NAKVI, Budapest
Wednesday, 27th June 2012

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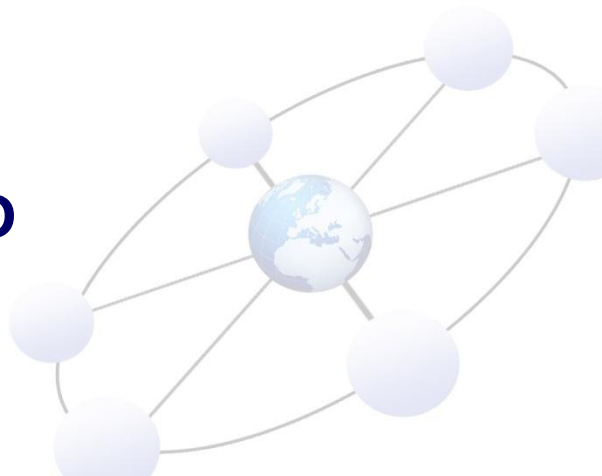
DRIVING THE DEVELOPMENT OF A SMARTER WORLD

Overview of the available technologies for the integration needs of Precision Farming and Traceability

Identification, Sensory Data Capture and Integration Framework

Anthony Furness

Technical Director, Smart ID



Agenda

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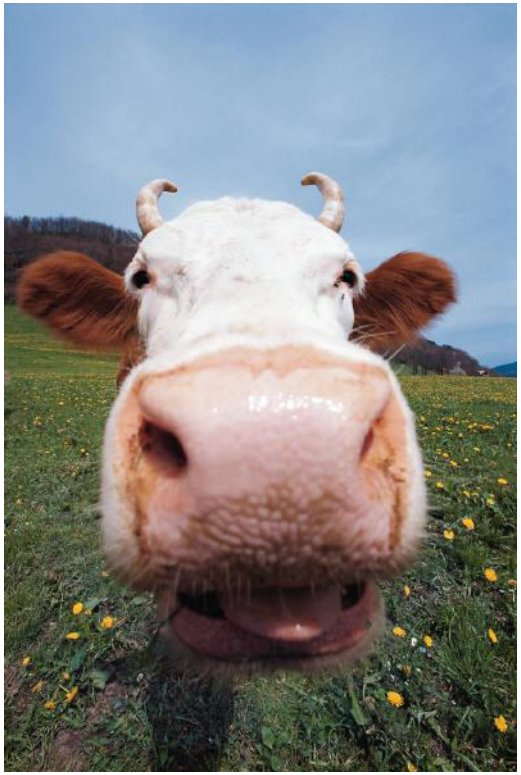

- Recognising the importance of Precision Livestock Farming (PLF) and Precision Farming generally
- The Nature of precision and Object-connected ICT
- The Nature of Service, Production and Supply
- The Nature of Supply Chain Track and Traceability
- The Internet of Things and potential for PF
- Identification, Sensory Data Capture and Integration Framework

Precision Farming – Global Importance in securing future food supplies

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A Five Step Plan*:

- **Controlling the agricultural footprint**
- **Improving the yields of existing farmland**
- **More effective and efficient use of resources**
- Shifting diets away from meat
- Reduction in food wastage

- Also – **Distribution, coupled with efficient track and traceability**

*** Foley. J A et al., (2011) Solutions for a cultivated planet, Nature, 478, 337-342, Oct 2011**

Precision Farming – Global Importance
in securing future food supplies

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The global needs translate to national, regional and individual farming needs, focused upon:

- Improving production through process enhancement and development
- More effective management
- More effective and efficient use of resources
- More effective use of radical, beneficially disruptive, information technologies and automation (including robotics) – (10's % improvement and fast return on investment)
- More effective integration

Precision Farming – Global Importance in securing future food supplies

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Developments expected to impact significantly upon precision farming, livestock and arable:

- **Object-connected ICT**
- **New identification techniques** and exploitation of multiple identifiers in process development
- Wireless, cable and satellite communications
- Positioning, location and ranging techniques
- Sensors and sensor networks
- Internet-based developments, including the **'Cloud'** and user-level interfacing and interaction through smart phones and smart media
- **Internet of Things**
- **Robotics,** including identifier-assisted robotics

Precision Livestock Farming

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One definition - "The management of livestock farming using the principles and technology of process engineering, whereby PLF treats livestock production as a set on interlinked processes, which act together in a complex network".

Wathes et al., (2005) Is precision livestock farming an engineer's daydream of nightmare, an animal's friend or foe, and a farmer's panacea or pitfall? Proceedings 2nd European Congress on Precision Livestock Farming (Ed S Cox), Wageningen Academic Publishers

Foundational developments exploiting precision…

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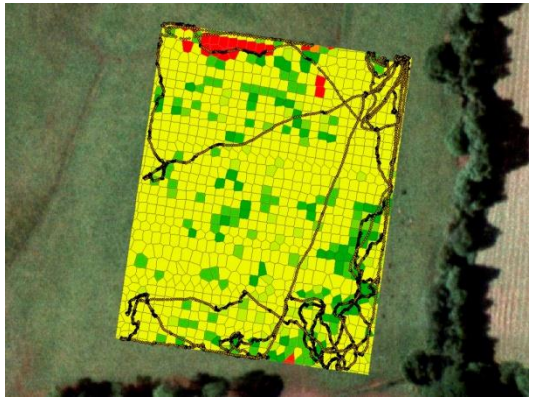
2.785mm



Precision implies better measurement,

better mapping of resources, better process control

Foundational developments exploiting precision…

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Precision implies better identification, better information and use of information and better communication – better information and communications technology (ICT)

But with greater use of automatic identification and data capture through object-connected ICT

Precision & Economic Justification

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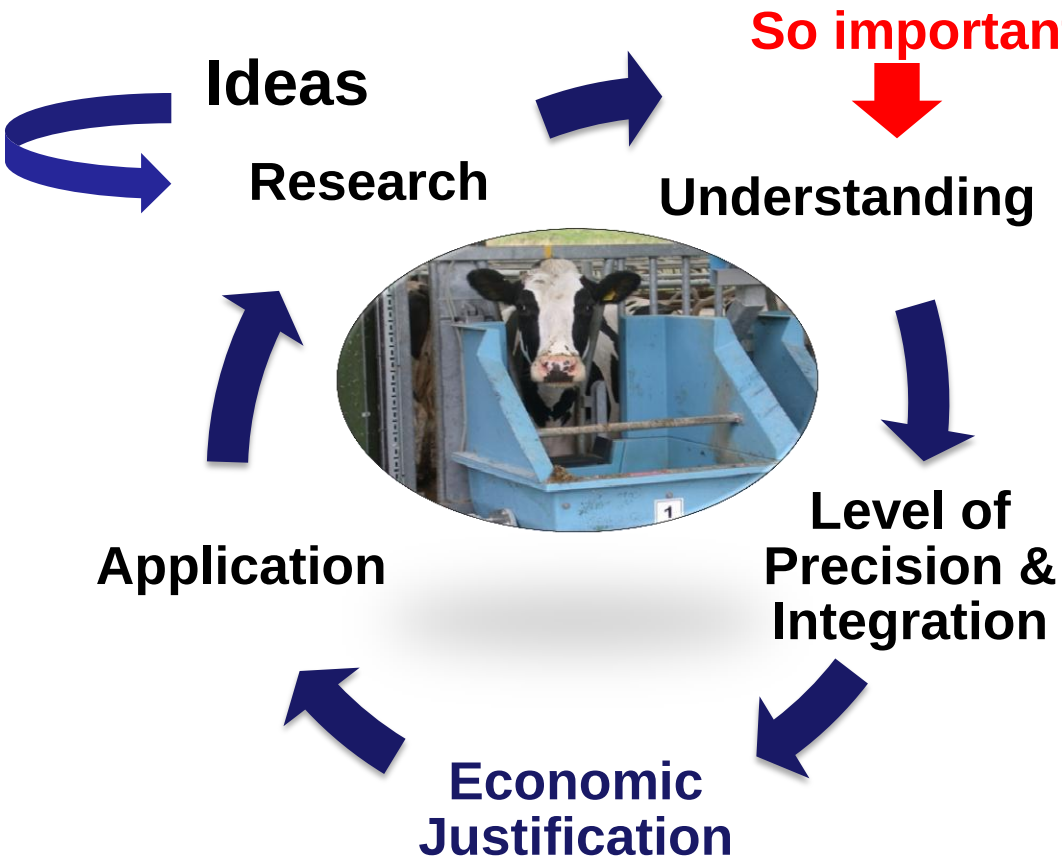

Examples:

- Irrigation and fertiliser control
- Feed and yield
- Grazing management
- …

Object-connected ICT

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The body of knowledge, techniques, principles, applications methodology and technologies used for automatic or semi-automatic identification, identification linkage, data capture and data transfer in management or other process support requirements with respect tangible physical items, including people, assets, animals and locations.

Object-connected ICT & Communications Technology (ICT)

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Object-connected Technologies

- Data carrier technologies
- Feature extraction technologies
- Positioning and Locating technologies
- Sensory technologies and networks
- Relay data collection technologies.
- Object-level communication technologies

+ Associate item-data / information management principles

= **Object-connected ICT**

Technologies for interfacing and interacting with the physical world

Scope of Precision Farming infrastructure

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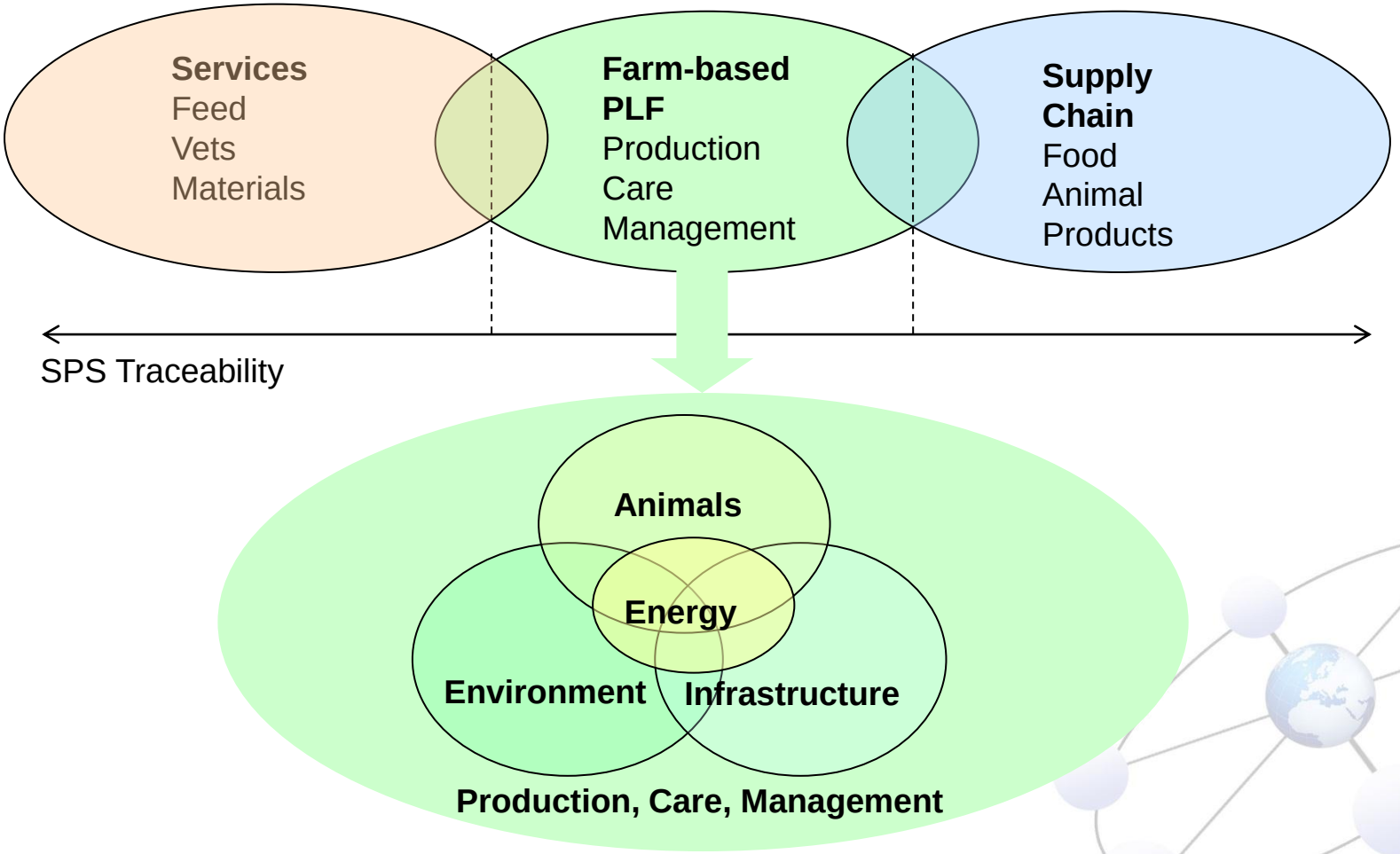
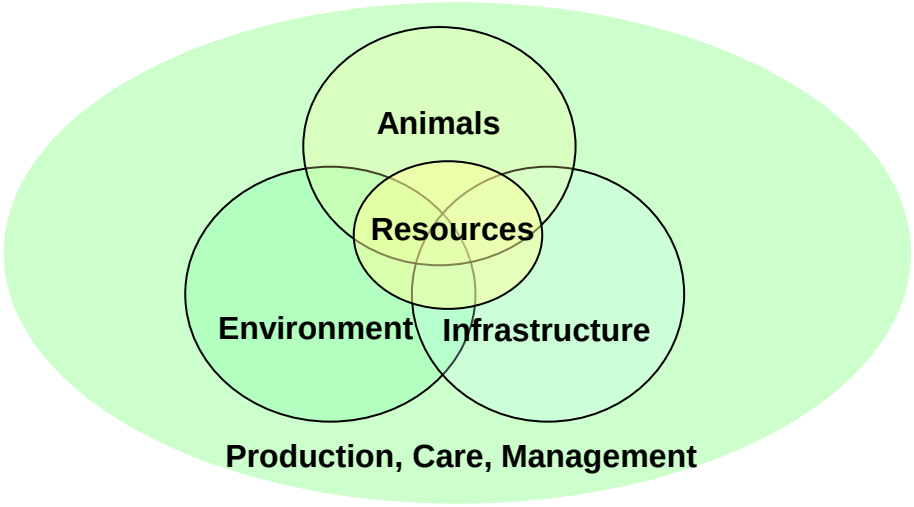


The Nature of Livestock Farming – General Perspective



Resources – including land, water and energy, and needs with respect to conservation.

Animals – the livestock on which the farm operates to deliver product
Infrastructure – the assets and utilities that are needed to efficiently and effectively support the realisation of the product and maintain the facility to do so
Environment – the internal and external structure and features that house and support the farming activities and the realisation of product
Management – the facility that defines and assures the functionality to achieve the objectives of the livestock farming activities and the specification, realisation and onward handling of product, with due regard to directives, standards, market factors and consequences of change or constraint (eg epidemics).

The Nature of Livestock Farming – Knowledge Requirements

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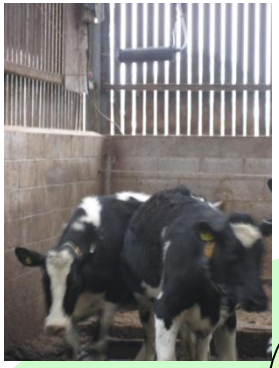
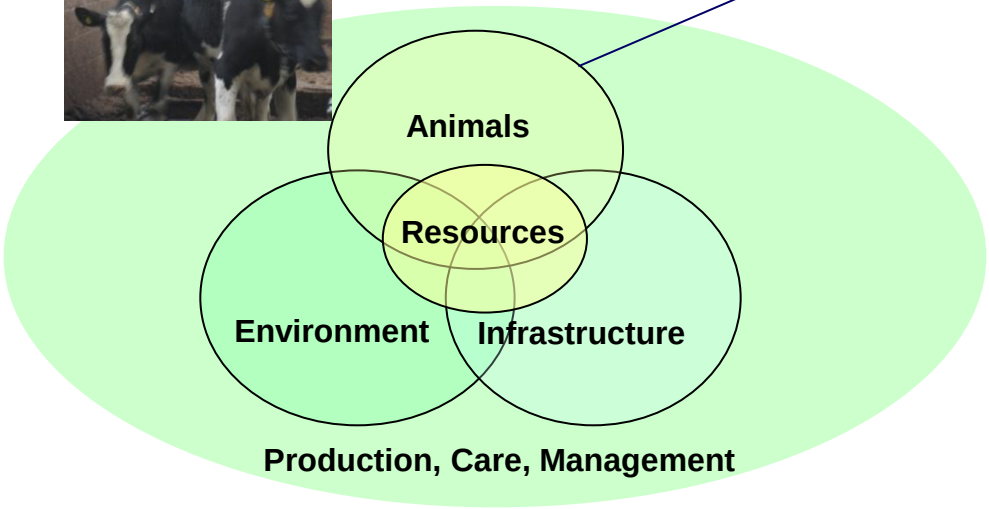
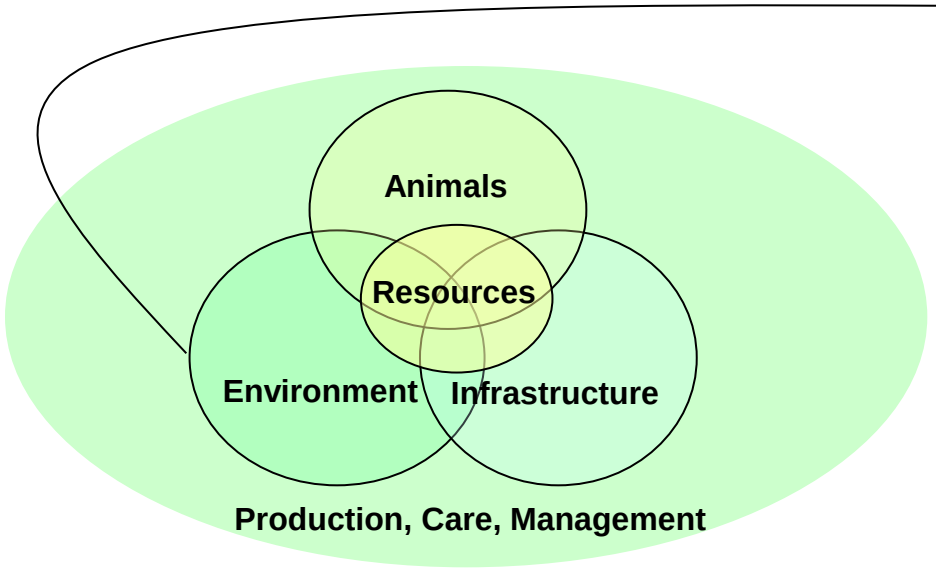




- **Animal health**
- **Animal welfare**
- **Animal activity and behaviour,** singularly and collectively, and in relation to influential factors such as physiology, environment, handling and other process demands and health condition
- **Animal handling**, process and procedural factors
- **Animal defined product** and the factors, singularly and collectively, that determine the quality and economic outcome

The Nature of Livestock Farming – Knowledge Requirements



- **Internal environment,** animal housing, conditions, waste management, energy management

- **External environment,** fencing and other aspects of containment and pasture management, water requirements, biomass and pasture optimisation, containment and management of slurry

The Nature of Livestock Farming – Knowledge Requirements

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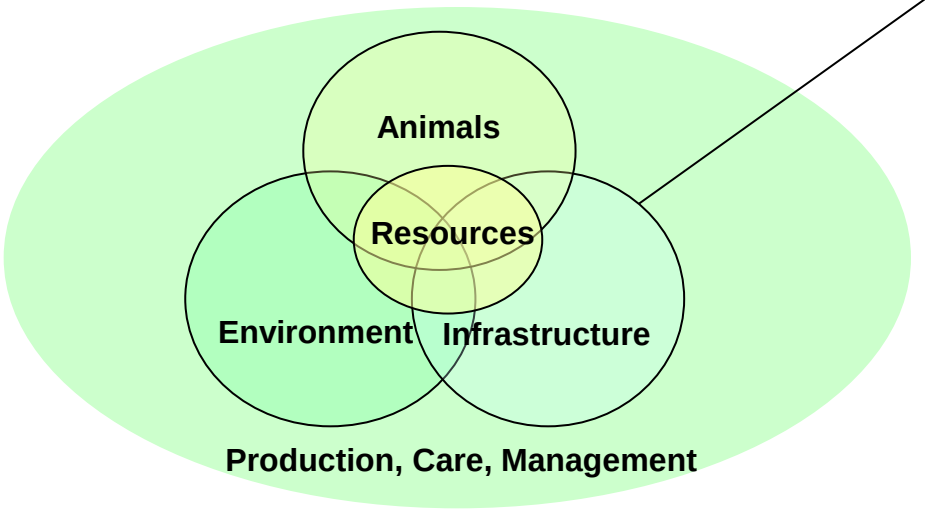
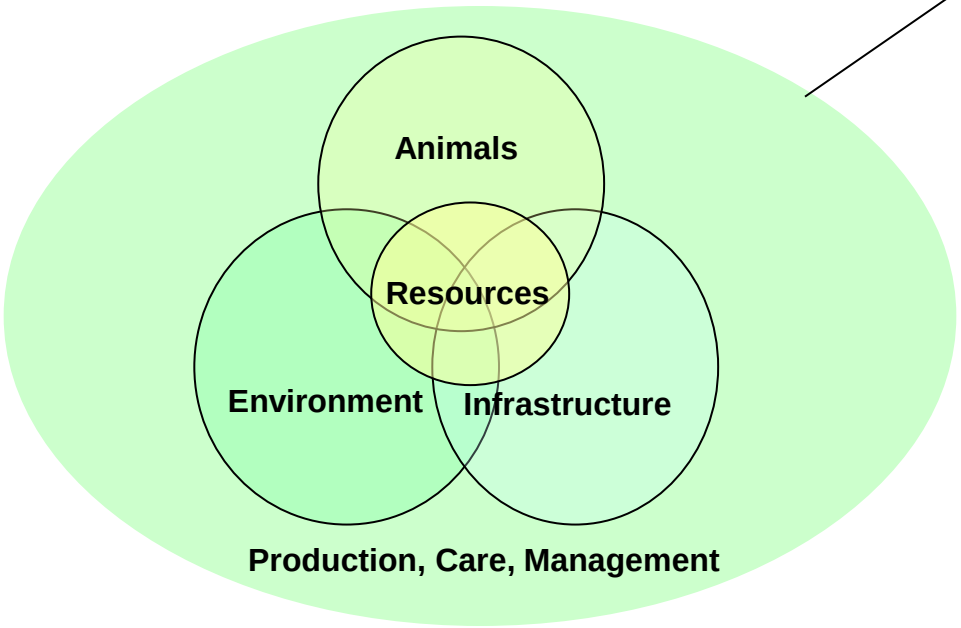


- **Internal infrastructure**, features including buildings, environmental control systems and mechanisation structures and systems for deriving product
- **External infrastructure**, more directed at structures for containment
- **Fixed assets**, including underground and above ground assets and utilities, such as water, electricity, communications, gas, waste removal.
- **Mobile assets**, including moveable farm machinery and transportation

The Nature of Livestock Farming – Knowledge Requirements



- Business management
- Animal management
- Infrastructural management
- Environmental management

Including modelling eg -
- Animal husbandry
- Lifecycle factors
- Feed and yield analyses
- Breeding analyses
- Environmental factors analysis
- Behavioural factors analysis

Management – the facility that defines and assures the functionality to achieve the functions listed above.

The Nature of Livestock Farming – Knowledge Requirements

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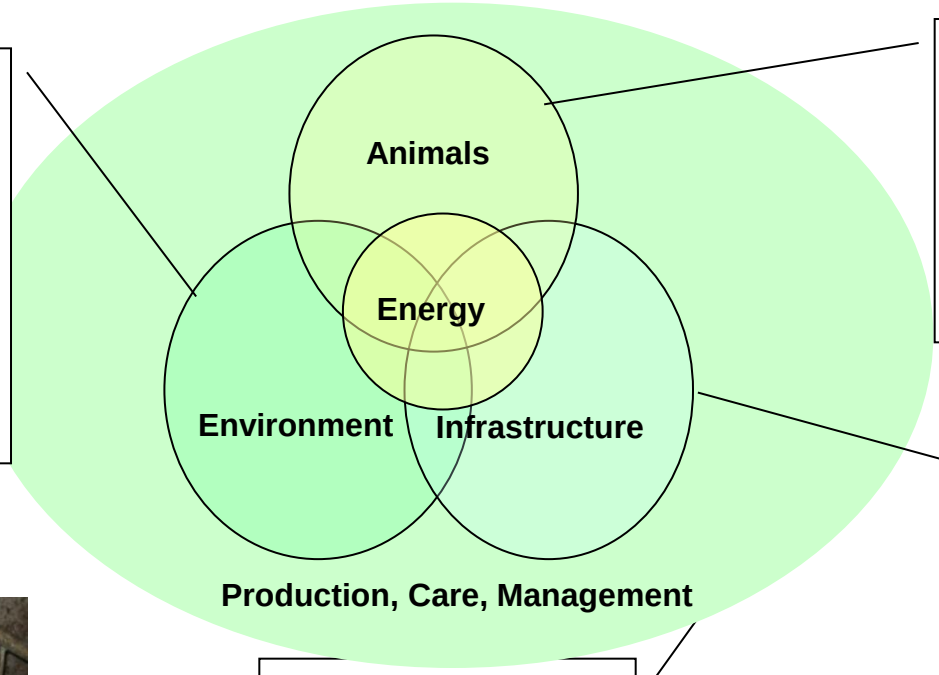
Identity
Location / positioning
Other Metrics
Communication
Actuation or control



Identity
Location
Other Metrics
Communication
Actuation or control

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Identity
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Actuation or control

Identification is fundamental to both Precision Farming and Traceability

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Revolutionary developments in technologies, from process-based data capture systems, supervisory control systems, sensory networks, unmanned aerial vehicle (UAV) platforms to Global Navigation Satellite Systems (GNSS) offering navigation, positioning, timing and mapping support and Internet supported applications and services –

Identification is key to exploiting this range of technologies with both a range of identifier systems and identifier / data carrier devices including linear bar codes, two-dimensional codes, magnetic code carriers and electronic code carriers (including radio frequency identification - RFID)

Ontology for Identification

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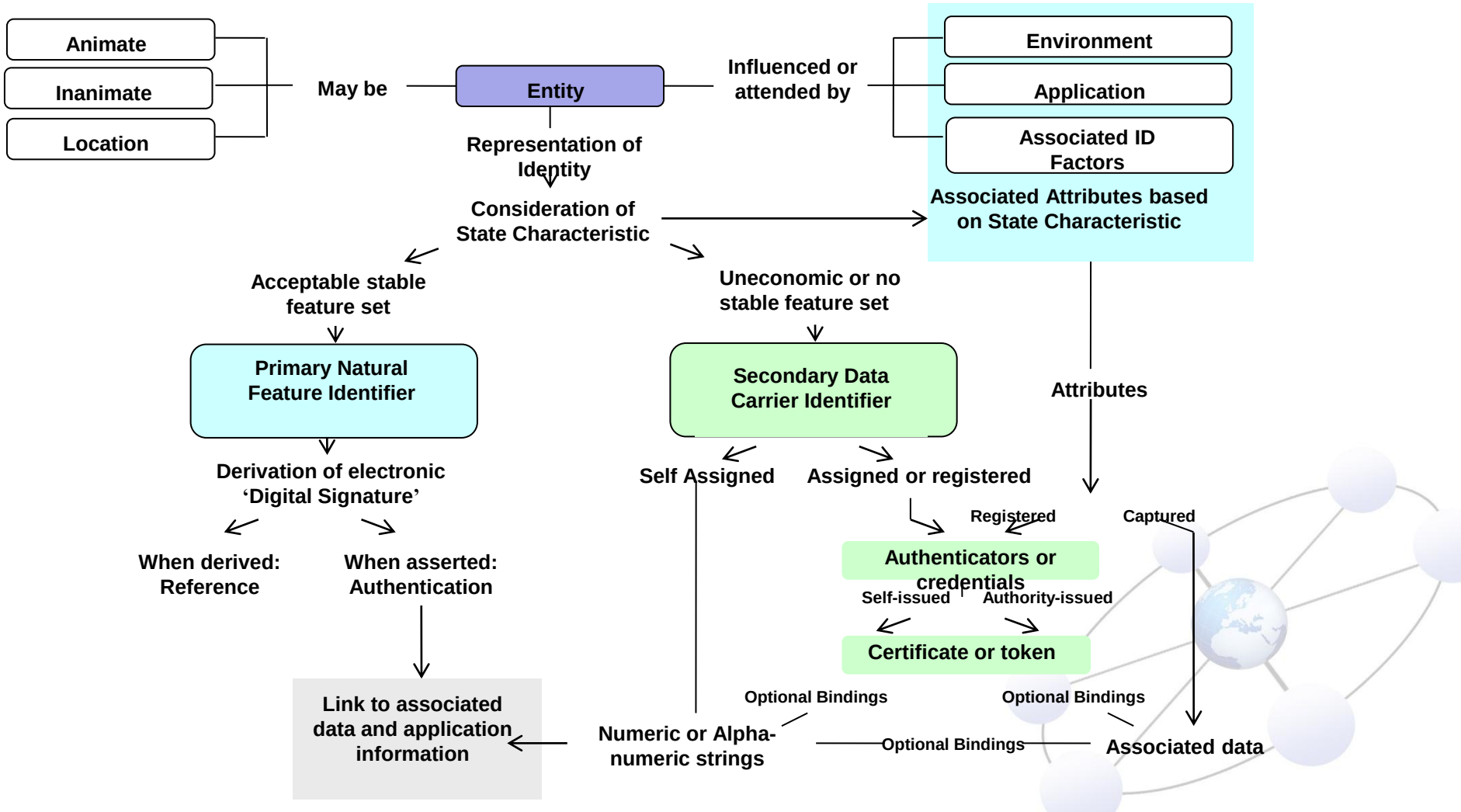

Automatic Identification and Data Capture (AIDC)

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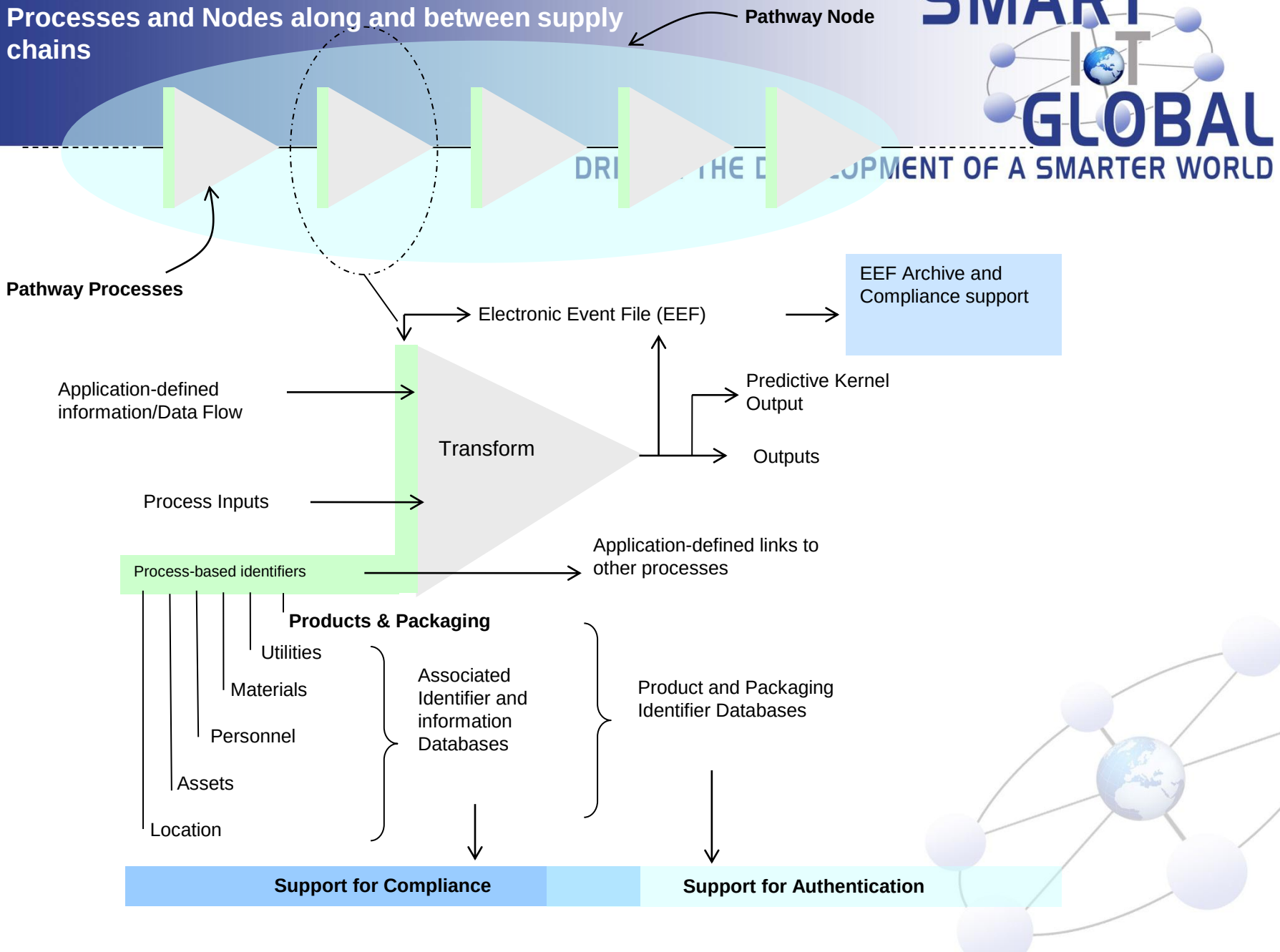
Appropriately viewed as identification and data carrier technologies, underpinned by a strong foundations of data carrier, transfer and management principles AIDC becomes a significant part of main-stream ICT, with relevance to virtually every sector industry, commerce and services.

Primary identification based upon natural features.

Secondary identification based upon specified numeric or alpha-numeric identifiers held in item-attendant data carriers.

Processes and Nodes along and between supply chains



Calf ID + Automated feeding & weighing Housing and environmental control

Weaning

Calf ID + Monitoring of grazing / feeding functions & health / behaviour monitoring

Post-Weaning

Beef Rearing

Finishing

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Pasture

Pasture / Herd management – Pasture biomass and nutrient value – Automated fencing, watering and weighing

Oestrus detection & Insemination

Activity monitoring for oestrus detection – insemination management

Calves for Herd replacement and Beef production

Pasture / Housing

Housing and environmental control – automated in-house feeding control, removal and treatment of waste for energy production and by-products (fertilizers and carbon dioxide)

Calving

Cows

Beef production

Health and behavioural monitoring Environmental control

Milking Herd

Lactation cycles ~ 3

Housing and environmental control & automated in-house feeding control

Housing

Milking cycle

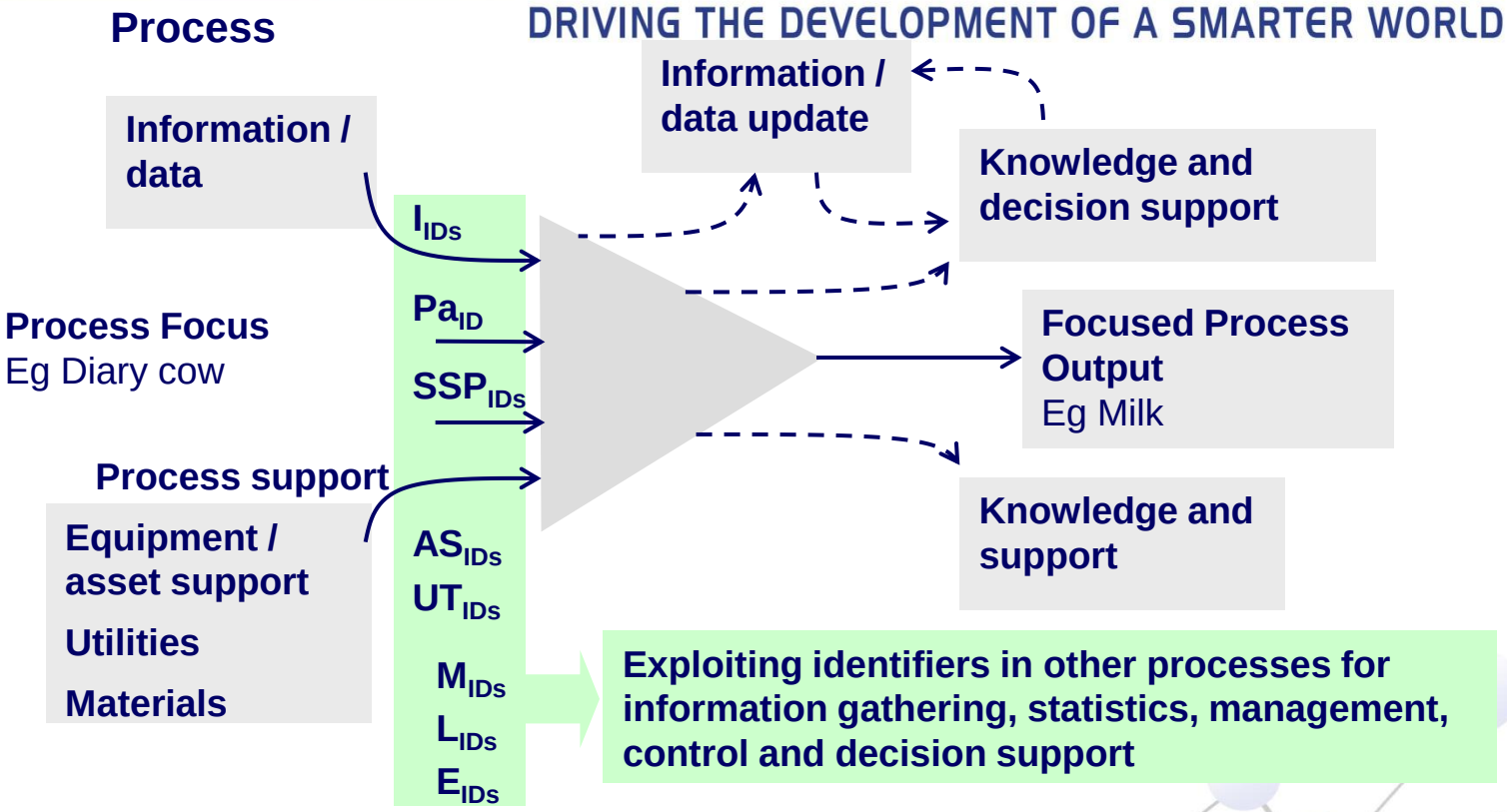
Automated milking systems & milk quality monitoring

Milking

Culling & natural losses

Disposal

Identification Linkage



I_{IDs} – Information identifiers, Pe_{ID} – Process entity IDs, SSP_{IDs} – Process Support Personnel IDs, AS_{IDs} – Asset IDs, UT_{IDs} – Utility IDs, M_{IDs} – Materials IDs, L_{IDs} – Location IDs, E_{IDs} – Event IDs (time stamps)

Sensors and Wireless Sensor & Actuator Networks (WSAN)

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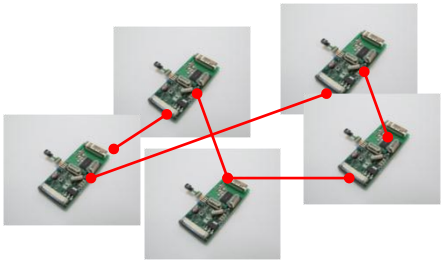
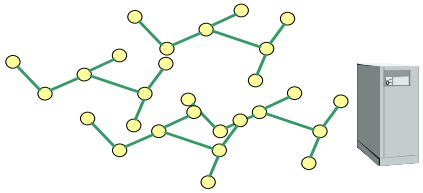
Capability too to link with the Internet





Better understanding of herd behaviour and management of herds – but much more in relation to PLF dimensions

Source: ETRI CASAGRAS Presentation

Sensor Networks in Precision Agriculture

Source – NIA – Korea – CASAGRAS1

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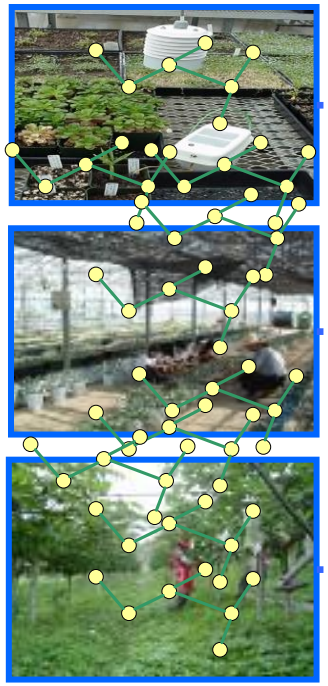
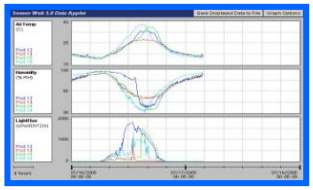
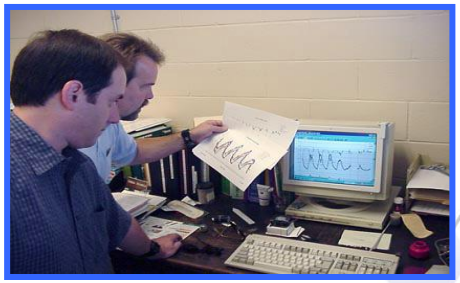


sensor data

Sensor Network

Collecting and analyzing





Management for optimal conditions

Food Supply Chains – Significant issues

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A number of significant issues continue to be seen to influence the development and management of Food Supply Chains:

- **Globalisation of trade**
- **Increasing regulatory demands for traceability, authentication, compliance and safety**
- **Complex products with ingredients from multiple supply chains**
- **Continuous production products**
- **Cross-supply chain complexity**

Traceability legislation

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- Traceability is addressed in Article 18 of Regulation (EC) 178/2002, the General Food Law
- “Traceability” means the ability to trace and follow a food, feed, food-producing animal or substance through all stages of production and distribution
- It must be established at all stages of production, processing and distribution for all matter to be incorporated in food

Traceability as a risk-management tool

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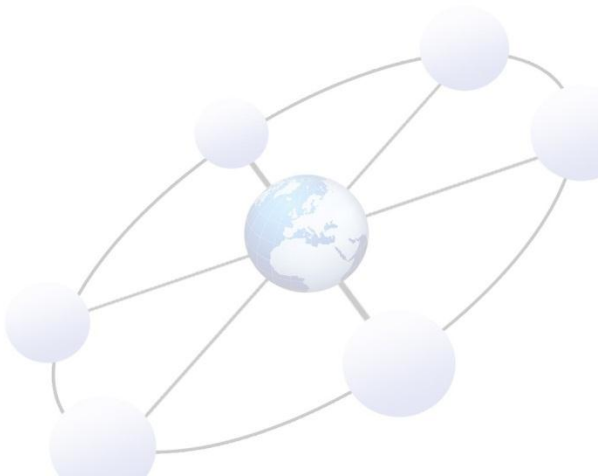
Traceability is a risk-management tool which allows food business operators or authorities to withdraw or recall products which have been identified as unsafe. It is a cornerstone of the EU's food safety policy.

(Fact Sheet on food traceability, June 2007)



A generic framework for Traceability

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Comprises the following requirements :

1. A universal means of numbering and identification allowing for total adoption by food supply chain businesses and capable of accommodating legacy systems.
2. Systems that can be defined and implemented in a manner which allows migration strategies from existing systems to **the universal system** with a minimum of disruption.

FOODTRACE

A generic framework for Traceability

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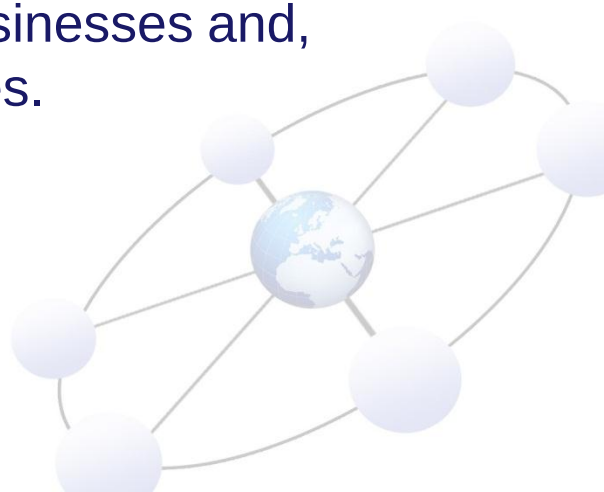
3. An implementation methodology for systems that will allow **added-value process development** in addition to the fulfilment of all traceability functions, including process developments that support better traceability.

4. Systems that allow **item-identification and linkage to associated information sets**. It will be held and maintained in the chain-supporting businesses and, as appropriate, in distributed databases.



Distributed Databases for Traceability

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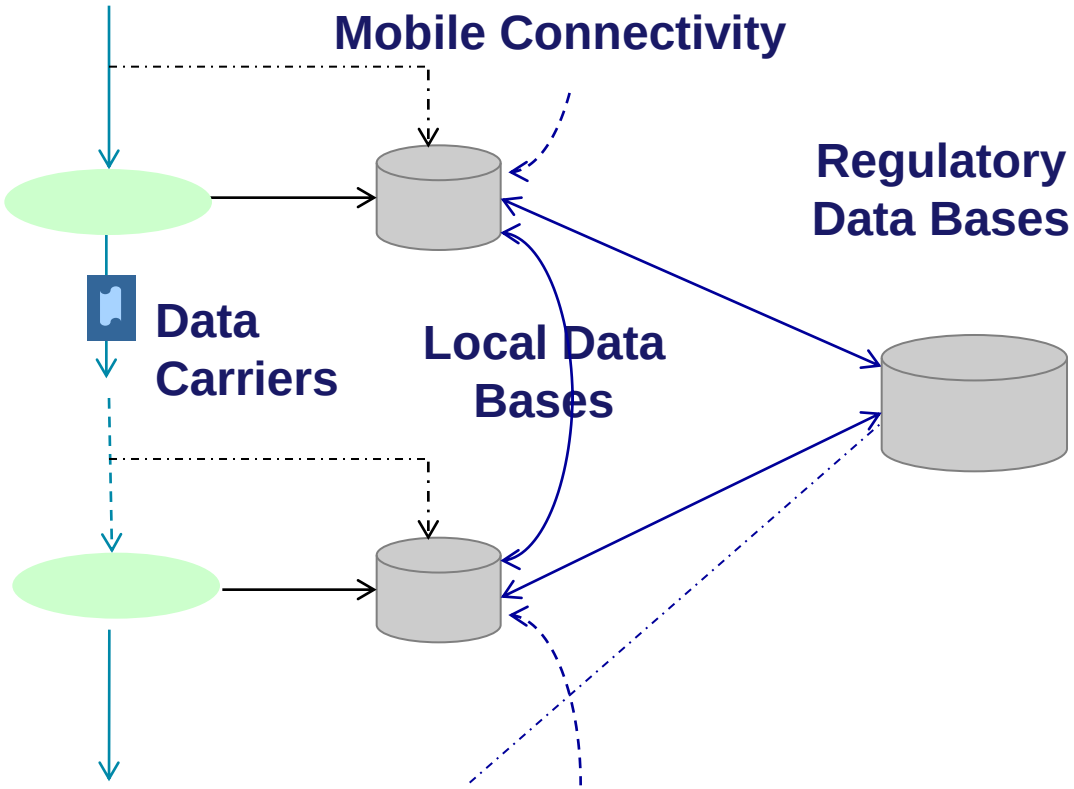

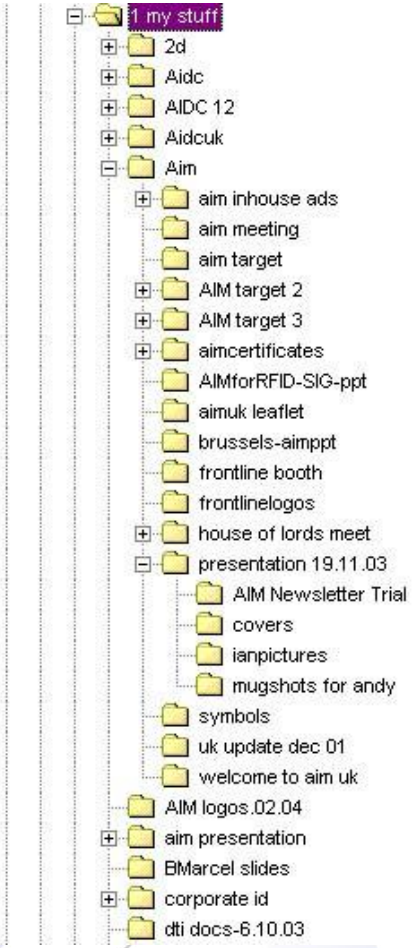

A generic framework for Traceability

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5. Systems that support a both **primary** (biological and other feature-based identifiers) and **secondary identification** (standardised data carrier-based numeric and alpha-numeric identifiers).

Note: Natural feature identification as primary identification techniques

Also Chemical and Bio-markers:

- Biochemical (including metabolic products and enzymes)
- Genetic / DNA alterations
- Immunological
- Physiological (Proteome transcriptome and metabolome)
- Histopathological / Morphological
- Man-made / engineered (Xenobiotics, Residua, Microflora)

FOODTRACE

Source: Raspor, P (2003) Primary Identifiers of Food Items using Bio(logical) Markers, FoodTrace Conference Proceedings, Sitges

A generic framework for Traceability

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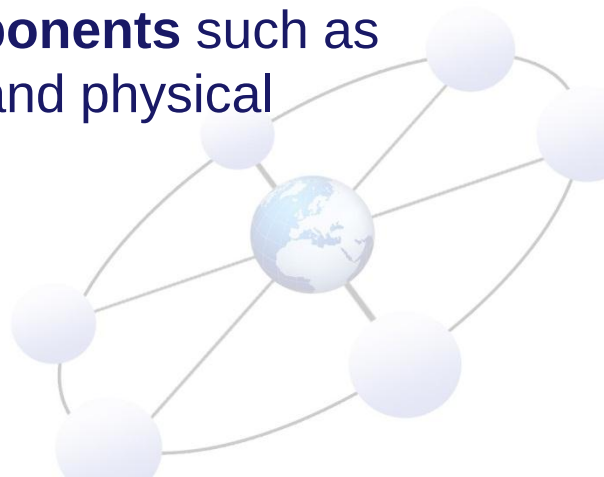
6. Systems that support a range of **data carrier technologies, data capture techniques** within and between points of handling in supply chains

   Note: FoodTrace accommodated both internal and external traceability without distinction – total traceability with information at change points – with vertical and transverse connectivity

7. Systems that **accommodate emergent data capture techniques and associated data components** such as those derived from chemical, biological and physical sensors.



A generic framework for Traceability

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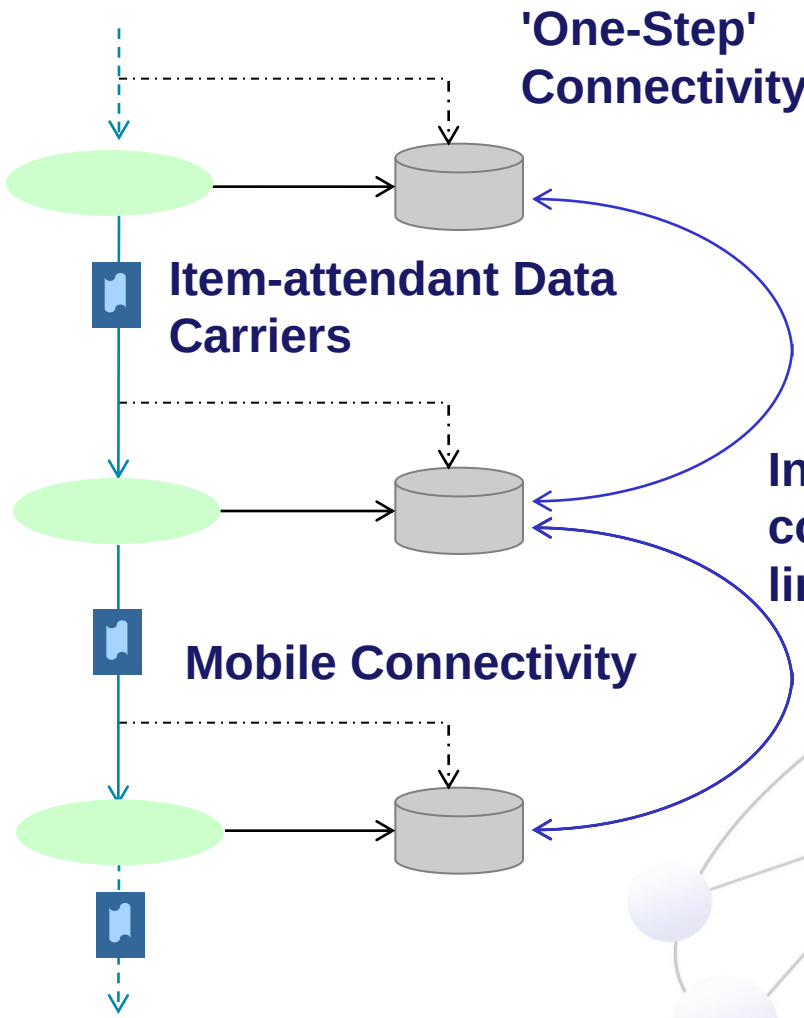
FOODTRACE

Vertical & Transverse Connectivity



A generic framework for Traceability

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8. Systems that **accommodate new developments in process modelling and applications where identification and traceability are of relevance**. An example could be flow modelling of continuous food manufacturing lines with a view to improved batch resolution – **also object-connected ICT**.

9. Systems that can **accommodate developments and standardisation in data transfer and communications** within the evolving e-commerce infrastructure.

A generic framework for Traceability

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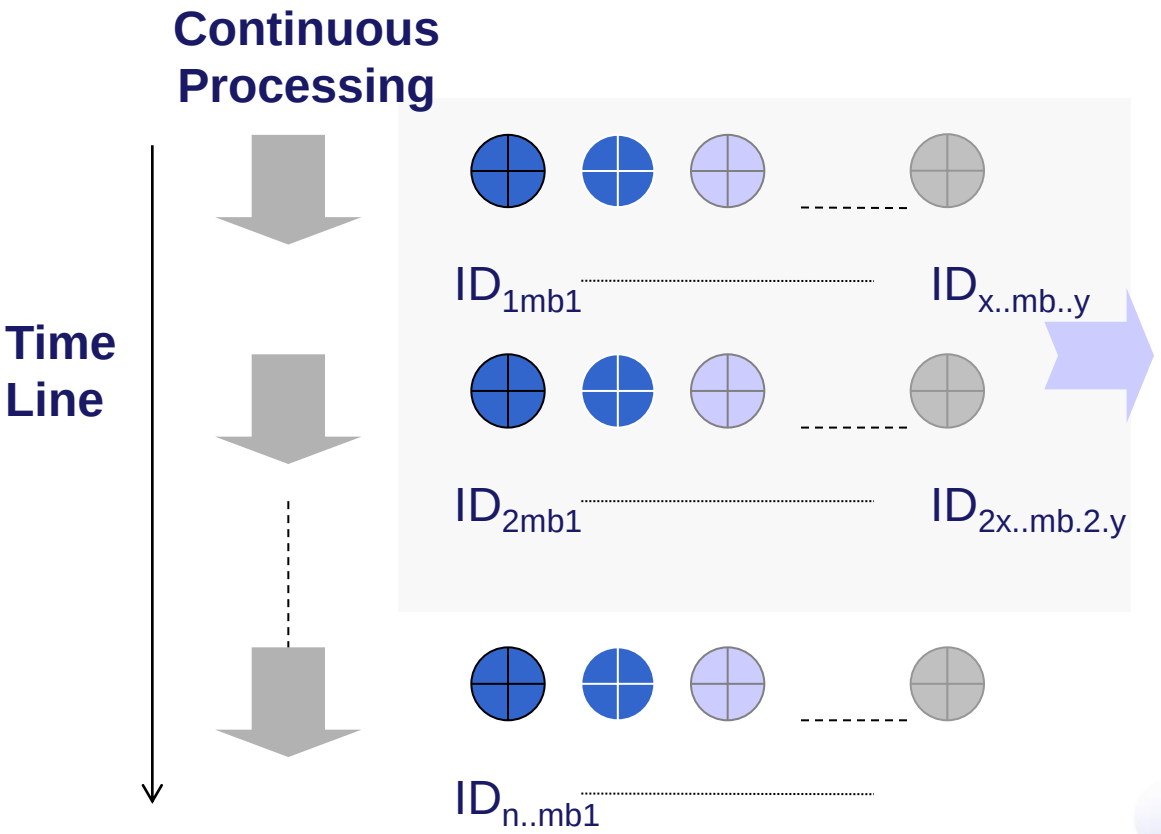
Item Processing and Identification – Continuous processing



Product or process output batch, unique ID_{pp1} [IDmb1….ID2x..mb..2y],

possibly with overlap to next and previous batch for traceability purposes - linked to source items or ingredients in portable data file or associated database

A generic framework for Traceability

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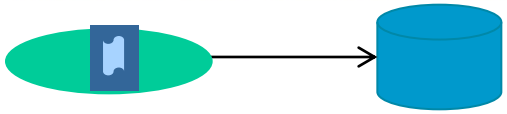
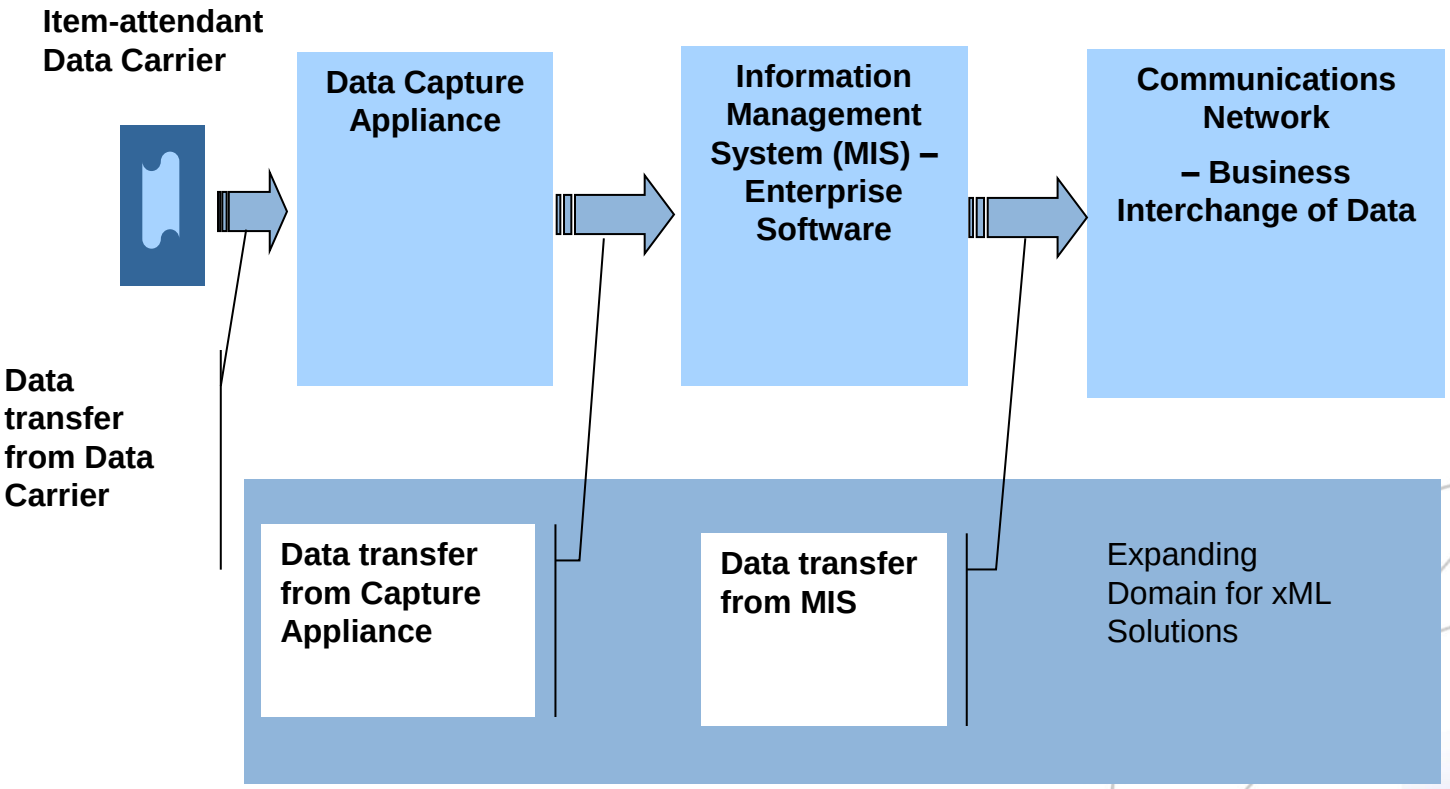
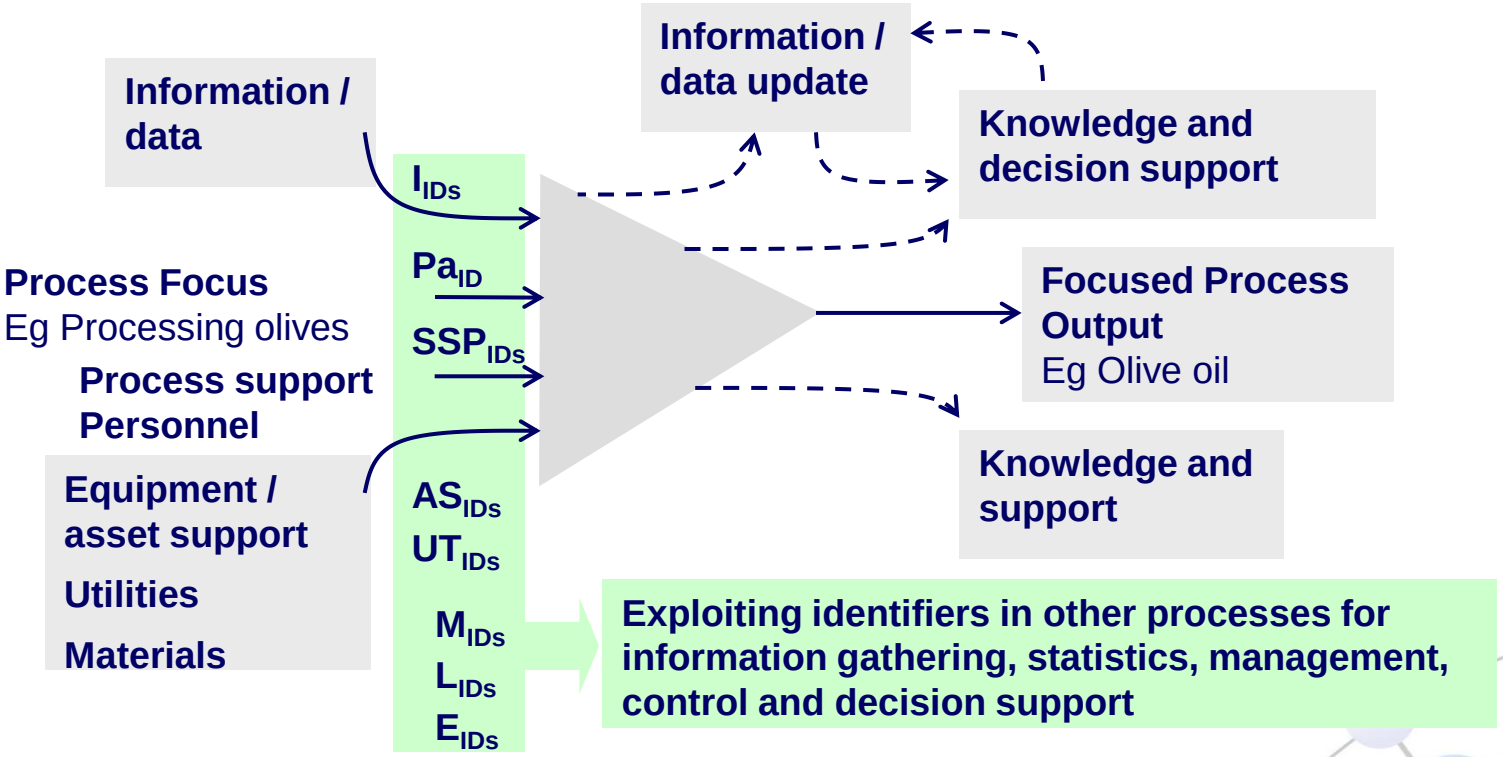
Nodal Data Transfer





Process and Multiple Identification



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Options & Dividends through Identification Linkage

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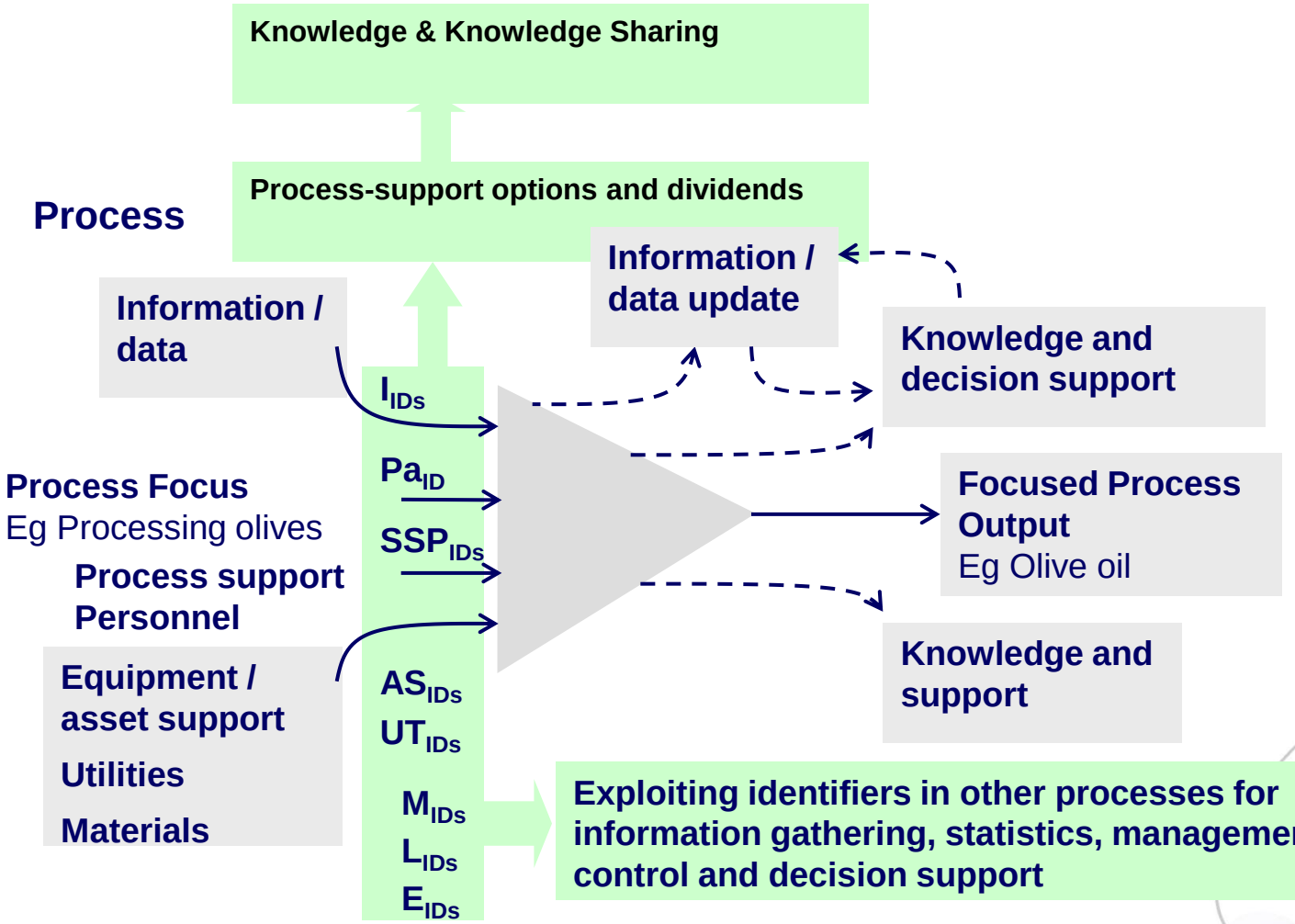

Pathways and exploiting wider area connectivity

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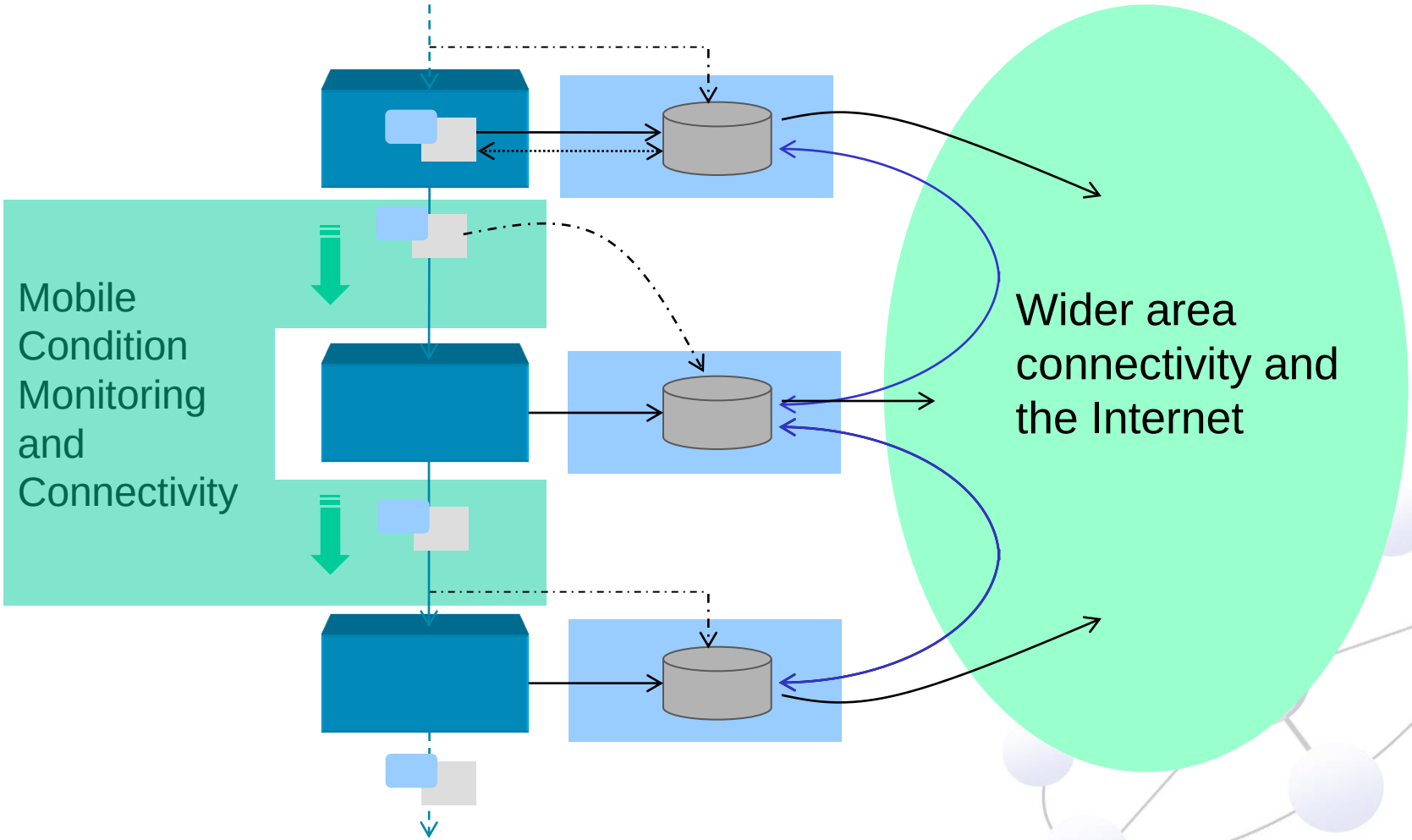

Sensory Capability & Exception Strategies

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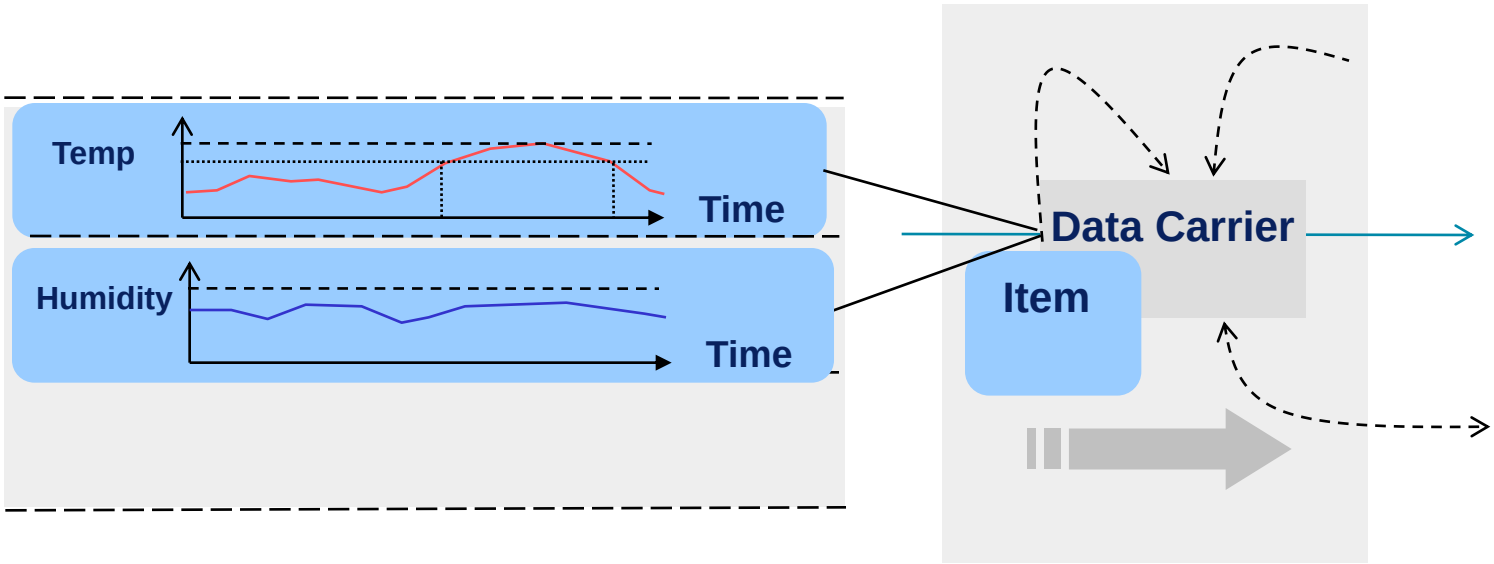

- Exception data may be stored or communicated depending upon strategy and sophistication of data carrier.
- Other sensory parameters may be supported depending upon strategy (eg contamination sensors).

Identification Levels and Nesting

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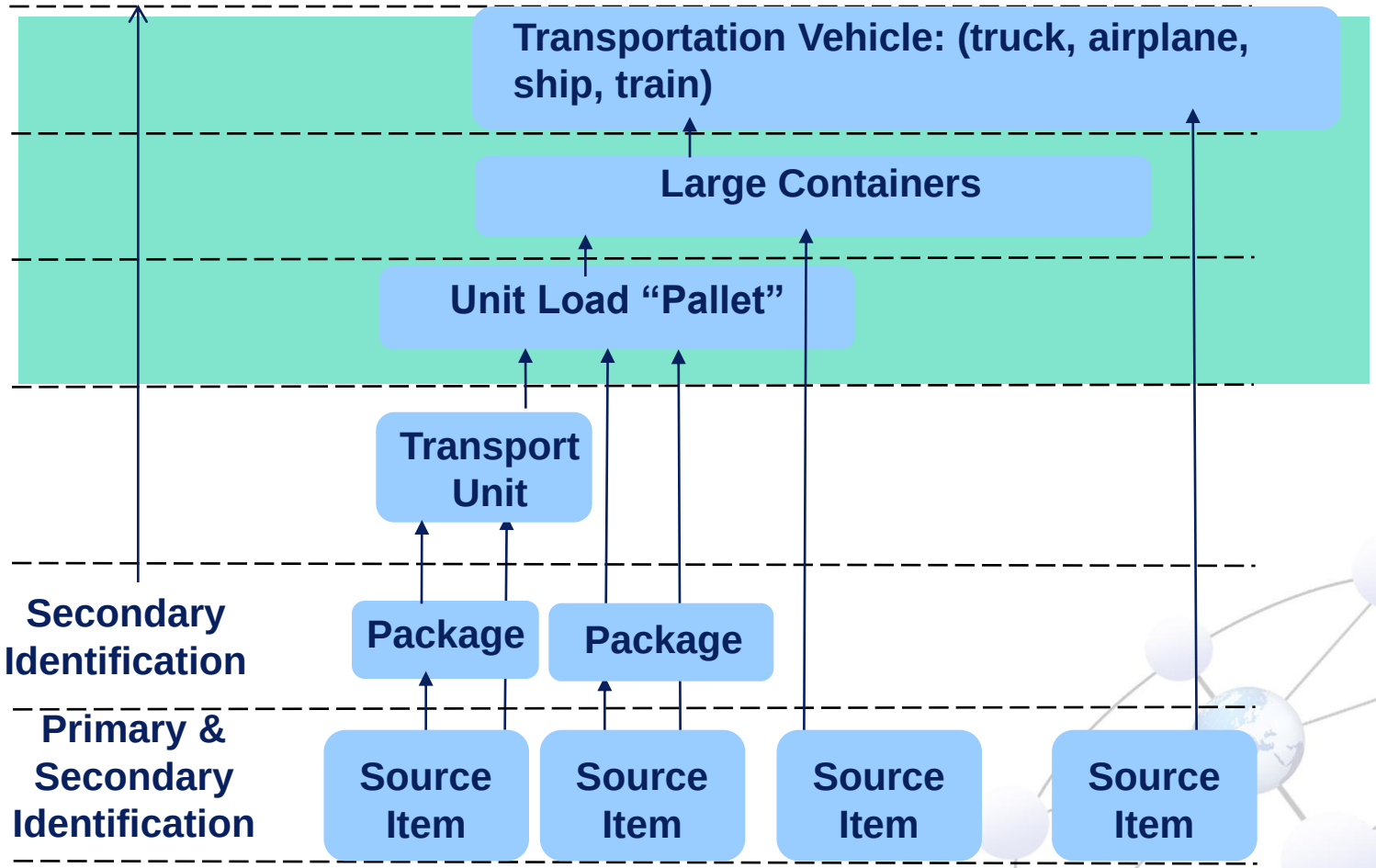

Exploiting the Internet

Network and Internet Layer

Other network nodes

Other network nodes

Information / data update

Information / data

Object Identifiers

Knowledge and decision support

Power of multiple identification

People

Physical item (s)

Utilities support

Equipment / asset support

Materials

Object-centric Process

Process - item transformation

Knowledge and support

Usage Information

Object identification information / data transfer, pre-processing and communication

Time Line

h_1

dc_1

Time Line + Item Identification + Usage Information

Edge Technology Layer

RFID in Relation to Framework Dimensions

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RFID/EM Examples	Identity	Location/ Position	Metrics	Commun-ications	Actuation/ Control
Animals	Ear tags Active Collar tags Sub-dermal Bolus Natural feature	RTLS GPS	EMG/ECG Skin temp, potential, resistance 3D activity Bio-metrics	RFID Readers WiFi Zigbee GPRS 3G	RFID-activated feed units Barriers
Infrastructure	Passive tags Active tags Energy Harvest	Embedded tags RTLS	Temperature Pressure Humidity Energy	RFID Readers WiFi Zigbee GPRS 3G	Access control Environmental control Sensory networks
Environment	Passive tags Active tags Energy Harvest	Embedded tags GPS Other GNSS	Temperature Pressure Humidity Biomas	RFID Readers WiFi Zigbee GPRS 3G	EM virtual fences Sensory networks
Management	Passive tags	RTLS Fixed readers	Time and motion	WiFi Zigbee GSM 3G	Access control Activity control

Object-connected Technologies in relation to PLF

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Object-connected Technology	Categories	Interface Requirements	Standards	Foundations for applications and services design
Animate, natural feature identification technologies	Anatomical and bio-dynamic (Physiological and behavioural) DNA-based type and unique identification	Technique- and device-specific issues	Standards required to rationalise data transfer and integration	Unique biometric identification in human-oriented services and applications, and potentially other animate object applications Potential for integration with other AIDC technologies
Inanimate, natural feature identification technologies	Different categories emerging – natural and fibre-assisted techniques	Technique- and device-specific issues	Standards required	Unique identification of objects, having wide potential in anti-counterfeiting, including food-based, applications. Potential for integration with other AIDC technologies

Object-connected Technologies in relation to PLF

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Object-connected Technology	Categories	Interface Requirements	Standards	Foundations for applications and services design
Data carrier, simple read-only identifier technologies	Linear bar code, Two-dimensional codes, composite codes, magnetic encoding, electronic encoding including RFID	Various interface protocols available	Strongly supported by technology and interface standards	Wide range of existing and potential secondary identifier (unique and type-based) applications and services, across all sectors of industry, commerce and services
Data carrier, portable data file, read-only technologies	Two-dimensional codes, composite codes, electronic encoding including RFID	Various interface protocols available	Strongly supported by technology and interface standards	Wide range of existing and potential secondary identifier (unique and type-based) applications and services, across all sectors of industry, commerce and services

Object-connected Technologies in relation to PLF

SMART IoT GLOBAL
DRIVING THE DEVELOPMENT OF A SMARTER WORLD

Object-connected Technology	Categories	Interface Requirements	Standards	Foundations for applications and services design
Data carrier, read-write technologies	Electronic encoding including RFID, contact and contactless smart cards	Various interface protocols available	Strongly supported by technology and interface standards	Wide range of existing and potential secondary identifier (unique and type-based) applications and services, across all sectors of industry, commerce and services – offering lower costs, extended process capability and flexibility through reuse of data carriers
Communication-based, read-write data carrier technologies	Electronic encoding, location-determining and data transfer devices	Various interface and communication protocols available – RFID, WiFi, ZigBee, Bluetooth, NFC etc	Supported by technology and interface standards	Networked communication between object-based structures a design attribute, offering prospects for networked applications from personal to international wide area applications and services

Object-connected Technologies in relation to PLF

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Object-connected Technology	Categories	Interface Requirements	Standards	Foundations for applications and services design
Sensor-based data capture technologies	Electronic based platforms for wired and wireless capture and communications	Various interface and communication protocols available	Supported by technology and interface standards – others, including RFID-based standards, in prospect	Both single and networked communication between object-based structures a design attribute, offering prospects for networked applications from personal to international wide area applications and services
Intelligent data capture and communication technologies	Electronic, smart, decision-based functionality	Various interface and communication protocols available	Further protocols and standards required	Both single and networked functionality, offering prospects for intelligent networked applications from personal to international wide area applications and services

The Internet of Things (IoT)*

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The Internet of Things viewed as a network for communicating devices and based upon four degrees of sophistication, involving:

- **Purely passive devices (RFID)** that yield fixed data output when queried
- **Devices with moderate processing power** to format carrier messages, with the capability to vary content with respect to time and place
- **Sensing devices** that are capable of generating and communicating information about environment or item status when queried
- **Devices with enhanced processing capability** that facilitate decisions to communicate between devices without human intervention – introducing a degree of intelligence into networked systems

* European Commission (2007) From RFID to the Internet of Things – Pervasive networked systems

The CASAGRAS Inclusive model accommodates any number of data carrier and other object-connected technologies, including positioning , location and ranging technologies

CASAGRAS IoT Inclusive Model

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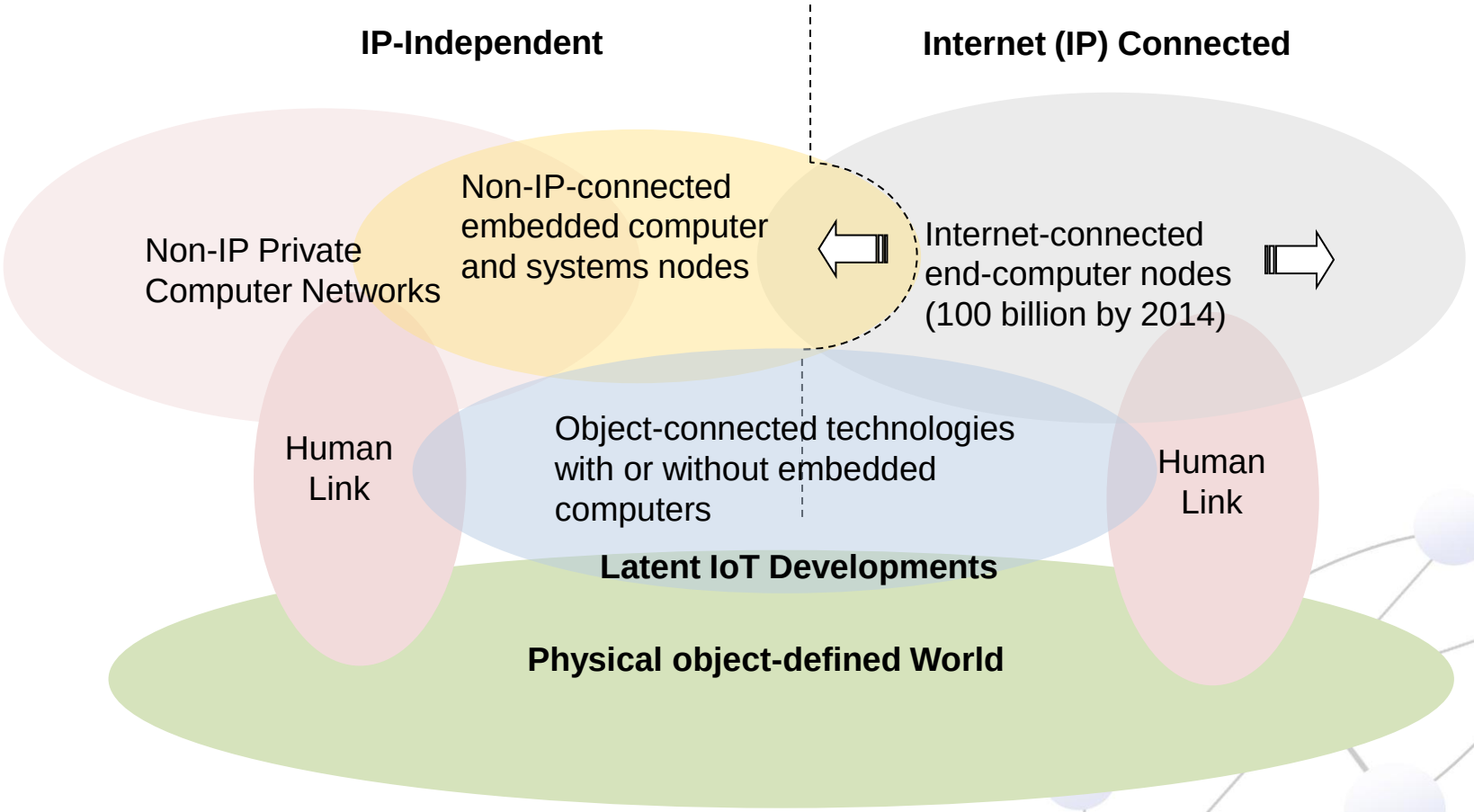

CASAGRAS IoT Inclusive Model

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Internet Connected

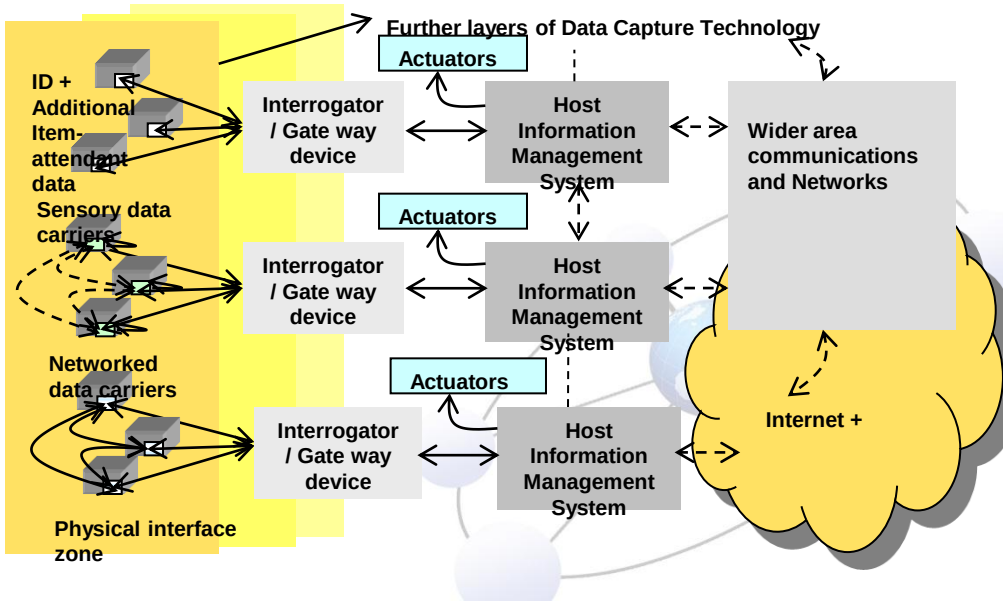
The Internet – Endpoint computers

Application Layer :
Web
Emails
Messaging

Object-connected entities without embedded computers

Specific Domains for IoT?
Specific application structure for the IoT?

CASAGRAS Inclusive Model – Internet connected



Internet, IoT and the 'Cloud'

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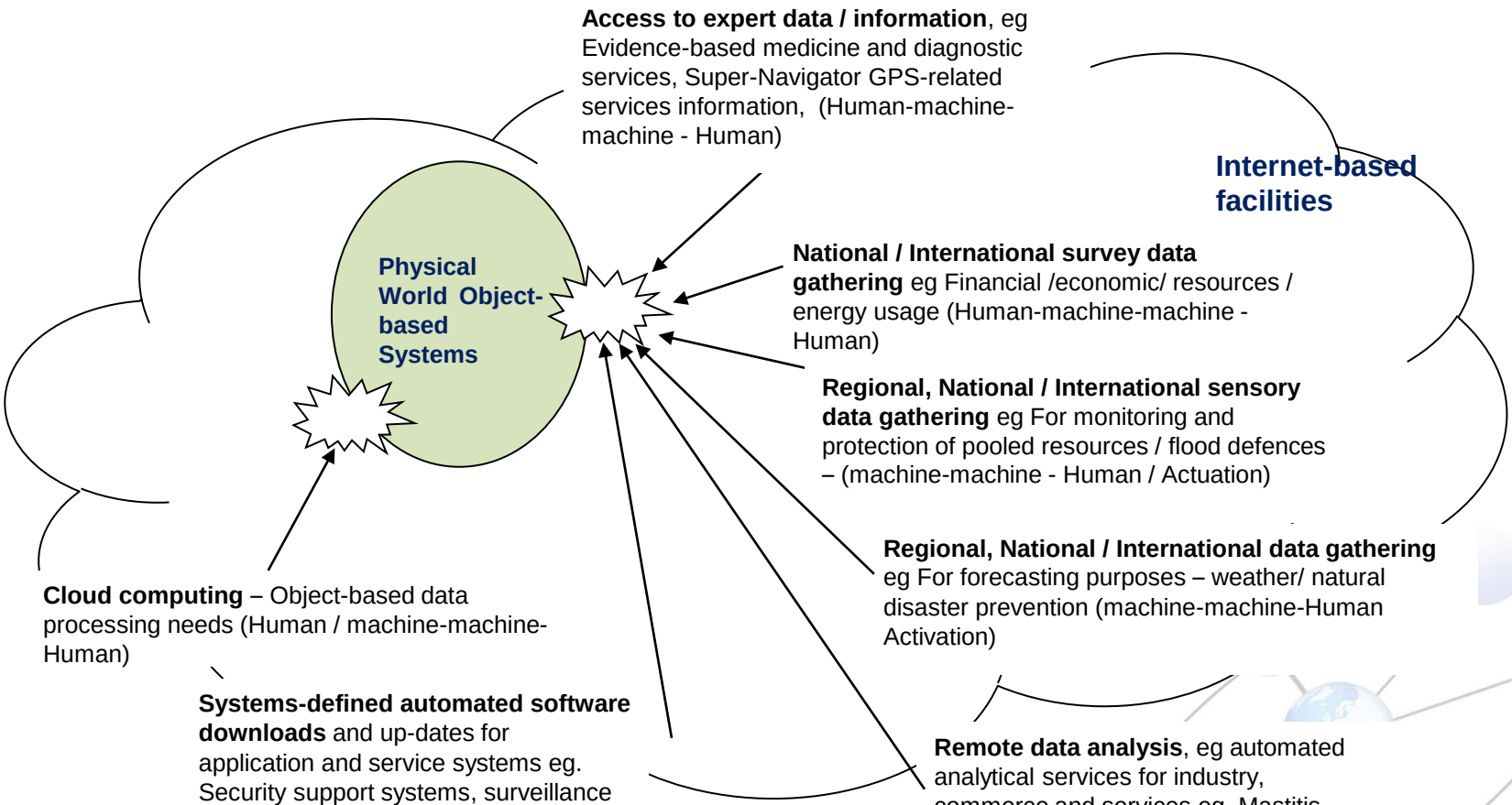

What does all this mean for Precision Farming (PF) generally?

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A rich technological base facilitating an integrated infrastructure with a service and application methodology for PF, exploiting the integration of precision system solutions and with the capability of supporting farm-based process reengineering and innovation to yield better, more economic, use of resources (water, energy, land, assets, utilities, animals and by-products), greater attention to environmental protection and climate change, greater attention to food requirements, wastage and supply chain developments to achieve and maintain socio-economic acceptance.

The key to exploiting this potential is through education, training and business assist.

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Thank you for your attention