Appendix 77

Knowledge Management and Systems Interoperability in Animal Health

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Abstract

The changing patterns in the spread and distribution of major infectious animal diseases, old and new, which pose a serious impact on animal and human health and welfare as well as human livelihoods, make animal health a matter of global public concern.

Wherever such diseases occur, they should be recognised promptly and be dealt with expeditiously. A major prerequisite is that knowledge about such high impact animal diseases and about good practices for their management be globally shared. Such knowledge should be instantly available to the global professional community, in developed as well as developing countries.

The spread of the Pan-Asian FMD Type O strain, which culminated in serious outbreaks in Europe, notably the UK in 2001, demonstrated the global risk that FMD constitutes.

During the 2001 FMD epidemic in the UK, there was extensive use of the internet, e.g. for accessing programs such as AVIS FMD, which at the height of the outbreak recorded over 8 million visits from users worldwide. But there was only partial interoperability of emergency management systems, and fragmented use of other IT tools, such as GIS and mathematical models.

Since 2001, a critical threshold has been crossed in the cost of information, which now enables all stakeholders, even in the most economically challenged of settings, to enjoy affordable access to expert knowledge, even at broadband speed, in both office and field settings. But there is not yet a coherent theoretical basis on which the strategic role of ICT, and in particular knowledge management and interoperable communications, in preventing, preparing for and responding to animal disease outbreaks or in the progressive control of such diseases (in areas where they are still endemic) can be planned, despite the growing recognition that effective responses to high impact diseases in particular are knowledge- and expertise-driven. Using FMD as an example, the paper sets out a possible model of a fully interoperable management systems design for use in the animal health setting, thereby indicating one way to harness the power, bandwidth and portability of ICT in disease surveillance, prevention and management.

In conclusion, the paper advocates interoperability as the enabling condition for a holistic disease management approach, using knowledge management systems to promote best practices, with biosecurity as the underlying driver.

Introduction

Marshall McLuhan famously predicted that the effect of television would be to make the world into a Global Village[1]. He also declared "the medium is the message". In retrospect, he was right to see that a change in the dominant information and communications technology would completely alter the world, but the medium that has brought about the global village is not television, but the internet.

Few threats to the well-being of the global village, especially its inhabitants and livestock, are greater than transboundary animal disease (TAD). But we are not yet skilled in approaching TADs from a global village perspective. At this seminal point in the evolution of the EUFMD Commission, this paper sets out a possible way forward for the Commission in harnessing the power of the internet to the prevention of, and protection from, disease threats to the "village".

The Internet

What has the internet changed? Perhaps the greatest impact of the internet is to fundamentally alter how access to knowledge and expertise is managed. In effect, it reverses the centralising tendency of university and library-based knowledge cultures by pushing access to knowledge out to the periphery, to the site of need. In this process some of the key barriers to access are lowered or removed:

1. **cost:** economists correctly focus on the "cost of information" as a key determinant of power and status. Now the internet opens up at least the theoretical possibility that anyone can access knowledge for the cost of a local phone call.
2. **time:** a website is open 24/7. It can be visited without leaving the office or home.
3. **distance:** there is no distance over the internet between the enquirer and the expert.

[1] Marshall McLuhan, Quentin Fiore and Jerome Agel, *War and Peace in the Global Village*, (1969)

The mere fact that these variables are undergoing such profound change does not, however, guarantee that only good and benefit will follow. Sites are vulnerable to hacking, and viral attacks; even simple power outages can render the system unusable, and there are constant security concerns with any open system, which means that a secure intranet may be the appropriate environment for the system described in this paper. Equally, if the lowering of barriers merely provides more people with cheaper access to inaccurate or, worse, maliciously mendacious information or data, the results are orders of magnitude worse not better than the current status quo. So the new challenges are to maintain the quality, accuracy and utility of the knowledge and expertise to which the internet (or secure intranet) grants access, and to do so in a manner that promotes the overall well-being of the global village.

What is interoperability?

Interoperability is a term commonly used by first responders (fire services, police, ambulance) in emergency planning and preparedness to describe the capacity of their communications system to talk to each other. It can equally be applied to describe the enabling condition of the internet, the fact that communications use a common language (HTML) and common communications protocols, meaning that at a certain level messages can flow from almost any computer or computer-like device to almost any other. The penalty paid for such high levels of interoperability however, can be severe, whether manifest in the form of virus attacks or spam, making oversight and security key issues in any fully interoperable system.

Interoperability failures were graphically and tragically demonstrated in two seminal events of 2001. During the 9/11 attack on New York it became clear that the radio and other communications systems of the first responders – police, fire, emergency services – were not able to talk to each other. Desperate attempts to patch together mobile phones ensued, but clearly to little avail. As one report indicated: “it was a bad time to be handing out business cards when the towers were on fire”. Since that time, considerable efforts have been made to bring systems together; but as well as the technology issues, culture plays a critical role in making the goal of interoperability achievable. Will different working groups, with often widely varying practices and discourses, be prepared to work together when for so long they have worked apart, even pursuing forms of rivalry, or turf wars?

In the UK 2001 FMD outbreak, interoperability was also an issue. Problems manifested themselves both at the technical level, in such matters as the incompatibility of computing systems and the lack of transparency across databases, but also at the cultural level, where groups such as veterinarians were suddenly required to work on the one hand with the military and on the other with mathematical modellers and scientists with an operational research rather than life science background. Those directly involved are perhaps best able to judge how severe the impact was of such problems. Harmonisation and interoperability of systems are likely to be the major determinants in the design of FMD contingency plans and the testing of those plans through simulation exercises.

Interoperability and the Global Village

If interoperability at the technology level is the goal for the Global Village, the balance sheet of benefit and penalty is quite mixed – the open standard of email and HTML permits the low cost, speedy communications of email and Instant Messaging, but also the plague of spam - the balance sheet, seems to the authors of this paper to be unequivocally positive at the cultural, or operational, levels. In reaching towards a definition of interoperability that suits the needs of those in charge of preventing and managing TADs, the term must be moved beyond meeting the requirements of “first responder” cultures, to include a capacity to manage and deploy coordinated expertise to the point of need, in a manner well demonstrated during 2002-03 by international collaboration on SARS.

This appropriation of terminology is similar in nature to, and to an extent inspired by, the migration of the term “biosecurity” from a process of preventing infectious agents leaving a secure facility to a goal encompassing the safety and security of the world’s supply of food and other key natural resources. So what are the dependencies for achieving interoperability at a cultural or operational level? They may be summarised as:

- Common discourse
- Common standards
- Common values
- Common good.

While clearly a village is in one way a loose coalition of individual and family interests, at a higher level it expresses a transparent value system for a whole tribe. It is this transparent value system which needs to underpin the practical and operational goal of creating a knowledge management system for FMD that meets the goal of interoperability.

The lack of a common value system was one cause of turbulence in the UK 2001 outbreak. It became rapidly clear that the general public was directly and emotionally involved in the outbreak, to an extent that no one had predicted. In respect of socio-economic impact, it was a secondary shock to realise that the recreational and tourism economy of the countryside and its amenity value to city dwellers had suffered as much from FMD as the farming and food industries, and in some senses more. While farmers were compensated for stock losses, guest houses and tea rooms had no way of recouping lost business. Public sympathy started to shift away from farmers to other parts of the rural economy.

The outbreak as a whole consolidated a widespread perception that something was seriously wrong in the fundamental relationship between people, especially in the developed world, and the animals they used to feed and clothe them. Restoring this relationship, practically, ethically and even spiritually, would be as important to future success in TAD management as progress in science and technology, vital as that is. As a result, the interoperability model proposed in this paper also assumes that only a "holistic" approach to TADs, which by nature engages with all stakeholder interests and uses a multi-disciplinary methodology, is likely to succeed. In other words, "extrinsic" drivers, such as stakeholder attitude, are now as potent as the "intrinsic" change drivers with which animal health professionals are grappling. The theory for this approach is well articulated in the "Farm to Fork" or "Stable to Table" methodologies, and do not need rehearsal here.

The Infectious Diseases Paradigm

During the last decade or so there have been three major paradigm shifts in animal health and the impact of animal health on human welfare and health:

- An increasing frequency of serious outbreaks of high impact, transboundary animal diseases such as foot-and-mouth diseases (FMD), classical swine fever (CSF), peste des petits ruminants (PPR) and avian influenza (AI).
- The emergence of either new diseases (such as BSE and Nipah) or old diseases with altered virulence (such as avian influenza transmission to humans in East Asia).
- The increasingly frequent emergence and re-emergence of zoonotic and food-borne diseases with international scope and global economic impact.

These change drivers are themselves consequences of the rapid changes in the farming systems (especially the emergency of large-scale, centralised industrial farming and processing conglomerates), the increasing demand for livestock products which is fuelling what has been termed "the livestock revolution", rapid and distant movement of humans and animals, climatic changes and the globalisation of trade and movement of livestock products.

In common with many commercially driven revolutions, the "livestock revolution" has witnessed increased specialisation in production and management processes, coupled with the emergence of ever more specific domains of expertise. These are relatively typical signs of a "second generation" business process, such as automobile production went through in the so-called Deming revolution. Out of this has come an emphasis on productivity, a secure supply chain, and just-in-time logistics, geared to meet the demands of the world's major retail supermarkets, such as Walmart, Carrefour, Aldi and Tesco. On the production side, this represents a quite extraordinary achievement, and the condition of interoperability is met.

But a casualty of this process has often been a capacity to look at animal production and welfare, disease prevention and management from a holistic point of view. This has meant that a major change in approach to the management of the consumption side has been forced on the "middle men", primarily the supermarket chains. Now both public opinion and regulatory pressure is moving the livestock revolution into much more of a "third generation" approach, where sustainability and traceability have taken centre stage, and the consumer wants to know from the label everything necessary to judge the quality and ethical acceptability of the product. Traceability is a manifestation of the cultural approach to interoperability, and it draws its strength and validation from the level of personal accountability now expected of producers. For example, the UK supermarket chain Waitrose now publishes pictures of the

local suppliers it uses immediately above their produce. If your meat tastes bad you can see whom to blame.

This trend towards personal accountability is one of many symptoms of the pressure in the market place to "act local", however much global production methods are in use. At a wider level, personalisation of production values is now being brought into line with personalisation of taste and consumption values, nowhere more evident than in the ICT industries. Paradoxically, while unified GSM telephony standards make it possible to use the same phone anywhere on the planet, even the ring tone of that same phone has to be totally personalised and responsive to rapid and unpredictable changes in consumer behaviour. Animal health professionals and the current regulatory systems will need to cope with the same paradoxical pressures.

In one sense, they are at an advantage over ICT colleagues. At their best, animal management practices, even in high input systems, have been personalised, and their owners have practised a holistic approach, probably without applying that term to their practice. In some ways the advocacy of a holistic approach to disease prevention is more of a reversion than a revolution. What has changed however, is that the personalisation process now extends to indirect stakeholders in animal production – the end consumers - rather than just farmers and the markets where they sell their stock. The most direct impact is obviously on the trend for ever more informative, and honest, labelling of foods; but because the nexus between our health and our diet is also growing ever tighter, there is also a new moral edge to the issue, bringing traditional bulk foodstuffs such as salt and sugar into the same moral twilight zone as alcohol and tobacco. In effect, interoperability is the practical and operational outcome of an effective, holistic, knowledge-driven approach, where the determining condition is now less the enabling function of interoperability – to enable all of us to talk to each other – but rather its content function, that we also understand more clearly what we are actually talking about.

Think Global: Act Local

The factors underlying the "livestock revolution", globalisation of trade in livestock commodities and changes in climatic patterns have led the UK Royal Society to conclude that the spread of transboundary animal diseases has changed from the previous pattern of episodic "natural spread" into adjacent countries and regions, to a pattern in which disease (e.g. FMD or Classical swine fever) jumps long distances to infect countries and regions distant from endemic areas[2]. Thus, ***animal diseases have become a one-world problem requiring a one-world solution.***

Foot-and-mouth disease (FMD) is now acknowledged as the prime example of the one-world problem requiring one-world solution. With respect to the three main facets of the new paradigm of animal infectious diseases, we now truly live in the "Global Village".

As an axiom, therefore, this paper rests on the proposition: **Think Global, Act Local**. To be effective locally, however, we need a mechanism for efficiently accessing, deploying and validating global expert knowledge at the point of need, the point of use and thereby the point of action.

We also contend that the management of the new animal health paradigm should be viewed not merely in terms of technical or veterinary interventions, but more and more in terms that treat the goal of animal and human welfare and health, i.e. the impact of the livestock sector on human livelihoods and well-being.

New Science Tools and Opportunities

The contemporary sciences which offer hope for the new paradigm can be grouped into four categories:

- Molecular Biology
- Quantitative epidemiology
- Risk Analysis, and
- Information and Communication technologies (ICT).

[2] Infectious Diseases in Livestock. London, The Royal Society, 2002 Policy Document, 15/02. ISBN 085403579 6
http://www.royalsoc.ac.uk/templates/search/websearch.cfm?mainpage=/inquiry/commissioned_papers.htm

Of these, ICT and possibly risk analysis are the only ones which are not a natural succession from the traditional approaches. Consequently, their potential may well be undervalued in the management of high impact diseases like FMD.

The Potential for Information and Communication Technologies

The tools that now exist, or that could readily be developed, for ICT include:

- Mobile phones, with cameras
- Satellite telephony and data management
- GIS/ GPS
- Real time data streams
- The Internet
- Dedicated devices integrating surveillance, diagnostics and communications.

The challenge is to develop an objective-driven strategy that recognises that knowledge management has to be "people-centred", has clear processes for capturing expert knowledge and transforming it into information that is transmissible to, and useable by, persons of different levels of competence and requirements. Therefore, in developing an effective knowledge management package there will be six key steps:

- Experience and expertise at an individual level
- Institutional knowledge capture and transfer/ preservation of "at risk" knowledge.
- Validation
- Interpretation
- Communication
- Concerted action.

While each step is necessary in its own terms, the validity of the system as a whole depends on combining all six into a "virtuous circle", through which the lessons of a given concerted action get digested into individual and institutional competence on an ongoing basis.

Interoperability

It is premature perhaps to offer a formalised definition of interoperability commensurate with the holistic vision we have described. But the concept of interoperability may be represented schematically, as shown below, as a means of moving towards such a definition. Interoperability has a number of obvious enabling conditions or critical dependencies:

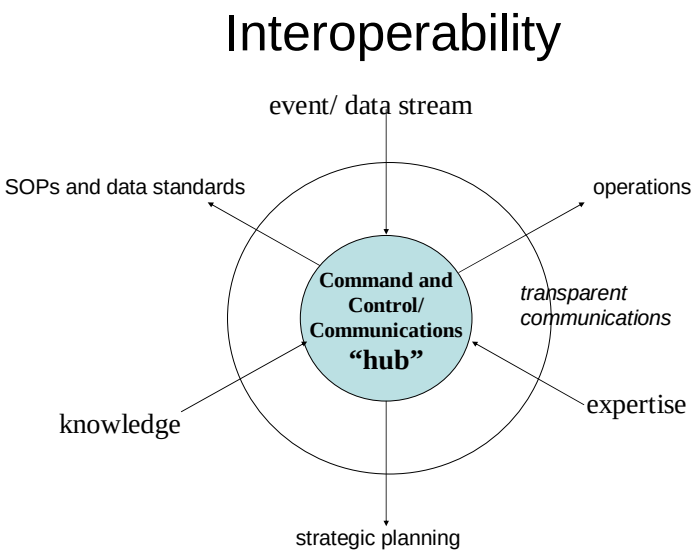
Systems connectivity/ transparency
Shared meta data
Single data dictionary
Common data interchange standards
Security
Cross-system SOPs
Trained users.

But these enabling conditions merely set the stage for the higher level of interoperability that we believe is of the essence in effective TAD prevention and control, a level we have described as "cultural". In such a model there are three key types of input that interoperability can make transparent to all direct and indirect stakeholders. These may be characterised as:

1. Event and data stream
2. Knowledge flow
3. Expertise.

These inputs are processed in a "hub", which may in practice be fully virtual and distributed, but is probably best operated with a significant degree of centralised control, and lead to three critical outputs which enable effective intervention and management:

1. Strategic Planning
2. Standard Operating Procedures (SOPs) and data standards
3. Operations

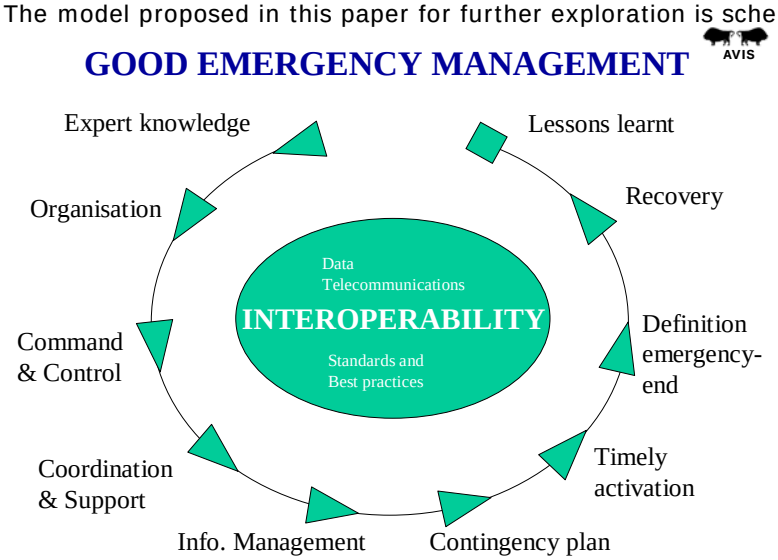


A Way Forward Using the AVIS FMD Program Model

The 2001 FMD outbreaks demonstrated significant advances in the use of information and communications technologies (ICT). GIS systems were applied to mapping and monitoring the outbreak, and there was extensive use of the internet, e.g. for accessing programs such as AVIS FMD, in the education and support of both professionals and the public (over 8 million users of AVIS FMD worldwide during the outbreak itself).

Since 2001, a critical threshold has been crossed in the cost of information, which now enables all stakeholders, even in the most economically challenged of settings, to enjoy affordable access to expert knowledge, even at broadband speed, in both office and field settings. But there is not yet a coherent theoretical basis on which the strategic role of ICT, and in particular knowledge management, in preventing and responding to animal disease outbreaks can be planned, despite the growing recognition that effective responses to high impact diseases in particular are knowledge- and expertise-driven.

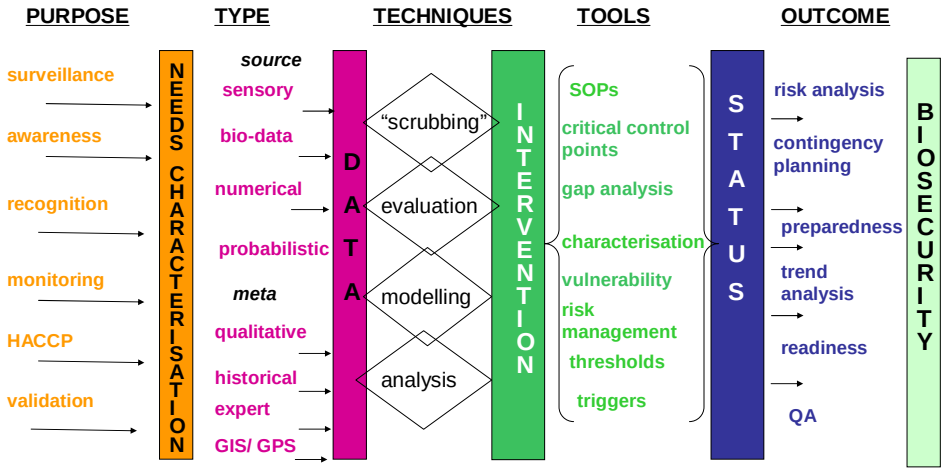
The model proposed in this paper for further exploration is schematised as follows:



Event and Data Streams

The critical dependency for effective command and control, once interoperability is achievable, is a fast, accurate event and data stream flowing into the communications hub. Using FMD as an example, the diagram below sets out a possible model of types of knowledge that are necessary for use in the animal health setting, so harnessing the power, bandwidth and portability of ICT in disease surveillance, prevention and management.

Data Typology & Interoperability Model: 1.2



The model is "cylindrical" & continuous

A defining condition of this model, not surprisingly, is complexity. or hurricanes. Because of this complexity the most critical requirement is that a multidisciplinary expert group is given the tools and the span of control necessary to deal with the problem, tools which are built to manage complexity to a point where actions can nevertheless be coherently executed.

Complexity

The key challenge at the "hub" is dealing with complexity. It is the characteristic of complexity which perhaps most clearly sets biological events apart from other naturally or maliciously occurring crises, such as fires or hurricanes. Given that the only response possible to complexity is a multidisciplinary one, the obvious secondary challenge facing command and control is one of communications across operating cultures. In the "heat and smoke" of a live event, communications failures and conflicts within the response teams can be symptomatic of a failure to cope with complex environments as much as "turf wars". As a first step in rectifying this problem, at a national level the various systems used by key stakeholders must converge and become transparent. But in due course, dictated by the intrinsically transboundary nature of many disease threats, the authors of this paper see great potential for benefit in development of highly expert, highly integrated supranational response teams capable of dealing quickly and effectively with such events. The highly distinguished achievements of the EUFMD Commission, founded over fifty years ago on such a vision of supranational collaboration, suggest that it is best placed to act as the point of focus for such considerations in the future.

Systems Solution

The event and data stream model proposed above derives in part from cybernetic theory, which proposes that in any management system the flow of work, and of the information that supports and drives that work, be as far as possible contributory to as smooth and "frictionless" an operational process as possible. Communications conflict, whether at the hardware, software or user level may be the first and most deadly site of friction, and even breakdown. And at the heart of many communications conflicts are less "intrinsic" factors, such as the phone not working, than the "extrinsic" factors, where people refuse to talk to each other.

In the cybernetic approach, the goal, however idealised, is to promote a "virtuous circle" of activity, where one event leads naturally and logically to the next, and where the incentive to perform well is aligned at each level. Using initially a HACCP derived analytical approach, it was relatively straightforward to detect points of weakness in current or recent historic systems, such as the inability of one laboratory's computer network to access another's (for example for "security" reasons), or the inability to move data sets from one system to another because either the database design or the electronic data interchange (EDI) standards necessary for such transfers were not in place.

If this theoretical approach is to translate successfully into operational practice, the paper also proposes that a trend which is beginning to emerge in veterinary services in response to the need to demonstrate higher levels of preparedness and readiness for emergency situations may need some careful scrutiny and modification. This trend is to follow a classical "incident command system" (ICS) model, derived partly from the military and partly from management practices in regard to natural disasters, such as wildfires.

There are two very striking benefits from following this model: 1. at the level of people-to-people communications, having unified command and control and a single communications systems is essential; and 2. at the level of data capture and exchange having a single, unified data dictionary, transparent architectures and common interchange standards can only promote swifter more accurate and more flexible responses. But there is also a significant weakness: a TAD outbreak is not the same as a fire; and the strategic skill set required to manage an outbreak is very different from that of responding to an acute natural disaster, however similar some of the tactical aspects may look. But if the animal health community does not come up with its own, disease-specific, model of how to respond, then the gap will be filled for it by a generic solution. Perhaps the EUFMD Commission will be willing to take leadership in such a strategic planning exercise, since by virtue of its scope and constitution whatever it can achieve for FMD will, *mutatis mutandis*, be highly transferable to other TADs.

The Pivotal Role of the EUFMD and Similar Regional Organisations in Knowledge Management

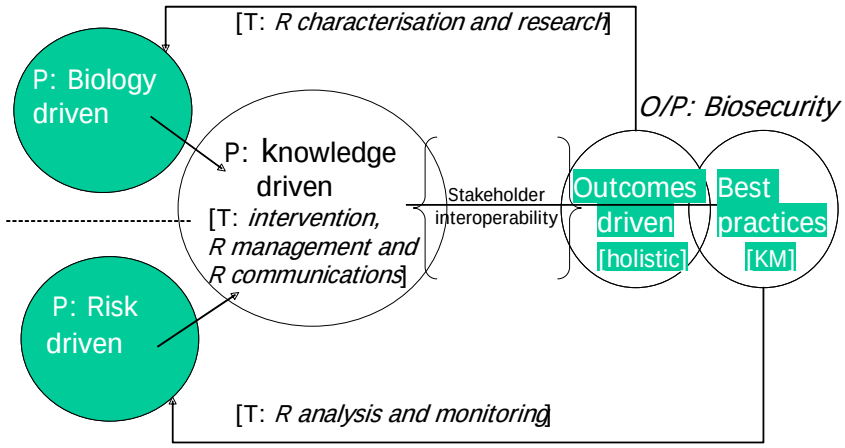
In dealing with the global animal health problems we need to advance the concept that was conceived some 50 years ago when some European nations decided to set up a semi-autonomous FMD Commission within the framework of the operations of an international organisation, i.e. FAO of United Nations. In the new Global Village, a key role of the EUFMD Commission, in terms of Knowledge and Disease Risk Management, must incorporate the concept of an inter-operability hub focusing on:

- Transparent communications technology
- Consistent key terms and common definitions
- System wide SOPs
- Best available practices
- Consolidated body of knowledge and experience
- Centralised, expert led, coordination [command and control]

Managing Animal Health by Biosecurity

The new animal health paradigm must also imply a new paradigm in animal health management with a unifying driver. We propose that such a driver is **BIOSECURITY.**

Management by biosecurity



P= Process; T= Task; R=Risk; O=Objective

FAO defines biosecurity for agricultural systems as:

> *"[…] a strategic and integrated approach that encompasses the policy and regulatory frameworks (including instruments and activities) that analyse and manage risks in the sectors of food safety, animal life and health and plant life and health, including associated environmental risk. Biosecurity covers the introduction of plant pests, animal pests and diseases, and zoonoses, the introduction and release of genetically modified organisms (GMOs) and their products, and the introduction and management of invasive alien species and genotypes. Biosecurity is a holistic concept of direct relevance to the sustainability of agriculture, food safety, and the protection of the environment, including biodiversity".*

To take into account the holistic concept advocated by FAO, an outcomes-driven management system based on best practices is herby advocated:

What is harder to model, as it is not yet fully instantiated anywhere in the world, is a systems model that genuinely supports multidisciplinary working. This goal may be sufficiently difficult to achieve that at this point may better be described as a vision. But in that the EUFMD Commission was set up as a model of collaborative, multidisciplinary research undertaken to meet a vision of a disease free Europe, at this fiftieth anniversary moment embracing a vision of systems and cultural interoperability may be a prudent and inspiring move.