two freedoms, any group of users can together exercise collective control over the program. With all four freedoms, the program is fully under the control if its users.

If any of the freedoms is missing or inadequate, the program is proprietary (non-free), and under the control of a single entity called the 'owner'. If that 'owner' wishes, it can design the software to spy on the users, and the users can't stop it. Surveillance features are known in Microsoft Windows, the software of the iThings, Flash Player, the Amazon Kindle, and the software in nearly all portable phones. Even nastier malfeatures, including Digital Restrictions Management and back doors, are widespread in proprietary software too.

Some proprietary software developers even cooperate with the NSA, which uses and even creates[8] security weaknesses in non-free software to invade our own computers and routers.

However, even the most rigorous self-protection is insufficient to protect your privacy on or from systems that don't belong to you. When you communicate with others or move around the city, everyone's privacy depends on the practices of society.

**We Must Design Every System for Privacy**

If we don't want a total surveillance society, we must consider surveillance a kind of social pollution, and limit the surveillance impact of each new digital system just as we limit the environmental impact of physical construction.

For example: 'Smart' meters for electricity are touted for sending the power company moment-by-moment data about each customer's electric usage, including how usage compares with users in general. This is implemented based on general surveillance, but does not require any surveillance. It would be easy for the power company to calculate the average usage in a residential neighbourhood by dividing the total usage by the number of subscribers, and send that to the meters. Each customer's meter could compare her usage, over any desired period of time, with the average usage pattern for that period. The same benefit, with no surveillance! We need to design such privacy into all our digital systems.

**Remedy for Collecting Data: Leaving It Dispersed**

One way to make monitoring safe for privacy is to keep the data dispersed and inconvenient to access. Old-fashioned security cameras were no threat to privacy. The recording was stored on the premises, and kept for a few weeks at most. Because of the inconvenience of accessing these recordings, it was never done massively; they were accessed only in the places where someone reported a crime. It would not be feasible to physically collect millions of tapes every day and watch them or copy them.

Nowadays, security cameras have become surveillance cameras: they are connected to the internet so recordings can be collected in a data centre and saved forever. This is already dangerous, but it is going to get worse. Advances in face recognition may bring the day when suspected journalists can be tracked on the street all the time to see who they talk with.

Internet-connected cameras often have lousy digital security themselves, so anyone could watch what the camera sees. To restore privacy, we should ban the use of Internet-connected cameras aimed where and when the public is admitted, except when carried by people. Everyone must be free to post photos and video recordings occasionally, but the systematic accumulation of such data on the internet must be limited.

**Remedy for Internet Commerce Surveillance**

Most data collection comes from people's own digital activities. Usually the data is collected first by companies. But when it comes to the threat to privacy and democracy, it makes no difference whether surveillance is done directly by the state or farmed out to a business, because the data that the companies collect is systematically available to the state.

The NSA, through PRISM, has acquired access to the databases of many large Internet corporations. AT&T has saved all its phone call records since 1987 and makes them available to the DEA[9] to search on request. Strictly speaking, the U.S. government does not possess that data, but in practical terms it may as well possess it.

*AT&T has saved all its phone call records since 1987 and makes them available to the DEA to search on request*

The goal of making journalism and democracy safe therefore requires that we reduce the data collected about people by any organization, not just by the state. We must redesign digital systems so that they do not accumulate data about their users. If they need digital data about our transactions, they should not be allowed to keep them more than a short time beyond what is inherently necessary for their dealings with us.

One of the motives for the current level of surveillance of the internet is that sites are financed through advertising based on tracking users' activities and propensities. This converts a mere annoyance – advertising that we can learn to ignore – into a surveillance system that harms us whether we know it or not. Purchases over the internet also track their users. And we are all aware that 'privacy policies' are more an excuse to violate privacy than a commitment to uphold it.

We could correct both problems by adopting a system of anonymous payments – anonymous for the payer, that is. (We don't want the payee to dodge taxes.) Bitcoin is not anonymous though there are efforts to develop ways to pay anonymously with Bitcoin. In reality, technology for digital cash was first developed in the 1980s – today we need only suitable business arrangements, and for the state not to obstruct them.

A further threat from sites' collection of personal data is that security breakers might get in, take it, and misuse it. This includes customers' credit card details. An anonymous payment system would end this danger: a security hole in the site can't hurt you if the site knows nothing about you.

**Remedy for Travel Surveillance**

We must convert digital toll collection into anonymous payment (using digital cash, for instance). License-plate recognition systems recognize all license plates, and the data can be kept indefinitely; they should be required by law to notice and record only those license numbers that are on a list of cars sought by court orders. A less secure alternative would record all cars locally but only for a few days, and not make the full data available over the internet; access to the data should be limited to searching for a list of court-ordered license-numbers. The U.S. 'no-fly' list must be abolished because it is punishment without trial.[10]

It is acceptable to have a list of people whose person and luggage will be searched with extra care, and anonymous passengers on domestic flights could be treated as if they were on this list. It is also acceptable to bar non-citizens, if they are not permitted to enter the country at all, from boarding flights to the country. This ought to be enough for all legitimate purposes.

Many mass transit systems use some kind of smart cards or RFIDs for payment. These systems accumulate personal data: if you once make the mistake of paying with anything but cash, they associate the card permanently with your name. Furthermore, they record all travel associated with each card. Together this amounts to massive surveillance. This data collection must be reduced.

Navigation services do surveillance: the user's computer tells the map service the user's location and where the user wants to go; then the server determines the route and sends it back to the user's computer, which displays it. Nowadays, the server probably records the user's locations, since there is nothing to prevent it. This surveillance is not inherently necessary, and redesign could avoid it: free/libre software in the user's computer could download map data for the pertinent regions (if not downloaded previously), compute the route, and display it, without ever telling anyone where the user is or wants to go.

Systems for borrowing bicycles, etc., can be designed so that the borrower's identity is known only inside the

[8] http://www.theguardian.com/world/2013/sep/05/nsa-gchq-encryption-codes-security
[9] http://www.nytimes.com/2013/09/02/us/drug-agents-use-vast-phone-trove-eclipsing-nsas.html?_r=0
[10 https://www.aclu.org/blog/national-security-technology-and-liberty-racial-justice/victory-federal-court-recognizes
[11] https://www.aclu.org/blog/national-security-technology-and-liberty/it-sure-sounds-nsa-tracking-your-location
[12] http://www.guardian.co.uk/world/2013/jun/06/nsa-phone-records-verizon-court-order
[13] http://www.motherjones.com/kevin-drum/2013/08/ubiquitous-surveillance-police-edition
[14] http://blogs.hbr.org/cs/2013/06/your_iphone_works_for_the_secret_police.html
[15] http://www.wired.com/opinion/2013/10/a-necessary-evil-what-it-takes-for-democracy-to-survive-surveillance
[16] http://www.gnu.org/philosophy/surveillance-vs-democracy.html

station where the item was borrowed. Borrowing would inform all stations that the item is 'out', so when the user returns it at any station (in general, a different one), that station will know where and when that item was borrowed. It will inform the other station that the item is no longer out. It will also calculate the user's bill, and send it (after waiting some random number of minutes) to headquarters along a ring of stations, so that headquarters would not find out which station the bill came from. Once this is done, the return station would forget all about the transaction. If an item remains out for too long, the station where it was borrowed can inform headquarters; in that case, it could send the borrower's identity immediately.

**Remedy for Communications Dossiers**

Internet service providers and telephone companies keep extensive data on their users' contacts (browsing, phone calls, etc.). With mobile phones, they also record the user's physical location. They keep these dossiers for a long time: over 30 years, in the case of AT&T. Soon they will even record the user's body activities. It appears that the NSA collects cell phone location data in bulk.[11]

Unmonitored communication is impossible where systems create such dossiers. So it should be illegal to create or keep them. ISPs and phone companies must not be allowed to keep this information for very long, in the absence of a court order to surveil a certain party.

This solution is not entirely satisfactory, because it won't physically stop the government from collecting all the information immediately as it is generated - which is what the U.S. does with some or all phone companies.[12] We would have to rely on prohibiting that by law. However, that would be better than the current situation, where the relevant law (the PATRIOT Act) does not clearly prohibit the practice. In addition, if the government did resume this sort of surveillance, it would not get data about everyone's phone calls made prior to that time.

**But Some Surveillance Is Necessary**

For the state to find criminals, it needs to be able to investigate specific crimes, or specific suspected planned crimes, under a court order. With the internet, the power to tap phone conversations would naturally extend to the power to tap internet connections. This power is easy to abuse for political reasons, but it is also necessary. Fortunately, this won't make it possible to find whistle-blowers after the fact.

Individuals with special state-granted power, such as police, forfeit their right to privacy and must be monitored. (In fact, police have their own jargon term for perjury, "testilying," since they do it so frequently, particularly about protesters and photographers). One city in California that required police to wear video cameras all the time found their use of force fell by 60%.[13] The ACLU is in favour of this.

Corporations are not people, and not entitled to human rights. It is legitimate to require businesses to publish the details of processes that might cause chemical, biological, nuclear, fiscal, computational or political hazards to society, to whatever level is needed for public well-being. The danger of these operations (consider the BP oil spill, the Fukushima meltdowns, and the 2008 fiscal crisis) dwarfs that of terrorism.

However, journalism must be protected from surveillance even when it is carried out as part of a business.

**Stop the Accumulation of Big Data**

Digital technology has brought about a tremendous increase in the level of surveillance of our movements, actions, and communications. It is far more than we experienced in the 1990s, and far more than people behind the Iron Curtain experienced in the 1980s[14], and would still be far more even with additional legal limits on state use of the accumulated data.

Unless we believe that our free countries previously suffered from a grave surveillance deficit, and ought to be surveilled more than the Soviet Union and East Germany were, we must reverse this increase. That requires stopping the accumulation of big data about people.

*A version of this article was first published in Wired[15,16] in October 2013.* 

*Richard Stallman* is a computer programmer and activist for free software. He is best known for launching the GNU Project and founding the Free Software Foundation, and has been a constant campaigner against software patents and digital rights management, pioneering the concept of copyleft. He has received fourteen honorary doctorates and professorships for his work.





# Engaging Digital Citizens for Children's Rights

*Gerrit Beger, UNICEF*

**The convergence of investment in broadband infrastructure in many countries, the proliferation of feature phones and flexible pre-paid schemes, has recently led to the creation of millions of new 'digital citizens' around the world. The internet – and specifically social networking – has changed the way people, and particularly young people, access and create information. These exciting developments mean that never before has there been such a rich opportunity to engage the world's digital citizens, including a newly empowered youth, in issues surrounding children's rights and well-being.**

**UNICEF has harnessed this potential, and today employs a range of web-based tools to share updates about their work, broaden understanding of development challenges, inspire young people with stories of success and progress, and mobilise support to help the organization reach the world's most vulnerable and marginalized children.**

No longer the privilege of developed nations with massive infrastructural capacity, the internet is going global. A study conducted in South Africa – a country characterised by very high socio-economic inequality – entitled *The New Wave* found that around 40 per cent of South Africa's internet users have an income of less than 200 USD a month – and among those using the internet for two years or less, two-thirds were classified as low income or living below the poverty line.

*Around 40 per cent of South Africa's internet users have an income of less than 200 USD a month*

In addition to web use, the explosion of social networking – in the broadest sense – and the proliferation of social networking sites and services has lowered the barrier to entry exponentially. For example, an individual, even a child, with a smartphone, or even a simple feature phone, and access to a reliable internet connection has the potential to be a creator of content, producer of information, and even a reporter. Furthermore, social networking has enabled people to connect directly with high profile personalities or organisations – from presidents and government ministers to journalists, activists and United Nations agencies – in a different way to traditional media outreach.

Via the creation of compelling evidence-based multimedia content within this context, UNICEF has successfully used social media to communicate directly with the people who are interested in their work, and to foster a sense of collaboration and trust. For example, the global UNICEF Facebook page, created in 2009, now boasts over three million fans, and the organization's combined global social media audience is around eleven million strong around the world. This includes multiple global platforms such as Facebook, Twitter, YouTube, Tumblr, Instagram, Pinterest and LinkedIn, as well as country- or region-specific platforms such as China's Sina Weibo and Tencent. In April 2013, UNICEF was recognised for being the top non-profit on Twitter for engaging its audiences, and is in the top five list for non-profit brands on Facebook.

**Empowering the World's Youth**

Children and young people are the most active users of social media and other digital tools. Even pre-dating the current social networking giants, there have been countless international and local platforms, networks

*Voices of Youth Maps has also been used in Haiti to engage young people from vulnerable communities to identify risks to their safety.*

and forums which have given young people a place to assemble online peacefully – to exchange ideas and opinions on matters that are important to them, or to engage in debate.

In 1995, UNICEF founded *Voices of Youth* – an online space for young people to learn about human rights, development and UNICEF's work. Users are encouraged to share their views and opinions on matters that concern them, to engage in dialogue and debate with other young people from different countries and contexts, and to become inspired to take action for positive change in their own communities. Designed with flexibility, and multi-platform and multi-language, use in mind, *Voices of Youth* has successfully attracted young people to its websites and social media platforms. Significantly, children are the primary content contributors – even in low-resource and low-connectivity settings.

In 2011, UNICEF staff in New York and Rio de Janeiro collaborated with digital innovators, government officials, community leaders and other partners to design a programme which would see young people creating maps that depict the social and environmental risks in their surroundings. Over three years later, the outcome is the *Voices of Youth Maps*, an initiative that promotes the use of digital mapping to help young people participate in improving their communities. By training young people to use a simple digital tool in the context of a structured programme, and partnerships with local authorities, the youth participants in the *Voices of Youth Maps* are able to play a critical role in improving their communities. In Brazil, following the success of the initial phase in Rio de Janeiro in 2014, the project is being expanded to 30 schools in three regions.

*Voices of Youth Maps* is one example of how UNICEF offices around the world are using simple digital tools to empower citizens, including children and young people, to be partners in development. In Uganda in 2011, UNICEF launched U-Report – a simple SMS-based system which enables citizens to monitor and report on conditions in their communities. In addition to the SMS-based polls and messages to and from users, there are also weekly radio programmes and regular news reports which share updates and select stories collected via SMS. To date the system has just over 250,000 members.

In Zambia, UNICEF and partners are utilizing U-Report to educate young people and to engage them on issues related to HIV and AIDS. By signing up to Zambia U-Report young people can access a wealth of information on HIV and sexually-transmitted illnesses, and can communicate directly with trained counsellors. The system also allows UNICEF and its partners to conduct polls with U-Report users, which can then be used to inform awareness-raising and information campaigns.

*In Zambia, UNICEF and partners are utilizing U-Report to educate young people and to engage them on issues related to HIV and AIDS*

**The Digital Divide**

It is important to remember that while the uptake of mobile internet has been remarkable over the past two years, there remains a 'digital divide' – the gap between people with effective access to digital and information technologies, in particular the internet, and those with limited or no access at all.

In fact, according to 2013 data from the International Telecommunications Union (ITU), the percentage of individuals using the internet in the developing world was only 30.7 per cent – less than half of that in the developed world. Lack of access to digital tools is even more likely among highly vulnerable groups of children and youth – young children, females, children living with disabilities, out-of-school children, unaccompanied migrant children and many others – who also struggle to access information through traditional channels, and who are most at risk of being left behind.

Additionally, while mobile use is helping to narrow the gap in access to the internet and is offering many of the advantages of internet access to people who have previously not had it, ownership rates, usage patterns and quality and cost implications vary wildly. Moreover, people who only access the internet via mobile phones have a significantly different user-experience than people who access it via a computer or even a tablet. For those who have access, there is also a significant imbalance in the quantity and quality of content in different languages on the internet – with a significant bias for those who speak English. In South Africa, for example, *The New Wave* study found that illiteracy in English was one of the greatest barriers to internet use.

When using digital tools to engage younger digital citizens it is also necessary to consider – and minimize – the range of risks they may be exposed to while they navigate the online world. Undesirable consequences may include, for example, new types and dimensions of bullying amongst peers, new channels of solicitation for sexual predators, greater potential for exposure to negative content, and concerns about personal data privacy and targeting by advertisers and marketers. Some of the key challenges in ensuring the safety and well-being of children online include the high degree of anonymity that the internet offers transgressors, the fact that the internet is borderless which has implications for jurisdiction when dealing with crimes, and the speed and ease with which content can be shared. Within *Voices of Youth*, to address this issue there is a regular focus on educating and empowering young people to make safe and responsible choices online through the *Voices of Youth Citizens* initiative.

Finally, there have been numerous examples in the media of instances where governments from around the world have taken severe actions against individuals who expressed unfavourable or critical views on political matters online, particularly through blogs and social media platforms. While the internet offers greater freedom of expression and assembly for activists – child or adult – such incidents, and fear of reprisal, impact on the realisation of these rights.

With every passing year, more and more global citizens become global 'digital' citizens. This presents an incredible opportunity for UNICEF to build on the successes of our engagement thus far, and to mobilize and empower even greater numbers of people to take positive action to improve the well-being of children in their own countries, and around the world.

*Gerrit Beger* is the global lead of UNICEF's social media and digital engagement team in New York City. He is also currently a fellow at the Berkman Center for Internet and Society at Harvard University.

# Advancing Health Research Through Online Social Networking

*Fahdah Alshaikh, Imperial College London*

**The past decade has seen technology advance so rapidly, it's almost difficult for industries and manufacturers to keep up. However, this technological shift has revolutionised the practice of medicine and healthcare with new treatments and medical devices launching at an ever-increasing rate. Alongside the development of new therapies, the recent explosion of internet-based communication and education tools has enabled practitioners and researchers to interact with patients in new and innovative ways. This has allowed the medical community to disseminate information, receive real-time feedback and collect data critical for scientific research.**

Exploring and exploiting the opportunities made possible by new technology is essential in all aspects of research. The internet is particularly notable in terms of its ability to reach a wide audience in a unique, interactive and efficient way. For example, Social Network Sites (SNS) allow people all over the world, particularly in the younger age range, to communicate with one another. This intrinsic ability to reach out to young people, with the potential to collect data, has been little utilised in health research.

SNS have gained a lot of attention from consumers and advertisers, including health organisations, in the recent past. However, whilst SNS is recognised as a powerful tool for communication; the question is raised, 'How effective can SNS be in engaging and reaching youth for health research and health surveys?'

**eHealth**

Since its emergence, the internet has grown to be an invaluable tool in healthcare. Demand from consumers for information about health and well-being has led to the establishment of a range of online regulated healthcare organisations whose aim is to provide accurate and clinically valid information. Methods of delivery of such information often include a range of media including short videos or images depicting conditions and treatments.

*Demand from consumers for information about health and well-being has led to the establishment of a range of online regulated healthcare organisations whose aim is to provide accurate and clinically valid information*

Online healthcare technologies also provide an opportunity for active communication between patients and health professionals, either via private messages (email) or publicly through forms and fan pages. For example, SNS users may spread health information and advertise surveys about health care by updating their status or by showing participation on their profiles. Another key feature of SNS is its ability to allow community interaction. Family members of patients can be involved, ideas can be shared and people can support one another. On the other hand, as the community is virtual, no geographical barriers apply. One such example of online patient interaction is Patient Opinion, a website developed by the Nottingham Healthcare NHS Trust[1], which provides an online forum for patients to share information on their health problems and questions about treatments with other patients, as well as qualified medical personnel.

**Social Surveys**

Allied to the dissemination of health information, and the facilitation of interaction between patients and the healthcare industry (and other patients), online technology can also play a role in health research.

Healthcare organisations undertaking survey-type research usually collaborate with a research institutions, as the latter are specialists in setting up; running studies; analysing data and reporting findings. For example, research surveys typically require health researchers to communicate with participants and send them a survey to be completed and returned by a set date. This mode of communication is predominantly 'one way' as participant feedback may be missed due to difficulties in reaching consumers or issues with response rates. Also any additional participant feedback may not be deemed useful for research purposes, and is hence disregarded.

*SNS surveys may also be adaptive, i.e., if participants choose gender 'male' then they are not asked any female related questions e.g. 'Are you pregnant?'*

However, using SNS as a mode of communication between researchers and participants allows participants to communicate with one another and with the community, generating more widespread interest. Participants are able to answer surveys anonymously as responses are unidentifiable, which in turn will encourage more truthful responses. Participant feedback is instantaneous, updated quickly, and easily processed and analysed. The researcher also has the opportunity to monitor the whole process in real time, quickly correcting any anomalies.

One of the key advantages of SNS surveys is their ability to reach a worldwide audience, and target specific groups easily e.g. for gender, age range, or ethnic origin. Researchers are able to filter results and exclude those responses that don't meet inclusion criteria e.g. exclude responses by participants outside of specified age range. SNS surveys may also be adaptive, i.e., if participants choose gender 'male' then they are not asked any female related questions e.g. 'Are you pregnant?'. Essentially this form of data collection allows secure and adaptive interaction between all parties involved.

From an economic perspective, cost, survey duration, resource availability and appropriateness of survey mode need to be taken into account. SNS surveys may be comparatively less costly to undertake when compared with traditional paper-based surveys especially if one is interested in comparing responses between large regions or even countries.

**Challenges**

It is critical for health providers and researchers to understand the potential that SNS holds for enhancing health communication in order to harness and subsequently apply this technology effectively.

**Case Study: SNS for Recruitment – 100 000 donors in 100 days**

17-24 year olds account for 40% of new blood donors in the UK each year. But the number of young donors registering has been falling steadily. In response to this decline the NHS launched an initiative to recruit 100 000 blood donations in just 100 days.

Their strategy focussed on a continually updated online and social media presence that appealed to young people and their desire to be seen to be making a difference. They harnessed existing donor communities' social network sites, (Facebook, twitter, YouTube), encouraging them to tweet personalised campaign messages, upload photos and be part of the appeal.

A total of 16,211 tweets were created using #100k100days, 1,815 posts were shared on Facebook and the campaign video viewed 1,346 times. Total spend was just 40p per thousand people reached. Through this innovative social networking approach the NHS exceeded its target and secured 120,000 new donors.

[1] Patient Opinion (Nottingham Healthcare NHS Trust). [online] Available at: https://www.patientopinion.org.uk/ [Accessed 15 February 2014]

[2] Bull et al (2011) Case study: An ethics case study of HIV prevention research on Facebook. (Journal of Pediatric Psychology). 36(10):1082-92

*The #nomakeupselfie campaign for breast cancer garnered thousands of enthusiastic followers raising awareness of the disease.*

**Case Study: SNS for Health Status and Intervention – Teen Sexual Health Information**

One study assessed the relationship between online social network usage and HIV risk behaviours, knowledge about HIV, and STI testing among urban, homeless, youth in Los Angeles. They found that social network usage was associated with an increased knowledge of HIV/STI prevention and an increased likelihood of having previously been tested for STIs.

Developing sexual health services and interventions on online social networks could reduce sexual risk behaviours. These online SNS provide a safe venue to discuss sensitive issues that are often not communicated in conventional face-to-face discussions. Since 79% of homeless youth use SNS almost every week, this may be an important platform to target an at-risk audience that are often the hardest to reach.

The most important aspect of SNS is the 'start up' stage; devising an appropriate survey; setting up the site; initial advertising; generating and maintaining interest thereafter. Hence it is essential to meticulously plan each stage with clearly defined inclusion criteria, to use accurate and reputable information sources for site content and ideas to generate discussion amongst participants. Furthermore, all surveys whether electronic or paper-based need to consider the nature and level of detail of information to be collated, to avoid capturing any participants' identifiable information unnecessarily. This will be one of the toughest challenges facing SNS-based health research, and will require rigorous ethics approval and deliberate attention to consent, confidentiality, and security[2].

Finally, SNS-based surveys are limited to ICT literate people with a SNS account, and are particularly appropriate when targeting a younger generation. It is perhaps better to use paper-based questionnaires if targeting an older audience not as fluent with ICT. However, as the number of people using electronic media increases, this mode becomes more and more appropriate and should be considered by researchers when designing future survey-type studies.

*Fahdah Alshaikh* is a doctoral researcher at Imperial College London interested in the use of Social Network Sites in research and health promotion.



# Mobile Health

## Patient, heal thyself (with a little help from your smartphone)

*Dr. Kit Huckvale, Department of Primary Care and Public Health*

**If you have ever a received a text-message reminder for a health appointment, then you have already experienced mobile or mHealth in action – but this is only the beginning. In the future, smartphones, apps and connected sensors will increasingly be used to support all aspects of health. As these technologies become prevalent there is a need to make sure they are effective and safe, but also to understand the implications for individuals and communities who will increasingly be asked to take charge of aspects of their own health.**

In 2007, a new era of personalised computing dawned with the launch of the smartphone. Capitalising on advances in displays, sensors, and miniaturised computing, this new generation of mobile phone introduced the app; a simple mechanism to add new functions on demand. Easily downloaded from online marketplaces, apps have proven extremely popular. The number of available apps can be measured in hundreds of thousands, and cumulative downloads in billions. Almost fifty percent of US adults now have a smartphone capable of running apps and the average user has installed over 40 apps on their device, spending around 40 minutes using them each day[1].

Almost immediately, there was interest in how apps and smartphones could be used for health. Amongst researchers, it had been recognised for a number of years that emerging networked technologies would have uses for what would become termed 'mobile' or 'm-Health'. However, it was only with the advent of smartphones and apps that mHealth began to gain wider attention amongst clinicians and policy-makers.

Driving this was, and is, a fortuitous intersection of three elements: novel technologies, a consumer phenomenon, and prevailing political priorities affecting health. While most people in developed economies will be smartphone owners by 2020, with developing settings not far behind, the phenomenon of the smartphone is more than one of scale: there has also been a shift in how people use such devices. For most, mobiles are now always-carried and always-on, raising the prospect of health-related services that integrate into the routine of daily life.

In developed settings, political priorities reflect the growing costs of healthcare and the increasing prevalence of long-term conditions associated with lifestyle and aging; for example, diabetes and dementia. As a result, policy-makers are actively searching for methods to reduce costs by reducing unscheduled or inappropriate use of services, increasing self-care, and focusing on preventative healthcare. The possibility that large numbers of patients could provide their own multifunction healthcare device would have seemed impossible even 10 years ago and yet now we have witnessed a UK health minister suggesting that smartphone apps be routinely offered "on prescription" for long-term conditions[2], and the US Secretary of Health and Social Services declaring that "the greatest technology breakthrough of our time, will ensure that 'control over your health is always within a hand's reach'.[3]" Lifestyle-associated diseases are also increasingly relevant in developing settings, but mHealth efforts here are also concerned with infectious diseases like malaria and HIV, maternal and child health, and limitations in existing health infrastructure and workforce capacity.

[1] The Nielsen Company (2012) State of the Appnation – A Year of Change and Growth in U.S. Smartphones. The Nielsen Company,.
[2] Department of Health (2012) Press release - GPs to 'prescribe' apps for patients. In: Department of Health, editor. London, United Kingdom.
[3] Sibelius K (2011) Guest Commentary - mHealth Summit Keynote Address. NCI Cancer Bulletin.

**Putting mHealth to work**

Although some apps are designed solely for clinician use, for example as calculators to help work out drug prescriptions, the business of mHealth will take place somewhere in the space that exists between patients (and the public) and health care professionals. The range of potential applications is extremely broad.

*The possibility that large numbers of patients could provide their own multifunction healthcare device would have seemed impossible even 10 years ago*

Instead of booking a face-to-face consultation, a patient with a minor complaint might be able to seek advice from their clinician using a smartphone app. Problems might be resolved using secure text-based and email messaging, with the option of speaking by phone or using videoconferencing if further discussion is required. The device camera can be used to exchange images, while standardised questionnaires presented within the app could be used to assist the diagnostic process. An app might be able to offer video or audio guidance about what to do in an emergency, helping people provide appropriate first aid as well as decide where to seek help. In settings where access to primary care is limited, such services may be transformative. For example, a smartphone microphone can become a rapid diagnostic test for childhood pneumonia, a condition with high rates of mortality in remote settings[4]. mHealth can also help with the routine business of interacting with health services for example, booking appointments, ordering prescriptions and completing health checks, for example by offering text message reminders or app-based booking services that offer convenience and help reduce missed appointments.

mHealth has a role to play in self-care and medication management for long term conditions, for example asthma or heart failure. Taking advantage of the fact that smartphones are always carried, an app might act as a convenient diary for logging symptoms and measurements. Summarised graphically, the information that is collected can be used to help people make decisions about their own day-to-day treatment, perhaps stepping up an asthma inhaler in response to a dip in measured lung function. It can also help highlight changes that might need medical attention, for example, detecting the gradual gain in weight that signifies worsening heart failure. mHealth technologies can also offer access to education and information about a condition and, when required, additional peer and expert support through social networks. Text messages can be used to send bite-sized, tailored information, while apps can offer a full range of multimedia content. Many people with long-term conditions find it hard to take their medication reliably[13]. An app might be used to provide reminders about medication taking, and keep a log of medication-taking and side effects that can be used to start a discussion with a clinician. Text messages have been used successfully to remind people with HIV in Kenya to take their antiretroviral medication[5].

Emerging sensor technologies will complement the functions offered by devices like smartphones. Indeed, the roots of mHealth lie in the world of novel sensors rather than the consumer technologies that have followed. The battery of sensors already in smartphones can already be used to measure heart rates (using the camera to detect changes in the light absorption of skin as blood is pumped through it with each heart beat [6]), detect falls, monitor activity levels, and diagnose changes in symptoms in conditions like Parkinson's disease. But much more is possible. Sensors woven into clothing or integrated into wearable artefacts like watches, affixed to the skin, worn as a contact lens[7], or even inserted subcutaneously, can track parameters like temperature, oxygen saturation levels and


[4] Abeyratne U, Swarnkar V, Setyati A, Triasih R (2013) Cough Sound Analysis Can Rapidly Diagnose Childhood Pneumonia. Annals of Biomedical Engineering 41: 2448-2462.

[5] Horvath T, Azman H, Kennedy GE, Rutherford GW (2012) Mobile phone text messaging for promoting adherence to antiretroviral therapy in patients with HIV infection. Cochrane Database Syst Rev 3: CD009756.

[6] Zhao F, Li M, Qian Y, Tsien JZ (2013) Remote Measurements of Heart and Respiration Rates for Telemedicine. PLoS ONE 8: e71384.

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blood pressure and blood measurements like glucose. Combined with other information using a smartphone provided by the user, they can help people with diabetes or hypertension adjust their own medication or send automated alerts to health providers in an emergency. A tablet with a miniaturised, biocompatible wireless circuit could transmit a signal to let a smartphone track medication use, perhaps measuring and transmitting information about activity levels as well as drug metabolites in the gut[8].

mHealth has also found applications in health promotion and behaviour change. Apps and text-messaging can be used to provide tailored support for people trying to stop smoking or lose weight. An app equipped with appropriate video or written messages can be used to provide motivational support to help people overcome cravings or low will-power 'in the moment'. Rewards and visual feedback like exercise-completion badges or 'money saved since quitting' totalizers can be used to help people sustain behaviour by indicating progress towards a goal. Future apps might also be able to use local information to help people make healthy choices, for example by flagging a walking route to work as an alternative to driving as the user leaves the house (having automatically checked that the weather is suitable for walking).

Finally, there is an emerging role for mHealth in health surveillance. Internet-connected smartphones and tablets can speed up information collection from field workers, both as part of routine disease and public health surveillance, and in the aftermath of humanitarian disasters. Current work is also exploring the feasibility of 'crowdsourcing' such information, for example by sending text-messaging questionnaires to new mothers as part of child health surveillance in China[9].

**Challenges for mHealth**

Despite its promise, mHealth faces substantial challenges. Perhaps the most pressing is the need for robust evidence that the range of applications can work in practice, at scale[10]. This means identifying how apps and other mHealth tools can fit into both clinical care and everyday life, and designing suitable evaluations – including randomised trials – that will take a whole systems approach to understanding their impacts, both positive and negative. Generating more data about individuals may usefully inform clinical decisions (and inform secondary 'big data' type analyses that can drive policy-type decisions) but it will also involve changed work practices for clinicians receiving those data, and unless tools are introduced to manage those new data flows, increased workload. Clinical models of disease management that are not predicated on such high-frequency, high-resolution data may be poorly adapted to distinguishing the signal of real problems amongst the inevitable noise that will result.

At an implementation level, there is much that remains uncertain, for example, about the best ways to target mHealth towards particular groups and address the rapid pace of technology turnover. One example of such turnover is the recent blurring of apps into services that you

can access on multiple devices, through the web and on traditional desktop computers. For healthcare, with understandable sensitivities about privacy and security, this raises concerns about how to secure such information as it shared across the cloud whilst making sure it remains accessible to those who need it. Efforts to standardise protocols for exchanging information, as well as an emerging approach towards regulation, by both the US Food and Drug Administration and European regulators will play a role.

In some areas, regulation may be overdue. For example, diagnostic inaccuracies have been found in apps offering services to analyse images of possible skin cancers[11]. Safety risks are clearly present when apps are providing services like diagnosis or offering treatment decisions, but can also arise in unanticipated ways whenever systems change as a result of a new technology being introduced. A balance must be struck, however, between clinical risk and the potential to stifle innovation by creating costly hurdles through regulation and certification.

**Putting the 'me' in mHealth**

Although evidence gaps and safety impacts are important, identifying and addressing them forms part of the routine landscape for most new health technologies. A defining issue for mHealth is the potential impact that it will have on patients and the public. It is us, as opposed to clinicians, who will have to 'do' mHealth as our devices, and time, are taken up for medical purposes, however unobtrusive and subtle the technology. Individuals and clinicians may hold a shared goal of better health, but there are different ways of achieving this that alter the balance of responsibilities expected of each. mHealth shifts that balance decisively towards the individual.

*Text messages have been used successfully to remind people with HIV in Kenya to take their antiretroviral medication*

There is no easy answer as to whether that is a good thing. In settings where healthcare provision is limited, the arrival of tools that help individuals manage their health might be welcomed. In settings with established provision, technologies that emphasise self-care and consequently reduce traditional forms of providing support, for example face-to-face consultation, might prove less acceptable. Some may find remote management convenient, whilst others see the loss of a source of social support offered by routine contact with a professional. Access to tailored education and tools may help individuals make 'better', more autonomous choices about their health. However those with limited health literacy, or literacy full stop, may not be able to realise those benefits. Certain monitoring data might be extremely useful to a clinician making disease management decisions, but a patient might simply want to get on with the business of living their life without having to record information that serves as a reminder of their ill health. Part of the mHealth evidence gap concerns empirical data that captures the extent and distribution of such attitudes, although efforts are currently underway [12].

At a provider and governmental level, there is understandable interest in technologies that might reduce healthcare utilisation and costs. In insurer-based systems it is easy to envisage the quid pro quo that might result: reduced premiums in return for a little mHealth-supported preventive healthcare. Such programmes may yet prove effective, but it is worth considering the extent to which individuals from poorer socioeconomic backgrounds really have a choice about whether to take up such offers. Discreet, pervasive monitoring might be seen as liberating by some, but raise unwelcome privacy and ethical implications for others. If the kind of consolidation that has characterised developments in internet search, social media and music affects health then there will be also be legitimate concerns about the hosting and processing of personal medical information by transnational corporations. Any data collected will have commercial and research uses for 'big data' population-level analyses, however the nature and extent of what is acceptable has yet to be explored.

mHealth offers an exciting breadth of possibilities for improving healthcare. The resulting technologies will undoubtedly benefit people, but they also create new demands that shift responsibilities for health away from clinicians. The debate about how best to balance those demands in ways that are both acceptable and equitable has only just begun.

A medical doctor by training, *Kit Huckvale* is an NIHR CLAHRC-funded PhD student in the Global eHealth Unit of the Department of Primary Care and Public Health. He has a special interest in the quality and safety implications of mobile technologies for long-term conditions.



# Smart Transport:
## Innovative Ways to Manage Urban Traffic Flow

*Dr. Andy Chow, University College London*

**Ever-increasing demand for transport services has given rise to various challenges such as congestion, energy and environmental problems, and safety and security issues. However, advancements in sensing and information technology for road transport performance measurement, such as wireless sensors and Automatic Vehicle Identification AVI, have recently begun to contribute to sustainable development and management of urban transport systems.**

Road congestion is a significant problem in the UK. The Eddington study, a government commissioned report aiming to examine the long-term links between transport and the UK's economic productivity, growth and stability, projected that the monetary cost of congestion will reach £22b per year for all road users by 2025. A massive 13% of road traffic will be subject to stop-start travel conditions. In a report published in 2009, UK Department for Transport also suggests that congestion across the English road network as a whole will increase by 27% between 2003 to 2025, and 54% by 2035. Construction of new infrastructure is unlikely to be a sustainable solution due to increasingly tight fiscal, physical and environmental constraints. Consequently, governments, businesses, and research teams around the world are exploring alternative ways to effectively utilize and manage existing road infrastructure.

*Construction of new infrastructure is unlikely to be a sustainable solution to increasing road congestion due to increasingly tight fiscal, physical and environmental constraints*

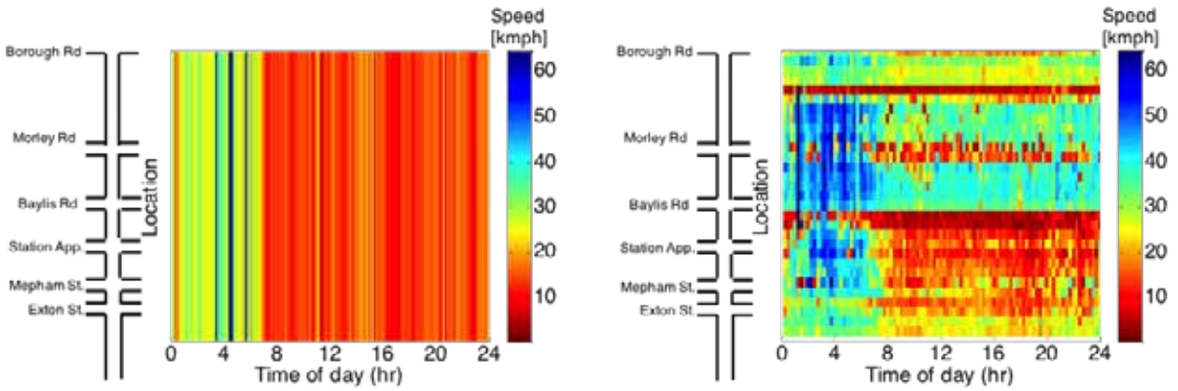
**Traffic Tools**

As the old adage goes "you can't manage what you don't measure". In a modern age, detailed and reliable traffic data are a prerequisite for effective transport management[1]. However, urban traffic data varies greatly in terms of collection method and reliability. Traditionally traffic data in urban environments are collected through various fixed location sensors such as loop detectors and automatic traffic counters, which provide information of traffic volume, composition of traffic, concentration and speed. Nevertheless, fixed sensors are expensive to install, operate and maintain. Installation of a loop detector requires extensive lane closures as well as significant saw-cutting of the roadway surface which is costly.

The 21st century is an era of information and communication technology. With costs decreasing, and increasing power and market share, various new sensing and communication devices such as wireless sensors, GPS and Automatic Vehicle Identification (AVI) techniques are cost-effective substitutes for traditional and expensive loop detectors.

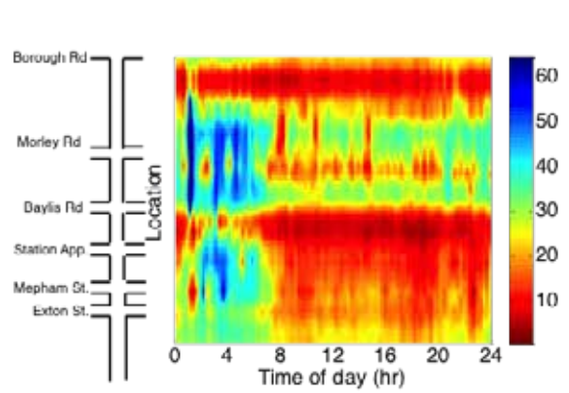
Journey times are amongst the most important performance indicators for urban transport networks. As an example, journey times in London are derived via an Automatic Number Plate Recognition (ANPR) technique. In London, there are around 500 cameras enforcing various policies such as congestion charging and low emission zones. Hence, journey times

[1] Chow A.H.F., Santacreu A., Tsapakis I., Tanaksaranond G., Cheng T. (2013) Empirical analysis of urban congestion. *Journal of Advanced Transportation.* In press










*Today journey times in London, such as a trip along Waterloo road considered here, are typically derived by an Automatic Number Plate Recognition (ANPR) technique (left). However, a major weakness with the ANPR journey times is that they do not capture many spatial features of traffic flow, because the distance between any pair of ANPR camera sites is typically in the range of kilometres, meaning they miss a lot of spatial variation among urban streets. An alternative method extracts more detailed spatial traffic features by using GPS–equipped car data provided by a traffic information provider called Trafficmaster (middle), yet a combination of both approaches yields the best results (right)[1].*

and car speed between two ANPR camera sites can be estimated by matching the license plate numbers. For example, there is a 1km stretch of Waterloo Road in Central London with a pair of ANPR cameras installed at both ends. Errors may arise in matching the license plate numbers due to various reasons such as misreading of license plates, vehicles taking unusually long route between the two camera locations, data loss due to road closure, or failure of hardware systems.

Consequently, a set of data filtering and processing rules has been adopted to improve the journey time estimation[2], which is supplemented by patching or imputation algorithms that estimate missing data. In London, this type of analysis is done by the London Congestion Analysis Project (LCAP). However, a major weakness with the ANPR journey times is that they do not capture many spatial features of traffic flow. This is because the distance between any pair of ANPR camera sites is typically in the range of kilometres, meaning they miss a lot of spatial variation among urban streets. To extract more detailed spatial information, it is possible to use GPS–equipped car data provided by a traffic information provider called Trafficmaster. For vehicles on the road equipped with the GPS devices, detailed information about position and speed can be recorded at short time-intervals. However, there are only a very limited number of Trafficmaster vehicles on the road (about 1,500 such vehicles in the Greater London Area). With such a small sample size, Trafficmaster can only reveal limited temporal characteristics of traffic.

*Successful avoidance of paralysing traffic congestion [during the London Olympics] was due to a range of management policies operated by the London transport authorities that included active traffic management, provision of alternative modes (e.g. subway), and restrictions on road-works*

Our team at UCL have developed an algorithm to integrate these two kinds of traffic data. The objective is to reconstruct urban traffic flows through processing and integrating data from different sources. This fusion algorithm is able to retrieve hidden features of traffic flow that are not observable by ANPR or GPS data alone. Estimated journey times can then be used to derive various performance metrics such as speeds, travel reliability, and impact of major events such as strikes[3] and the Olympics[4]. This enables transport engineers to calculate the benefits and costs associated with different policies or control plans in order to improve the day-to-day operations.

**Olympian Speeds**

For example, during the 2012 Olympics, traffic gridlock was anticipated by many Londoners and visitors alike. We can compare both weekday and weekend congestions patterns during this period in 2011 and 2012:

- There is a clear speed drop during 06:00-20:00 due to traffic of commuters' or other commercial activities.
- Speed profiles show less variation during weekend although the congestion charge is not in operation.
- Traffic was actually travelling faster during the Olympics period.

Successful avoidance of paralysing traffic congestion was due to a range of management policies operated by the London transport authorities that include active traffic management, provision of alternative modes (e.g. subway), and restrictions on roadworks. Empirical studies on the Oyster card system also noted a significant change in travel behaviour that led to the improvement of road network performance during the Olympics period[4].

**Smart Sensors**

Recent innovation in the collection and analysis of new data such as trajectories data derived from mobile sensors like GPS, Bluetooth devices, smart cards (e.g. Oyster) and even smart phones has enabled researchers to develop new solutions to congestion management. With decreasing costs and increasing penetration, mobile sensors are now a potentially viable substitute to conventional fixed sensors, given their high sampling rate and high spatial coverage. More importantly, these sensors already exist and are used by travellers. In London, GPS transponders have been installed on all London buses, police vehicles and most taxis. Smart-phone data can monitor, for example, pedestrians. Oyster cards facilitate observation of flows on public transport (buses tubes, trains, ferries), and the Barclays Cycle Scheme records usage levels at bike stations on a real-time basis with their GPS installation.

Considering the importance of transport systems to both economic and social development, the creation of tools to analyse and manage transport systems will be particularly beneficial to developing countries. For example, in Indonesia and Kenya, transport authorities must rely heavily on manual traffic counting and control on major roads due to a lack of resources and budget for installing fixed sensing infrastructure. Applications of innovative mobile sensing and communication technology can help these countries to improve the efficiency, reliability and security of their transport infrastructure at a reduced cost.

*The author would like to acknowledge Transport for London for providing relevant data for analysis. The contents of this report reflect the views of the author and do not reflect the official views or policies of Transport for London and other organizations. This article also does not constitute a standard, specification, or regulation.*

*Dr. Andy Chow* is a Lecturer in Transport Studies at University College London. His research lies in developing tools for analysing and managing transport systems, including system performance analysis, space-time data mining, and optimal control.

[2] Robinson, S, Polak, J (2006) Overtaking rule method for the cleaning of matched license plate data. *ASCE Journal of Transportation Engineering.* **132(8)**: 609 – 617.

[3] Tsapakis I., Turner J., Cheng T., Heydecker B.G., Emmonds A., Bolbol A. (2012) Effects of tube strikes on journey times in the transport network of London. *Transportation Research Record.* **2274:** 84 – 92.

[4] Chow A.H.F., Tsapakis I., Manley E., Tanaksaranond G., Heydecker B.G., Cheng T., Emmonds A. (2012) Fusion of heterogeneous urban traffic data. 1st European Symposium on Quantitative Methods in Transportation Systems. September 4-7. Lausanne, Switzerland.

# The Virtual Drive

*Prof. Michel Ferreira, Pedro Gomes, Michelle Krüger Silvéria, Fausto Vieira, University of Porto*

**Augmented Reality (AR) technology, which aims to 'augment' reality via the use of technology, can modify one's perception of the world around them. For instance, a rotating virtual billboard could be placed on top of the Empire State Building in New York City, showing specific advertisements to different people using an AR system. This emerging technology has significant economic potential because it embeds virtual objects into physical reality at negligible marginal costs, while maintaining targeted advertising capabilities similar to those of the internet. AR will play an ever-increasing role in other fields too. For example, in cars AR improves human perception though additional sensory aids while still relying on visual-spatial acuity and the ability to navigate in dynamic 3D environments.**

Smartphones and tablets have provided an important push to the daily use of AR systems. Such platforms have become ubiquitous, combining data connectivity, cameras and micro-electromechanical systems (GPS, accelerometer, compass) which are important to create AR content. However, even the most popular AR apps installed on smartphones or tablets only occasionally achieve ontinuous use for long periods of time. A range of new technologies, such as wearable equipment in the form of, for example, Google Glass, are aiming to solve this issue.

*Lane departure warning is conveyed to the driver through the vibration of electronically controlled steering wheels, mimicking the sensation caused by physical rumble strips*

In particular, cars especially offer tremendous potential as highly-used, state-of-the-art AR platforms. Cars are particularly suited to AR as, on average, people use their cars for more than two hours per day and, while it is a challenge to compel people to constantly look at a few inches of their smartphone display, drivers tend to look constantly at their windshield screens. Cars offer other important features for the creation of AR content including very high power autonomy and highly immersive environments. Cars also offer control tools such as steering wheel and pedals, information systems, such as a sound system, and other electromechanical systems and sensors (GPS, speedometer, compass), which are interfaced with very high computing power. Furthermore, wireless connectivity is now becoming embedded in cars, using dedicated frequencies and standards for vehicle-to-vehicle communications.

Historically, AR in cars existed even prior to the invention of electronic displays. Rear view mirrors were invented to augment the visual perception of drivers with a perspective of the road behind. However, the current use of AR systems in production vehicles has expanded far beyond such optical mirrors. In-car AR systems are now used in visual, acoustic and tactile forms. Starting with the latter, many cars now use what is known as drive-by-wire (or throttle-by-wire) technology, where the accelerator pedal is not mechanically connected to the throttle, but rather electronically connected to a throttle control unit. Similarly, in steering-by-wire, the steering wheel is not mechanically connected to the wheels, but rather to an electronic control unit that manages the steering.

[1] BMW Media Information. The new BMW M5, September 2011.

By using such technology, vehicles are able to reduce the lock–to-lock steering wheel travel as a function of the vehicle speed, and convey variable force-feedback to the driver through the steering wheel or pedals, replicating the traditional mechanical feel through AR. For instance, in some cars the lane departure warning is conveyed to the driver through the vibration of electronically controlled steering wheels, mimicking the sensation caused by physical rumble strips.

*Electric vehicles are too silent at slow speeds and [...] electric cars now produce an audible warning of their presence at slow speeds*

With throttle-by-wire, steering-by-wire, or even brake-by-wire, the set of pedals and steering wheels found in many modern cars is not very different from the PC gaming controls that are used to play racing games. All physical feedback conveyed to the driver through the steering wheel or pedals is in fact created by computer-generated AR.

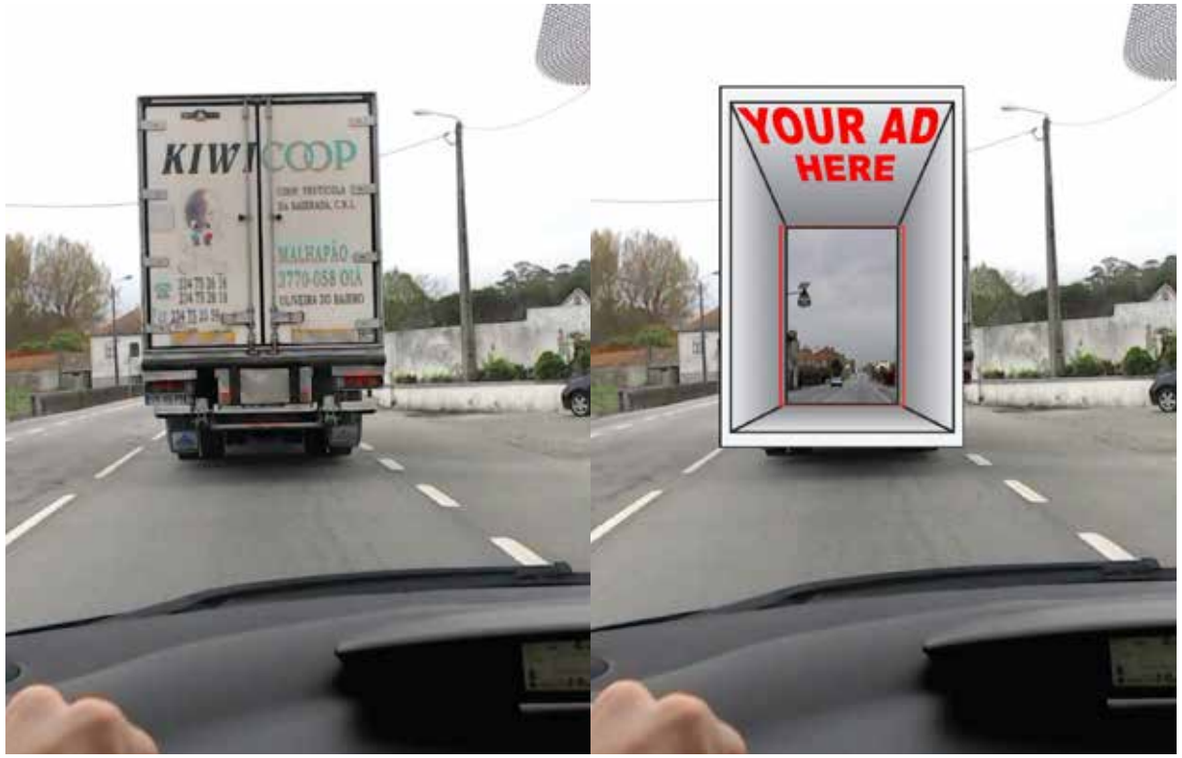
In terms of acoustic AR, we find highly innovative systems currently deployed in production cars. In some German sport sedans, with powerful V8 engines, the noise isolation from the exterior is so effective that the engine is hardly heard. For some owners this can be considered a disadvantage and thus a clever solution based on acoustic AR has been developed and named Active Sound Design[1]. A pre-recording of the non-isolated engine sound is made at the different rotations-per-minute (RPM) of the engine, and played through the vehicle's sound system, making the sound vary according to the actual sound of the engine. Using this AR technology it becomes possible to please both drivers who enjoy a quiet ride, as well as drivers who enjoy hearing the engine sound.

Acoustic AR is even becoming mandatory for some cars. Electric vehicles are too silent at slow speeds and have become dangerous to pedestrians that are not made aware of their presence. Legislation has thus mandated that electric cars now produce an audible warning of their presence at slow speeds. Car design now includes the figure of the composer, responsible for creating the acoustic signature of a rolling electric vehicle.

In addition to the optical rear-view mirrors mentioned above, other visual AR systems are also becoming common in modern cars. The video-see-through form is the most common, and examples of such systems include the rear-view cameras that display real-time video on a dashboard monitor, with super-imposed guidelines to help in a reverse parking manoeuvre. Other examples include night-time driving assistants, which display video captured by infrared or thermal cameras on a driver-centric dashboard monitor. This video can be augmented with computer-generated highlighting of pedestrians. Optical-see-through AR, where the windshield is used as a projection screen where digital content is merged with reality, is also emerging in production vehicles. Laser holographic projection is able to display navigation arrows that appear to be painted over the road pavement, or traffic signs as roadside virtual objects.

**Vehicle-2-vehicle**

The above examples show that AR systems are already heavily used in the production of automobiles. However, these current systems base the creation of AR content on on-board sensors or information stored within the car. Wireless connectivity, which is important in the




*Cars are particularly suited to AR as drivers tend to look constantly at their windshield screens.*

establishment of smartphones and tablets as AR platforms, has previously largely been absent.

Our research has focused on the design of novel AR systems that leverage the emergent standard for vehicular communications[2], in the form of vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) systems. The transmission range for such communication can easily reach 500m on motorways but can drop to 150m or even less in urban environments. The frequency band is divided into several channels, including a control channel for coordination and transmission of traffic safety messages. These safety messages can be viewed as SMS that vehicles send to each other, which can contain information such as "ambulance approaching from the left" or "airbag deployed 500m in front".

*Vehicular ad hoc networks allow digital content to be created based on sensors that reside in neighbouring vehicles or roadside infrastructures*

An important challenge is how to present this information to the driver in a relevant and timely manner. Other service channels allow for multiple applications, from infotainment services to real-time video-streaming. This is only possible because regulations ensure that quality-of-service mechanisms give priority to certain delay-sensitive data streams. The same mechanisms are found in latest generation Wi-Fi routers that provide high quality audio in voice-over-IP applications.

In terms of AR systems, these vehicular ad hoc networks allow digital content to be created based on sensors that reside in neighbouring vehicles or roadside infrastructures. Instead of a video see-through system to assist in reverse parking manoeuvres, where the video feed comes from a camera installed on the back of the vehicle, we can design assistance systems that use perspectives from cameras installed in other vehicles.

This has been the inspiration for the design of the See-Through System (STS) overtaking assistant[3], which works as follows. A vision-obstructing vehicle such as a bus or a truck is equipped with a dashboard camera and a V2V communication device. As a car equipped with a virtual windshield approaches the vehicle in front, it establishes a real-time video stream from the windshield camera to the virtual windshield. Based on the vision-obstructing vehicle's dimensions and relative position to the car, the video stream is overlaid onto the vehicle using the AR capabilities of the virtual windshield and computer vision to seamlessly overlap the preceding vehicle. A virtual depth effect is added to the frame surrounding the video in order to account for the blind spots created by the vehicle's length. The end result is a transparent vehicle that is inherently safer to overtake – and the ad shown on the back of the original vehicle can be replaced by a new virtual ad, specifically targeted at the overtaking driver.

*Virtual traffic lights are only created if they are necessary, and [...] it has been shown that the average travel time in cities with dense traffic conditions could be reduced by 60%, while emissions and fuel consumption would be reduced by 20%*

While AR systems are especially relevant for the automotive environment, the road is shared with pedestrians, cyclists, emergency vehicles, buses and trucks. AR systems can be beneficial in improving the perception of other road users, especially with the increase of vehicle sensing capabilities, as well as ubiquitous connectivity of individuals and vehicles. AR can also create virtually segregated road segments in order to improve safety by separating road usage between different vehicles as well as creating virtual paths for emergency vehicles.

It should be noted that the adoption of AR systems is not only dependent on the technology, but also on the regulatory environment. On this front, AR systems have a straightforward adoption roadmap since they usually provide safety improvements or have no impact on driving behaviour. Furthermore, autonomous vehicles have a much higher burden-of-proof since they could endanger lives if not properly implemented.

**Virtual Traffic Lights**

An important aspect of AR is that the creation of digital objects is much cheaper than the creation of physical objects. The more expensive a physical object is, the more advantageous it is to create it as AR content. In terms of both installation cost and operational cost, traffic lights are found at the top in the road signage infrastructure. Such costs are raised if the traffic lights governing an intersection have the ability to adapt the cycle to the traffic conditions, based on inductive loop detectors. The ideal adaptation of a traffic light would be to have it actually disappear under some traffic conditions. However, such retractable traffic lights are too expensive to install in reality. An affordable and existing alternative is to attach a 'Part Time Signals' label to traffic lights that only work during some periods of the day.

With AR windshields and V2V communications it becomes possible to have virtual traffic lights, whose creation, cycle and phase durations are self-organized based on wireless communication between vehicles approaching an intersection[4]. No road infrastructure is necessary, as a stopped vehicle (a vehicle seeing a red light) is a very good and reliable temporary infrastructure to provide the computerized control for an intersection managed by a virtual traffic light. This vehicle uses V2V communications to broadcast the virtual traffic light messages, which are received by other vehicles and used to create the appropriate traffic light as a virtual object on the windshield. As the current cycle ends, this control is handed over to another stopped vehicle, which continues with another cycle.

Such virtual traffic lights are only created if they are necessary and they could be created only at times when they would be useful for current traffic conditions. A

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[3] P. Gomes, C. Olaverri-Monreal, M. Ferreira. Making Vehicles Transparent through V2V Video Streaming, IEEE Transactions on Intelligent Transportation Systems, 2012.
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ubiquitous infrastructure of such retractable traffic lights is very much affordable using AR. It has been shown that the average travel time in cities with dense traffic conditions could be reduced by 60%[4], while emissions and fuel consumption would be reduced by 20% [5]. This paradigm of traffic control based on virtual traffic lights has been shown to be deployable gradually, assuring compatibility between equipped and non-equipped vehicles[6].

**Virtual Billboards**

Augmented reality could not only reduce the costs of road infrastructure, such as physical traffic lights, but also provide a revenue stream to make major highways self-sustainable.

Most developed countries have an extensive highway network at the core of their communications infrastructure, with many indicators correlating economic development with the density and extension of the network. However, the costs of developing and maintaining this network can be quite high, and are usually supported by a mix of direct public funding, fuel taxes and tolls.

The concept of virtual traffic lights can be generalised to an entire range of virtual objects based on AR windshields and V2V communications. Virtual roadside billboards are a natural step in bringing internet-style targeted advertising to highways, and also a user-friendly alternative to tolls. Most internet services are fully or partially supported by advertising due to their ability to reach mass audiences at a negligible cost while providing high value targeted advertising. In a similar way, if highway users were offered a choice between having ad-sponsored free highways or paying tolls with static billboards, the end result would be overwhelmingly in favour of toll-free highways.

With virtual billboards, the vehicle employs V2I communications to roadside physical billboards with internet-connected V2I roadside units that fetch targeted advertising and transmit it to the vehicle so that it can be superimposed on AR windshields over the physical billboard. Eventually, the entire billboard could be removed and roadside units would only be necessary to create persistent virtual billboards. Overlaying with existing physical billboards guarantees that the visibility conditions that could affect the driver's perception are maintained, as we only replace an existing ad with a more targeted one.

For a highway service provider, just 2 cents per view per billboard would more than compensate for the toll revenue from a typical suburban highway[7]. On the other hand, advertisers are able to reach an adult market segment with a high car ownership ratio and provide targeted and localised ads to a captive audience. The idea of virtual billboards could be combined with STS overtaking assistance. Instead of a fixed ad painted onto the truck's rear, the area could be used to display different ads, selected based on each drivers' mobility profile. Note that the truck's owner should also be part of the revenue chain, similar to a website that adheres to an internet-advertising display network.

**Autonomous Vehicles**

With the emergence of autonomous vehicles, virtual windshield technology presents a range of interesting possibilities. Currently, tactile AR systems in drive-by-wire cars try to augment the driving feel for the driver. In autonomous vehicles, the self-driving nature is assumed and this type of AR disappears. The driver assistance systems will also disappear, as there is no driver. Note, however, that the V2V communication part of systems such as STS or Virtual Traffic Lights still makes sense for autonomous vehicles.

With autonomous vehicles, AR content aims to benefit the comfort of the passengers. It is unlikely that the windshield will be used as a large Smart TV, completely obscuring the road and outside environment. But, as we do not need to convey information that is necessary for driving manoeuvres when a human driver is in command, a number of comfort-oriented enhancements could be designed. Other vehicles could be made invisible. Curved roads could be made straight. Underground routes could become scenic and a Sunday drive could be made totally safe, with almost no fuel consumption, in the landscape of your choice.

*Pacific Coast Highway, anyone?*

*Michel Ferreira* is a Professor of Computer Science at the University of Porto and a researcher at Instituto de Telecomunicações in Porto, where he leads the GeoNetworks group. He is also the co-founder of Geolink, a technology-based company specialized in the optimization of vehicular mobility.


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WARNING!
FLAGGED IN PARKING LOT (STATIC CAMERA) ACTION: REQUIRE SECONDARY SPOT CONFIRMATION
ALERT!
PASSENGERS STRIDE: MATCH
KINEMATIC MOVEMENT: 35.46
SPEED: .56
CLEARED
PN: 3959023
CHECK BAG
MATERIALS OF CONCERN FOUND IN BAGGAGE
CLEARED
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