FUTURE TECHNOLOGY ANALYSIS FOR BIOSECURITY AND EMERGING INFECTIOUS DISEASES IN ASIA-PACIFIC

Nares Damrongchai, Ponpiboon Satangput, Greg Tegart, and Chatri Sripaipan

APEC Center for Technology Foresight. Corresponding Author's E-mail Address: nares.damrongchai@gmail.com

Summary

Emerging and re-emerging infectious diseases has been increasing at an alarming rate during the recent years, posing a clear biosecurity threat to the region of Asia-Pacific. For the region to have sufficient preparedness, all control options - pharmaceutical or non-pharmaceutical, must be considered and fully explored. In most cases these options require capabilities in new technological development and usage, and/or convergence between existing technologies.

This paper presents a collaborative research conducted by a group of international experts and stakeholders in the Asia-Pacific region to analyse some future technologies and develop roadmaps for the prevention and management of emerging infectious diseases. Experts and stakeholders from economies throughout the region were identified and called to participate via the network of the Asia-Pacific Economic Cooperation (APEC) Industrial Science and Technology Working Group (ISTWG) and the Health Task Force.

A combination of many foresight methods were used to conduct the research. A group of converging technologies were first identified by using bibliometric analysis, online survey and scenario planning. Then experts in various technological areas throughout the region were invited to jointly build roadmaps of these technologies by using the method of technology roadmapping. Workshops to conduct the foresight process were held in Thailand, Japan, and Chinese Taipei.

The study resulted in four scenarios and six technology roadmaps for the region to combat emerging infectious diseases. The roadmaps of diagnostic technologies is presented in this paper as an example of the voluminous research outputs. Overall, particular attention was given to providing analysis and clear guidance for technological and human capacity building in developing members of the Asia-Pacific region, where infectious diseases are prevalent and resource is scarce.

As a short-term outcome, this participatory process apparently stimulated actions taken both by individual experts and institutions involved, to work together in finding practical solutions to prevent and manage infectious diseases as well as bioterrorism. For the longer term policy implication, the technology roadmaps should provide guidance and specific recommendations for governments of member economies, the academia, and the industry on how to cooperate and respond to the region’s need for biosecurity.
1 Introduction

1.1 Biosecurity and Infectious Diseases

Biosecurity is the policies and measures taken to protect from biological harm. It encompasses the prevention and mitigation from diseases in human and animals, and bioterrorism that impacts the economy, environment, and public health. More technically, dealing with biosecurity can be considered in terms of information generation and collection, information management, information analysis, and use of analysis. Each of these covers a number of disciplines and requires the application of different technologies to deal with them. Furthermore, biosecurity, and security in general, is also typically related to critical infrastructure, particularly public health. Compromising biosecurity can have far-reaching impact on many other social infrastructure and many aspects of human activities, population structures, or even the survival of humankind (in case of global pandemic).

One major threat to biosecurity is the outbreak of infectious diseases. Infectious diseases account for a quarter of all human mortality but developing countries have a disproportionate share because of poverty, limited access to health care, drug resistance and changing food supplies due to impact climate change on land and water supplies.

1.2 Emerging Infectious Diseases (EID)

While SARS and avian influenza have attracted major attention in recent years there are other diseases which have emerged and also present threats to humans and animals. More new diseases have emerged in the past 20 years than in the previous 50 years with a majority of these originating in wildlife. Further, old diseases such as dengue and foot-and-mouth disease have re-emerged to cause costly epidemics. Eight categories of infectious diseases have been identified as potential threats. These are:

- New diseases such as SARS and BSE with variants such as H5N1;
- Infections becoming resistant to treatment such as tuberculosis and staphylococcus aureus;
- Zoonoses: i.e. infections transferring to humans from animals such as SARS, avian influenza, plague;
- HIV/AIDS, tuberculosis and malaria;
- Epidemic plant diseases;
- Acute respiratory infections;
- Sexually transmitted diseases, and
- Animal diseases.

The categories are not mutually exclusive but illustrate the wide range of threats.

The world health sector continues to seek new technologies and approaches which are needed to combat these threats, to reduce costs of treatment and to improve the human and animal health situation in both developed and developing countries. As an example, recognition of the role of information technology provides a powerful driver of change for approaches to bio-security when linked to genetics, biotechnology, nanotechnology and bioinformatics.

1.3 Converging Technologies

Theme: FTA in Security and Sustainability
Recently, the concept of “converging technologies” has emerged in the USA and in Europe, emphasizing productive interactions between previously separate fields of research and technological development. Such shifts can result in new technological possibilities, with potentially revolutionary impacts associated with changing innovation patterns, industry structures and broader developments in society. It has been proposed that a new paradigm is developing in the 21st century based on the combination of nanotechnology, biotechnology, information technology and cognitive science (NBIC) and that these converging technologies could radically change society, economy and culture in the next 20 years.

Areas suggested are: societal productivity; security from natural and man-made disasters; providing sustenance for an ageing population; combating environmental degradation; promoting sustainable development; and creating capabilities for managing international crises.

In the USA the term “converging technologies” was first used in a December 2001 workshop organized by the US National Science Foundation and the US Department of Commerce entitled “Converging Technologies for Improving Human Performance”. This workshop proposed the concept of NBIC and discussed possible applications to human health and performance. Subsequently several conferences on specific applications have been held in the US.

In Europe the concept of NBIC was studied by a High Level Expert Group which produced a report in 2004 directed to the application of converging technologies to development of a European knowledge society. This report contains the pragmatic definition: “Converging technologies are enabling technologies and knowledge systems that enable each other in pursuit of a common goal”. A Knowledge NBIC project focused on a study of the patterns of knowledge production of the four key fields was launched in 2006. The concept has been extended in the Seventh Framework Program to the possibilities at the interface of micro-nano systems and the living world.

Source: Suthee Phucharoenchanachai, NECTEC (2005)
Figure 1 Converging Technologies

Figure 1 illustrates how nano, bio and info can interact in biomedical applications. In the present study we have applied the concept of converging technologies to combating emerging infectious diseases. The study has highlighted the importance of interdisciplinary approaches that cross traditional intellectual boundaries in dealing with emerging infectious diseases.

Thus a better understanding of patterns of infectious diseases needs input from anthropology, economics and climatology supported by statistics and mathematics. The mechanisms of animal-human transmission need input from medicine and veterinary medicine coupled to virology, bacteriology, mycology and parasitology. Vaccine development and delivery can be speeded up using genetics, nanotechnology, molecular biology and bioinformatics. Moreover health systems research using social sciences, epidemiology and anthropology is needed to understand how new technologies can be used most effectively from the viewpoints of the needs, expectations, capabilities and cultural sensitivities of the end users.

This paper provides evidence of how the analysis of future-oriented technologies can address societal issues and challenges, and have impacts to decision-making and actions in the private and public sector through cooperation over a wide geographical area, in this case the Asia-Pacific region.

2 Methodology

2.1 Conduct of the Project: Overview

The project was organized into two phases. Phase I was designed to identify the potential issues related to emerging infectious diseases. Those issues were such as the trends of potential infectious diseases, the timing of emergence of those diseases, the level of severity of the impacts from the spread of those infectious diseases to communities, etc. Phase II was designed to take the findings from Phase I to determine the possible preparation for the future research and development needed in managing, preventing, or combating emerging infectious diseases.

To complete the objective in Phase I, a combination of literature review/bibliometric analysis and online surveys were conducted to preliminarily capture the trends of infectious diseases. The publication trends were analyzed by using the medical databases of MEDLINE, to present the potential trends of emerging infectious diseases. Then, an online survey, using the network of experts in the Asia-Pacific Economic Cooperation (APEC), was launched to get international experts involved in reviewing the identified trends of emerging infectious diseases. After the survey completion, a face-to-face workshop for scenario planning was organized at Phang Nga in Thailand on 5-7 February 2007. Using scenario creation techniques, 33 experts from 7 APEC member economies shared their views about the severity of the impacts from the spread of emerging infectious diseases and identified the key research domains which the community of medical experts should emphasize so that those diseases can be effectively prevented, managed, or combated.
In Phase II, the objective was to determine directions for future research and development so that APEC member economies can prepare themselves ready to respond to the region’s needs. To achieve this objective, the technology roadmapping technique was applied to analyze the linkage between the development of supporting technologies and the future changes of medical requirements in each research domain as identified in Phase I. Two roadmapping workshops were organized at Tokyo in Japan on 22-24 May (42 experts from 9 economies) 2007 and at Taipei, Chinese Taipei on 24-26 October 2007 (41 experts from 8 economies) to enable infectious disease specialists and technologists to work together in completing the roadmap development.

Experts discussed the future changes of medical requirements in each research domain, the types of supporting technologies needed, the key challenges that could possibly hinder the development progress, and R&D activities. At the end of Phase II, a final symposium was arranged in Bangkok on 13-14 December 2007. Approximately 60 experts from over 10 APEC economies, and covering many disciplines and sectors discussed a longer term perspective to enhance the region’s capacities that contribute to the successful prevention and management of emerging infectious diseases.

Information flow through the two phases of the project can be illustrated by the following chart (Figure 2).
2.2 Scenarios

We used scenarios in attempts to develop internally consistent stories about possible futures where emerging infectious diseases becomes threat in the Asia-Pacific region over the next 10 years and beyond. This was done by inviting experts to a workshop and organised them in breakout groups where the key drivers of future change relevant to the study are identified. Then the uncertainties influencing these drivers are developed. Self-consistent scenarios are then constructed for an agreed time in the future. By working back (backcasting) from these pictures of the future, critical turning points can be identified which can be used to assist in policy decisions.

Thirty three experts from seven economies met in Thailand in February 2007 to develop scenarios for the future of EID in the Asia Pacific region.

2.3 Technology Roadmapping

The structure of roadmaps used in this study was designed by adapting from the generic format of a product/technology roadmap. The basic elements of a generic roadmap representing market, products, technology, R&D programs, and resources, were changed into the elements as listed below:

- medical requirements and users requirements
- development of technologies supporting the requirements
- key technical and policy challenges that could possibly hinder the progress of technology development
- R&D programs/activities required in delivering desired technologies

The timeframe of the roadmaps was divided into three periods: short term (2007-12), medium term (2012-2017), and long term (beyond 2017). The structure of roadmaps used in this study is shown in Figure 3.
In this roadmap, drivers; D1, D2 and D3, are determined to be key forces driving the future changes of medical requirements in using drug and vaccine treatment to deal with infectious diseases. These changes present as R1, R2, and R3 on the diagram. For example, D1 leads to the medical requirement; R1, which it can be supported by the use of existing technology; T1. Few years after that, the medical requirement; R1, is expected to be enhanced to the new stage which it is represented as R2 in the diagram. To respond to this new requirements; R2, the new technology; T2, needs to be developed. Ct1 is anticipated to be a key technical challenge hindering the development progress of T2. To overcome this challenge, an organization needs to invest in the R&D program; RD1. Following the same time horizon, new drivers; D2 and D3, are expected to gain more influent leading to the new medical requirement; R3. T2 will still be used in conjunction with the new technology; T3. A multi-stage R&D; RD1-5, needs to be planned to integrate these two technologies together. Also, a series of activities; A1-3, needs be organized in order to ease the key policy challenge; Cp1, in completing the development of T3.

3 Results and policy impact/implications

3.1 Scenarios and EID Life Cycle Model

The scenario workshop listed key drivers for emerging infectious diseases in the areas of social, technology, economics, environment, and politics (STEEP). It also identified key uncertainties such as massive natural disasters, man-made global security issues, and unpredicted breakthrough technologies. These resulted in four distinctive scenarios titled “Malaria in Miami 2017”, “20,000 People Now Confirmed Dead from Mystery Disease”, “Mysterious Death”, and “Emerging Rainforest Syndrome (RFS)”. 

THEME: FTA IN SECURITY AND SUSTAINABILITY
Discussions revealed an EID lifecycle model as shown in Figure 4, with four stages from preventive measures to surveillance and detection to treatment and prevention of spread. This model was originally proposed at the workshop by Dr. Richard Silberglitt, a participant from Rand Corporation, USA^5^.

![EID Life Cycle Model](image)

*Source: Adapted from Dr. Silberglitt, Rand Corporation*

**Figure 4 EID Life Cycle Model**

According to the model, technological approaches can be used to combat EIDs at every stage of their lifecycle, from preventive measures such as vaccines to biosensors for surveillance, bioassays for detection, drugs for treatment, and filters, membranes, and fabric coatings for prevention of spread.

A key area of interest for the project is how technologies can converge to contribute to the overall capabilities for more effective biosecurity and EID management in the four designated lifecycle domains. Examples of these are:

1) Preventive measures (PM), which is the stage before emergence of EID. This covers technological approaches such as use of mosquito nets and insecticides in the case of malaria; future measures could include a preventive vaccine and new approaches to control the vector.

2) Surveillance & Detection (S&D) is the stage after emergence of EID. Current S&D includes diagnostic testing and monitoring of cases by person/place/time characteristics; future diagnostic or communication technologies could potentially improve upon the likelihood and timing of diagnosis and reporting.

3) Treatment (Tr). Current treatment options include drugs such as artemisinin-based combination therapies; future drugs could potentially be even more effective and cheaper.

4) Prevention of Spread (PoS). PoS include procedures to limit the transmission of the parasite, for example using animal tracking/monitoring.

Future decisions regarding interventions should use all available information about the disease and possible interventions, together with current data from sensors and assays, health clinics, hospitals, and other sources, to estimate the severity of disease effects if no action were taken, the time window for effective intervention, and the efficacy of possible interventions.
This EID lifecycle model was employed throughout the project as the structure for discussions in the technology roadmapping workshops in both Japan and Chinese Taipei and the final symposium in Bangkok.

### 3.2 Technology Roadmaps

During the first roadmapping workshop, held in Tokyo during May 2007, experts have identified the technology domains of modelling, vaccines and animal tracking as having a high impact on combating EID and achieving biosecurity. Results were analyzed and presented as shown in the following Tables.

The key user requirements for the three technology research domains were identified as shown in Table 1.

#### Table 1 Key User Requirements

<table>
<thead>
<tr>
<th>USER REQUIREMENTS</th>
<th>SHORT TERM</th>
<th>MEDIUM TERM</th>
<th>LONG TERM</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>UBIQUITOUS COMPUTING</strong></td>
<td><strong>INFORMATION OF EID</strong></td>
<td><strong>LAMP DIAGNOSTIC EQUIPMENT URGENTLY NEEDED FOR DEVELOPING COUNTRIES</strong></td>
<td><strong>FORECAST OF POSSIBLE HOTSPOT</strong></td>
</tr>
<tr>
<td></td>
<td><strong>FAST DETECTION OF EID</strong></td>
<td><strong>REAL TIME DYNAMICS MAP/GIS</strong></td>
<td><strong>SMART DUST HEALTH WORKER</strong></td>
</tr>
<tr>
<td></td>
<td><strong>EID PREVENTING NETWORK SYSTEM IN ASIA</strong></td>
<td><strong>ANIMAL PROTECTION</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>IT FOR PREVENTING SOCIAL PANIC</strong></td>
<td><strong>BORDER HEALTH SECURITY ARRIVAL GATE</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>BIO-TERRORIST ALERT SYSTEM</strong></td>
<td><strong>REALTIME RFID HEALTH MONITORING</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>ANALYSIS OF LONG TIME SERIES LAND COVER SATELLITE DATA</strong></td>
<td></td>
</tr>
</tbody>
</table>

| USER REQUIREMENTS       | **THE NEED TO IMPROVE**                                                   | **THE NEED TO DEVELOP EFFECTIVE DRUGS/VACCINE/TREATMENT**                 |                                                                             |
|-------------------------|----------------------------------------------------------------------------|---------------------------------------------------------------------------|                                                                            |
| **TREATMENTS**          | **THE DEVELOPMENT OF EXISTING DRUGS/VACCINES/TREATMENT TO REDUCE SIDE-EFFECT** | **WHICH HAS THE FOLLOWING CHARACTERISTICS:**                             | **THE NEED TO DEVELOP STABLE, LONG LASTING, SAFE AND AFFORDABLE DRUGS/VACCINE/TREATMENT WITH THE FOLLOWING DETAILS:** |
|                         | **DEVELOPMENT OF EMERGENCY VACCINATION PROGRAM**                          | **SAFE AND ZERO SIDE-EFFECT**                                             | **PERSONALIZED MEDICINE**                                                 |
|                         |                                                                            | **USE OF NEW METHODS FOR DRUG DESIGN**                                   | **UNIVERSAL VACCINE FOR INFLUENZA**                                       |
|                         |                                                                            | **USE OF ANIMAL MODEL FOR DRUG DEVELOPMENT**                             | **UNIVERSAL FOR STRATEGY FOR STRUCTURE-BASE DRUG DESIGN**                |
|                         |                                                                            | **HIGH THROUGHPUT SYSTEM**                                                | **EDIBLE VACCINE**                                                        |

| USER REQUIREMENTS       | **INDIVIDUAL**                                                             | **COST**                                                                  |                                                                             |
|-------------------------|----------------------------------------------------------------------------|----------------------------------------------------------------------------|                                                                            |
| **DIAGNOSIS**           | **NO PHYSICAL BURDEN**                                                    | **CHEAP**                                                                 |                                                                            |
|                         | **TEST WITHOUT PAIN**                                                     |                                                                            |                                                                            |
|                         | **EID EDUCATION**                                                        |                                                                            |                                                                            |
|                         | **FAST, NO REPETITION**                                                   |                                                                            |                                                                            |
|                         | **COST**                                                                  |                                                                            |                                                                            |
|                         | **CHEAP**                                                                 |                                                                            |                                                                            |
|                         | **CONTINUOUS MICROBIAL MONITORING SYSTEM**                                |                                                                            |                                                                            |

**Theme:** FTA in Security and Sustainability

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Recommendations related to the three technology research domains are listed in Table 2.

Table 2 Technology-Research Recommendations

<table>
<thead>
<tr>
<th>Ubiquitous Computing</th>
<th>Recommendations</th>
<th>Recommendations</th>
<th>Recommendations</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>RECOMMENDATION</strong></td>
<td><strong>SHORT TERM</strong></td>
<td><strong>MEDIUM TERM</strong></td>
<td><strong>LONG TERM</strong></td>
</tr>
<tr>
<td><strong>HRD:</strong> experts who can manage the epidemiological event /training candidate who can participate epidemiological events</td>
<td>Supplying teacher (train the trainer) for sanitary education of EID</td>
<td>Triage-knowledge should be educated to public</td>
<td><strong>APEC vaccine production company</strong></td>
</tr>
<tr>
<td><strong>EDUCATION OF COMMUNITY LEADER WITH “CRUDE” SURVEILLANCE TECHNOLOGY TOOLS</strong></td>
<td>Regional alert &amp; response network of EID</td>
<td>Predictive model of locating possible outbreaks</td>
<td>Educate people for GM materials</td>
</tr>
<tr>
<td><strong>WARNING SYSTEM BASED ON SEASONAL DISEASE OUTBREAK</strong></td>
<td>Predictive pandemic model (proactive based on many inputs + response)</td>
<td>Network diagnostics for non-doctor</td>
<td>Research on field diagnostic devices</td>
</tr>
<tr>
<td><strong>TREATMENTS</strong></td>
<td><strong>NEED TO HAVE SUFFICIENT INCENTIVE TO INDUSTRIES</strong></td>
<td><strong>NETWORK OF APEC CENTER FOR CLINICAL TESTING DRUGS</strong></td>
<td><strong>RESEARCH ON FIELD DIAGNOSTIC DEVICES</strong></td>
</tr>
<tr>
<td><strong>NEED TO RESTRUCTURE TRADING REGULATION TO SUPPORT THE EXCHANGE MATERIAL AND SPECIMENS ACROSS THE BORDER</strong></td>
<td>Need to prepare public to be aware of unknown future</td>
<td>New light source for internal body scan</td>
<td><strong>NEW LIGHT SOURCE FOR INTERNAL BODY SCAN</strong></td>
</tr>
<tr>
<td><strong>DIAGNOSIS</strong></td>
<td><strong>IMPROVING DATABASE OF GENOME, PROTEOME OF CAUSATIVE MICROBE</strong></td>
<td><strong>RESEARCH ON PERSONAL DIAGNOSTIC DEVICES</strong></td>
<td><strong>VISUALIZATION OF PATHOGENS</strong></td>
</tr>
<tr>
<td><strong>NEED TO HAVE INTERNATIONAL/DOMESTIC SYSTEM FOR SAMPLE DELIVERY</strong></td>
<td>Need to solve problem on benefit sharing</td>
<td>Detection method of infected cells</td>
<td><strong>DETECTION METHOD OF INFECTED CELLS</strong></td>
</tr>
</tbody>
</table>

The second roadmapping workshop was organized in Chinese Taipei in October 2007. Forty one experts representing eight APEC member economies participated. The goal was to develop the three technology applications identified during the technology road mapping workshop in Japan.
They were: modelling, vaccines and animal tracking. These three technology applications seem to be unconnected. However, the discussions of the workshop revealed their inter-relationships and the role of technology convergence as the key to success in developing the technologies.

Development of the roadmaps resulted in the recommendations listed in Table 3.

**Table 3 Roadmapping Recommendations**

<table>
<thead>
<tr>
<th>RECOMMENDATION</th>
<th>SHORT TERM</th>
<th>MEDIUM TERM</th>
<th>LONG TERM</th>
</tr>
</thead>
</table>
| **MODELING**   | • Study climate changes and natural disaster impacts  
                 • Should have an EID 9/11 model  
                 • Need a CDC-WHO integrated approach  
                 • Need to work with E-SCI industry  
                 • EID model training for doctors  
                 • Global models include social data + epidemic + economic risks  
                 • Global collaboration  
                 • Strategies to confirm public acceptance respect and utility of models  
                 • Develop disease spread simulation  
                 • Economic impacts clearly identified  
                 • Simulate personalized/genotyped response to unique genetic drugs  
                 • Alignment with leading whole system models (health + security)  
                 • EID system standards for diverse model / action elements |
| **VACCINES**   | • Chemical libraries exchange information  
                 • Support for patenting procedures  
                 • International coordination of human clinical trials  
                 • Research on detection and removal of contaminating material  
                 • Modelling for development of vaccine delivery system  
                 • Set up core-lab available for state-of-the-art technologies  
                 • Risk assessment of GM organisms used for vaccine production  
                 • Multidisciplinary collaboration between laboratories in material, data and information sharing |
| **ANIMAL TRACKING** | • Government-funded wildlife capture and RFID tracking  
                      • Should have common system for collecting and analyzing data  
                      • Establishment of standards/protocol for data sharing  
                      • Need to track illegal immigrants  
                      • Develop specific enzyme or protein marker for EID |

From Tables 1-3, all together the six technology domains identified in the roadmapping workshops fit with the Life Cycle Model as shown in Figure 5. In keeping with the theme of converging technologies, there are links between all of the technology domains as shown earlier in Figure 4.
To better illustrate the specific roles that technologies can contribute in combating EIDs and achieving biosecurity, this paper gives an example of diagnostic technologies roadmap (Table 4) as one among the six technology roadmaps developed in this project.

Diagnosis of infectious diseases is usually done by detecting causative agents (virus, bacterium, etc) and/or anti-pathogen antibodies. The former includes antigen detection, genetic, and cultivation methods. Diagnosis plays a critical role in the treatment of disease and in developing response strategies. In an outbreak situation, vaccination may need to be accompanied by a diagnostic test that can discriminate between the response to a vaccine and a natural infection. Appropriate diagnostic technologies are also critical for surveillance programs. Diagnostic technology also plays a crucial role in the prevention of spread.

Table 4 Roadmap for the Development of EID Diagnostics

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>User’s requirement</strong></td>
<td>Validated, easy to use in the field or local site, low cost, suitable for developed and developing countries, no cold chain required.</td>
<td>Low opportunity cost testing for many infectious agents simultaneously</td>
<td>Personalised medicine with testing linked to information networks and personalised treatment</td>
</tr>
<tr>
<td></td>
<td>Higher sensitivity and specificity</td>
<td>Ability to test large number of people in a non-interventionist manner</td>
<td></td>
</tr>
</tbody>
</table>

Figure 5 The Contribution of Technologies in Combating EIDs
## Technology

<table>
<thead>
<tr>
<th>Tool</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Broad screening tools</td>
<td>Improved border biosecurity</td>
</tr>
<tr>
<td>High throughput technologies</td>
<td>Rapid pathogen genetic characterisation, high biosecurity level capacity</td>
</tr>
<tr>
<td>Access to latest technologies</td>
<td>Automated data collection and analysis</td>
</tr>
</tbody>
</table>

### Towards low cost, high sensitivity and specificity, rapid, multi-agent diagnostic devices linked to automated data collection and analysis

### Technology

<table>
<thead>
<tr>
<th>Location</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Local site</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Regional Health Centers</strong></td>
<td>Lateral flow and other point of care devices, low cost</td>
</tr>
<tr>
<td><strong>International Institutions</strong></td>
<td>Low cost tests of greater sensitivity- gene amplification</td>
</tr>
<tr>
<td></td>
<td>Screening technologies for airports, thermal, chemical</td>
</tr>
<tr>
<td><strong>Rapid high throughput systems, high PCR capacity.</strong></td>
<td>High throughput genetic sequencing.</td>
</tr>
<tr>
<td><strong>Access to latest and developing diagnostic technologies</strong></td>
<td>Multiplex testing</td>
</tr>
<tr>
<td><strong>Validation processes established</strong></td>
<td>A high level investigative capacity and capability</td>
</tr>
<tr>
<td><strong>Information collection and sharing system from the local diagnostic systems through to the International Institutions</strong></td>
<td>Personal Diagnostic Devices, implantable or wearable bio-sensor - transmitter</td>
</tr>
</tbody>
</table>

### Challenges:

| Technical | Sensing systems of adequate sensitivity, Low cost, point of care amplification systems |
3.3 Policy Implications

With strong user inputs in scientific and management issues, the foresight project appears to have high potential to inspire and influence decision-making regarding EID and biosecurity throughout the Asia-Pacific region. Such a continuity of effort to disseminate the outputs of the project and inspire other activities during the later stages of the project and after its termination is usually called “Post-Foresight Engagement Activities”.

In this project, many fruitful discussions took place and they suggested potential activities that could have a high impact in efforts to combat EID. Although the formal announcement of the project conclusion has not yet taken place (a full report is under preparation), hence no policy commitment at this stage, there are already a number of the activities related to the foresight project initiated during the conduct of the project that also raised the awareness in biosecurity throughout the region. These include:

- Rand Corporation, who participated in the key events of the project, has proposed a decision model to identify and evaluate an optimum mix of interventions and measures for a specific disease as improvements in health infrastructure, which can concurrently benefit more than just a single disease. The model will take into account the existing situation on the ground, evidence-based metrics of coverage and efficacy, financial requirements, and the intended time horizon. The proposal is being considered by the Rockefeller Foundation for funding, with potential involvement of the APEC Center for Technology Foresight and its partnering scientists. It is hoped that eventually the outcome of this project will assist developing APEC member economies in order to
optimize the research budget and set policy directions in an effective manner. (*Proposing Institution: Rand Corporation, USA*)

- A discussion which developed mainly in the diagnosis roadmap suggested a new network system could be based on a fully scientific base, and this should be established as a research and diagnosis center of infectious diseases among APEC economies. This proposed center could be used as a hub of the network, with samples, information and human resources shared by Asian countries. Currently, RIKEN, the leading governmental research institute of Japan, is developing laboratories in collaboration with Thailand, Vietnam, China, Indonesia, India, Philippines, Zambia and Ghana. Subsequently, Dr. Okamoto from RIKEN, who was a key contributor to the foresight project, also addressed the possibility of using one of the RIKEN research bases as an APEC diagnosis center, combining with establishment of a new network system to utilize other research sites effectively for the benefit of the APEC. In order to make significant progress in combating EID, sharing of samples, people and information will be highly required. Therefore, this initiative could provide a great benefit among APEC member economies as it would establish strong partnerships within APEC and also could enable African research organizations and researchers to study or analyze local samples collaboratively. (*Proposing Institution: RIKEN, Japan*)

- It was stressed in the meetings/workshops of the project that in order to make the best use of the foresight roadmaps, the results should be disseminated to a broad range of (and certainly to those in positions of authority) stakeholders. In Thailand, M.D. Ram Rangsin, a Thai medical expert, has been conducting a project on developing policy recommendations of EID surveillance system for the Thai government. The findings from this APEC-wide project were shared and information was provided to this surveillance project especially with respect to the technological trends and policy recommendations of technologies in ubiquitous computing, modelling, and disease tracking. Dr. Rangsin’s project is expected to conclude and provide policy recommendations to the Thai government by the end of 2008. (*Proposing Institution: National Science and Technology Development Agency, Thailand*)

The findings from this foresight project will be integrated as policy recommendations and disseminated to all APEC member economies by the end of 2008⁶.

4 Conclusions

Bibliometric analysis and Scenarios have been used to study the factors involved in initiation and spread of emerging infectious diseases under the framework of EID Life Cycle Model. These are preventive measures, surveillance and detection, and treatment and prevention of spread, and to guide the future development of responses in controlling these factors.

The Life Cycle Model can be linked to six significant technology domains namely, vaccines, diagnostics, ubiquitous computing, tracking, modelling and drugs. Each of these provides opportunities for converging technologies to make significant contributions to R&D and commercialization of devices and systems.
Technology roadmaps have been developed for each of these domains to provide the basis for national and regional strategies for combating emerging infectious diseases. The significant findings for each of the roadmaps are:

- **Vaccines:** vaccine development, production and delivery are essential components of any strategy to combat EID and must be strongly supported. New approaches based on genetic manipulation and molecular design will allow more rapid development of vaccines.
- **Diagnostics:** a range of tools to enhance capability in these areas needs to be developed specifically for the Asia-Pacific region, particularly focused on low cost, portability and rapid information flow.
- **Ubiquitous computing:** the concept of smarter information collection and management is an integral part of adoption of new processes and tools. Increased effort is needed to improve the automated analysis of surveillance data to enable early detection of outbreaks. Information technology is an integral part of developments in all the domains.
- **Modeling:** availability of realistic models can assist policy makers in developing options for coping with outbreaks but they cannot be used in real time when input data are changing rapidly.
- **Tracking:** miniaturized systems are being developed to track both animals and humans but standards and protocols are needed to enable tracking across national boundaries.
- **Drugs:** more effort is needed on the development of therapeutic drugs for more effective risk management, even for those infectious diseases for which vaccines are available.

The implication of this project is that it has created a new network of knowledgeable and concerned scientist and technologists in the field of biosecurity in the APEC region. This can provide a focus for further co-operation. The APEC structure may provide a route to developing this co-operation by sharing of information, facilities and training in combating EID across the region.

The translation of research outputs into policy is of critical importance. Politicians have to make decisions on the basis of available information which is often imperfect and hence the prompt and efficient transfer of information from the research environment into the policy environment is a critical component of effectively combating EID. Particularly in the APEC region, security and emerging infectious diseases is given high priority as evident in the APEC Leaders Declaration. However, the application of these new technologies in developing economies needs to be undertaken with great care, recognizing that there are major infrastructural, cultural and social differences. The “people factors” are crucial features of disease management through all phases of the life cycle model from detection to response.

This project is a contribution to the better understanding of the provision of accelerated technological responses to combating EID and biosecurity in the APEC region and of the role of science and technology in providing those responses through the concept of converging technologies. It is only a beginning and there is a need for further action by individual economies and by APEC itself as a co-ordination body to ensure that the region is adequately prepared for the outbreaks of emerging infectious diseases that will inevitably occur in the future.
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6 References


