Road 4 FAME

A Strategic Roadmap for Manufacturing

Haydn Thompson, THHINK Ltd.

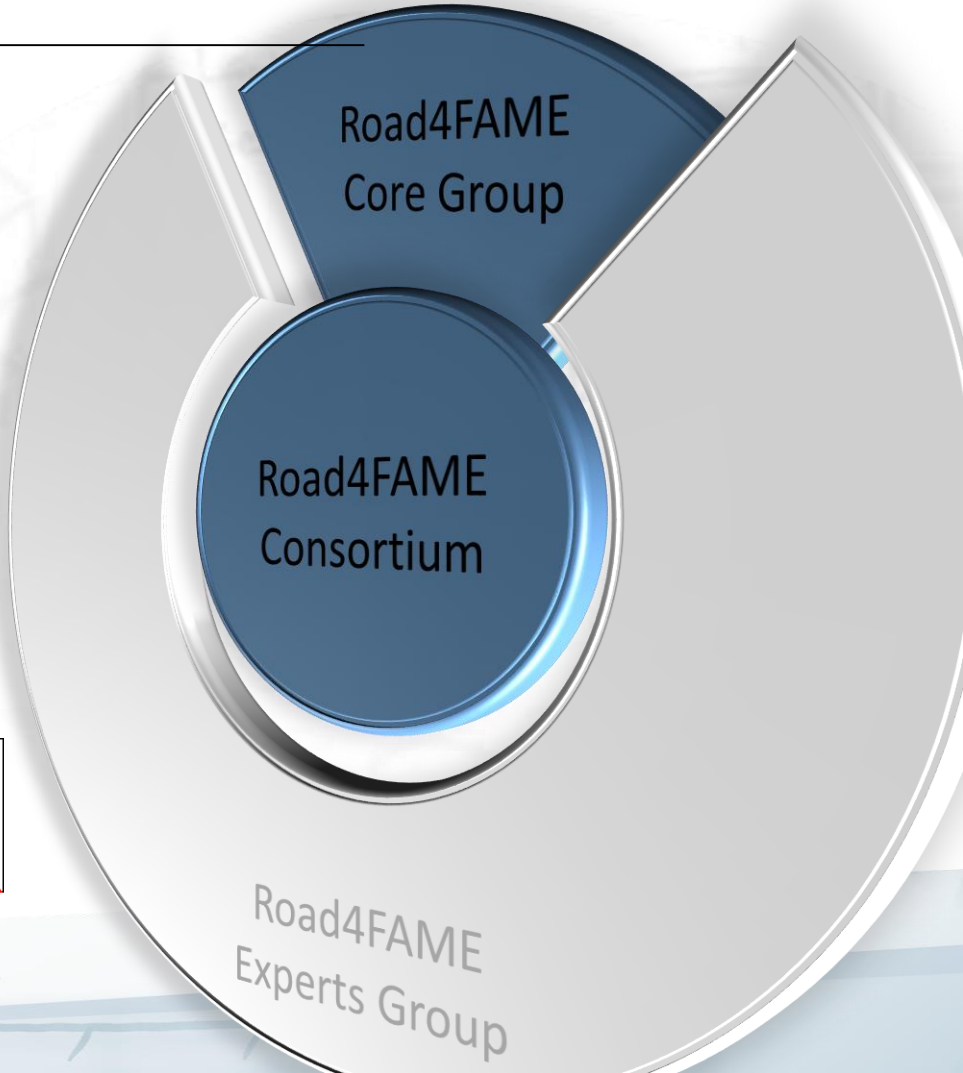
Road4FAME in a nutshell

Roadmapping and technology transfer experts and manufacturing IT experts

Road4FAME in a nutshell

Selected experts and representatives from industry and the FoF roadmapping ecosystem for:

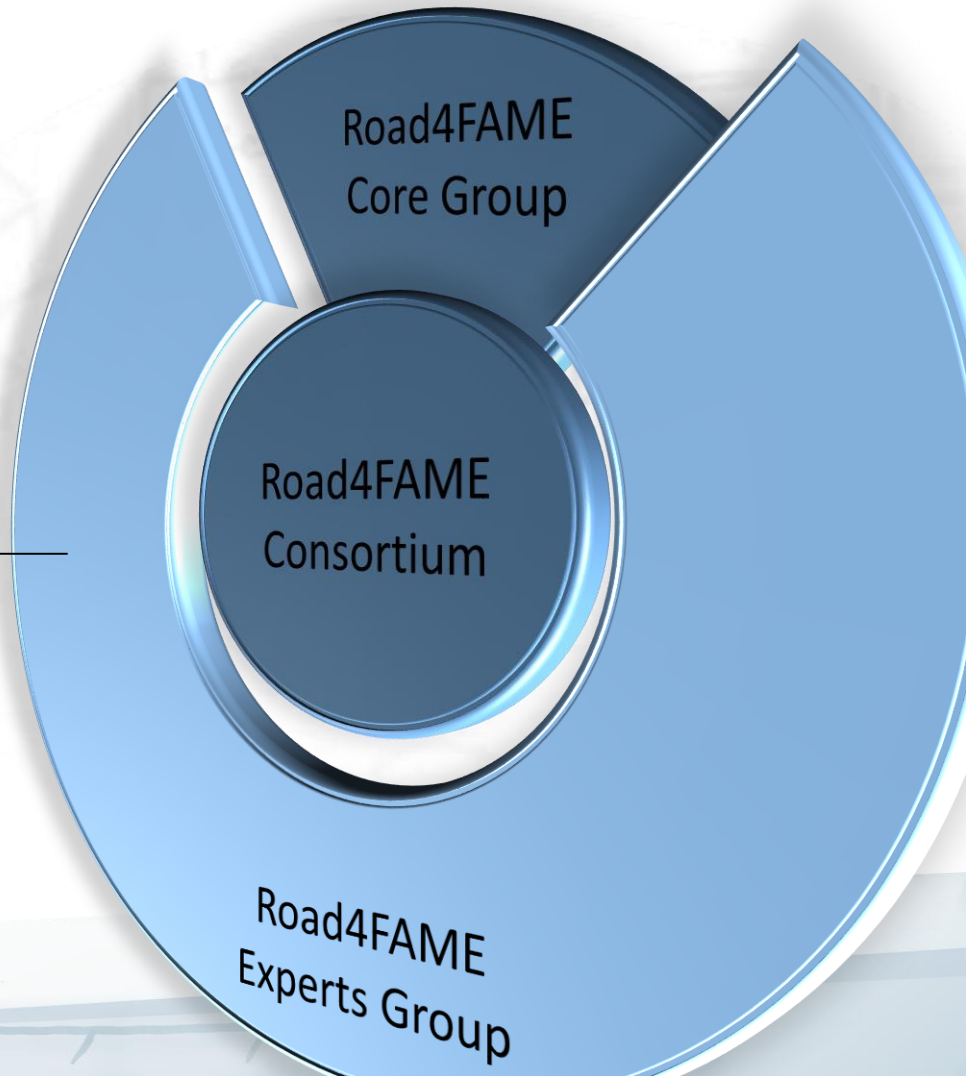
- Strategic advice
- Link to expertise
- Validation of project results
- Multiplicators for project results



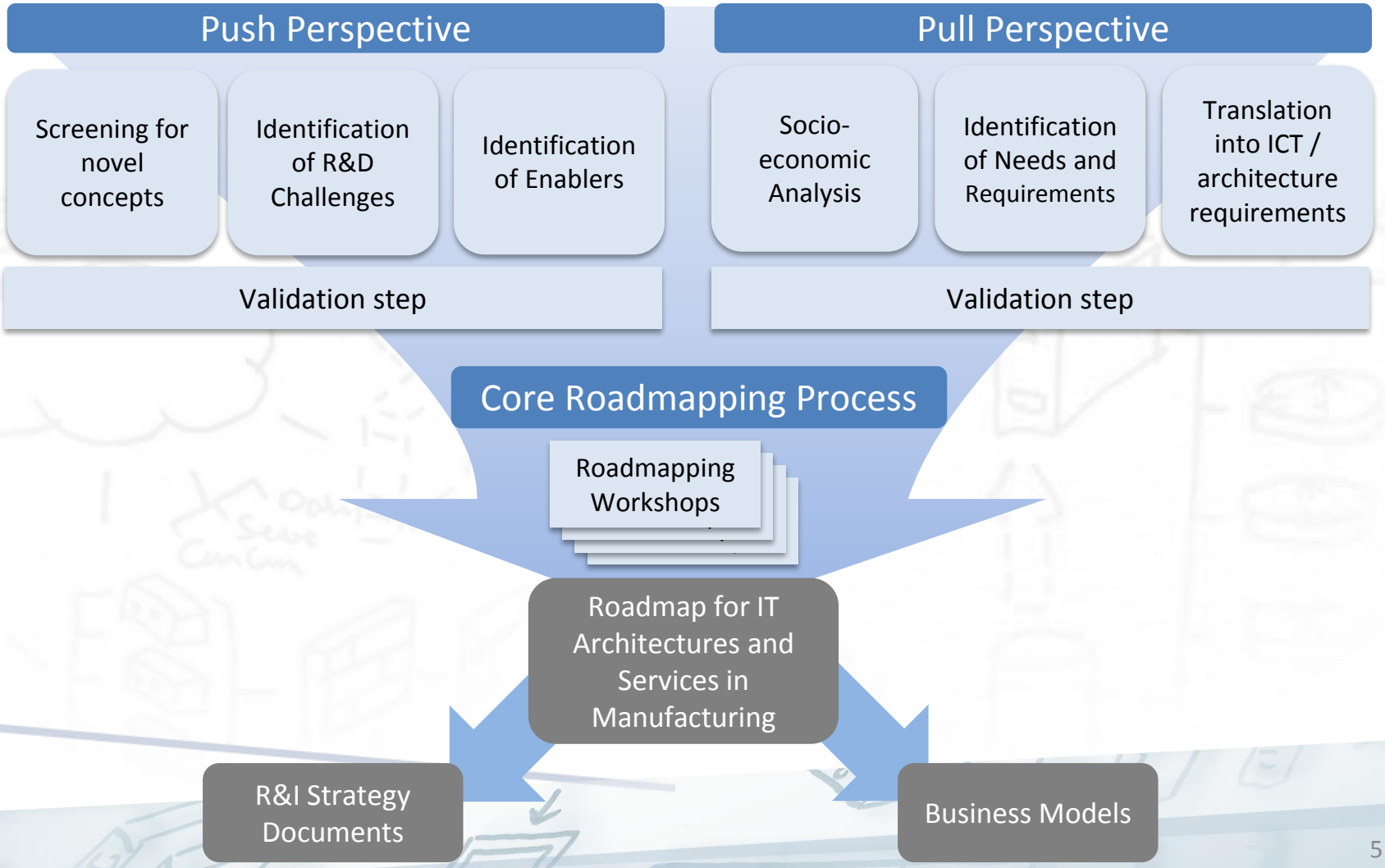
Road4FAME in a nutshell

Around **100** experts and representatives from industry and academia for:

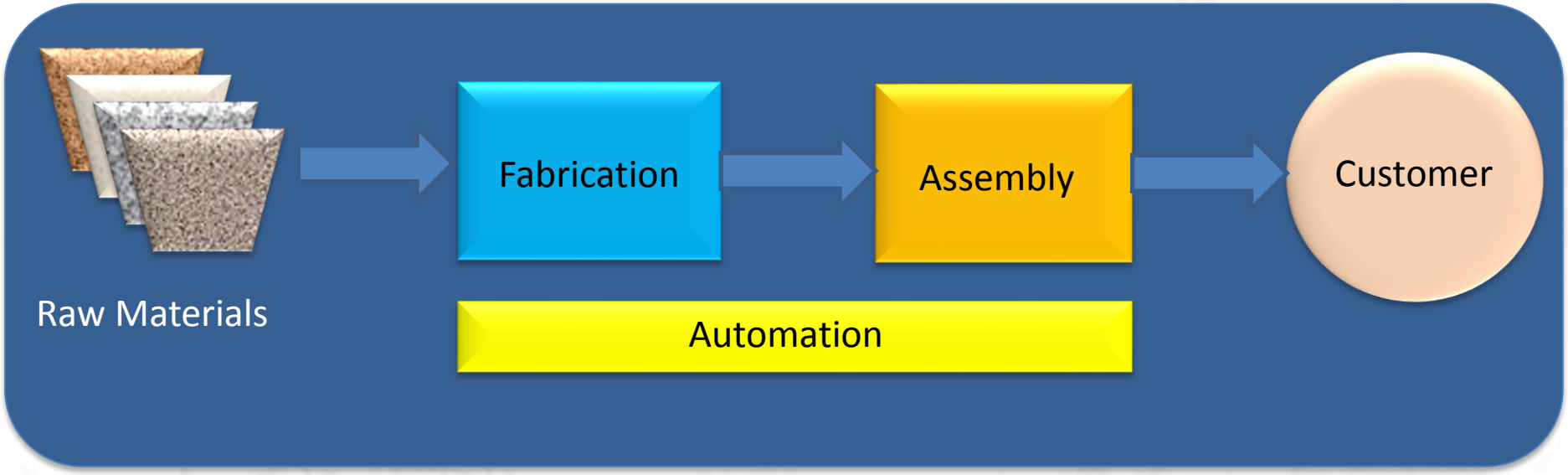
- participation in expert consultations / interviews
- participation in workshops
- involvement in internal deliverable development and review process



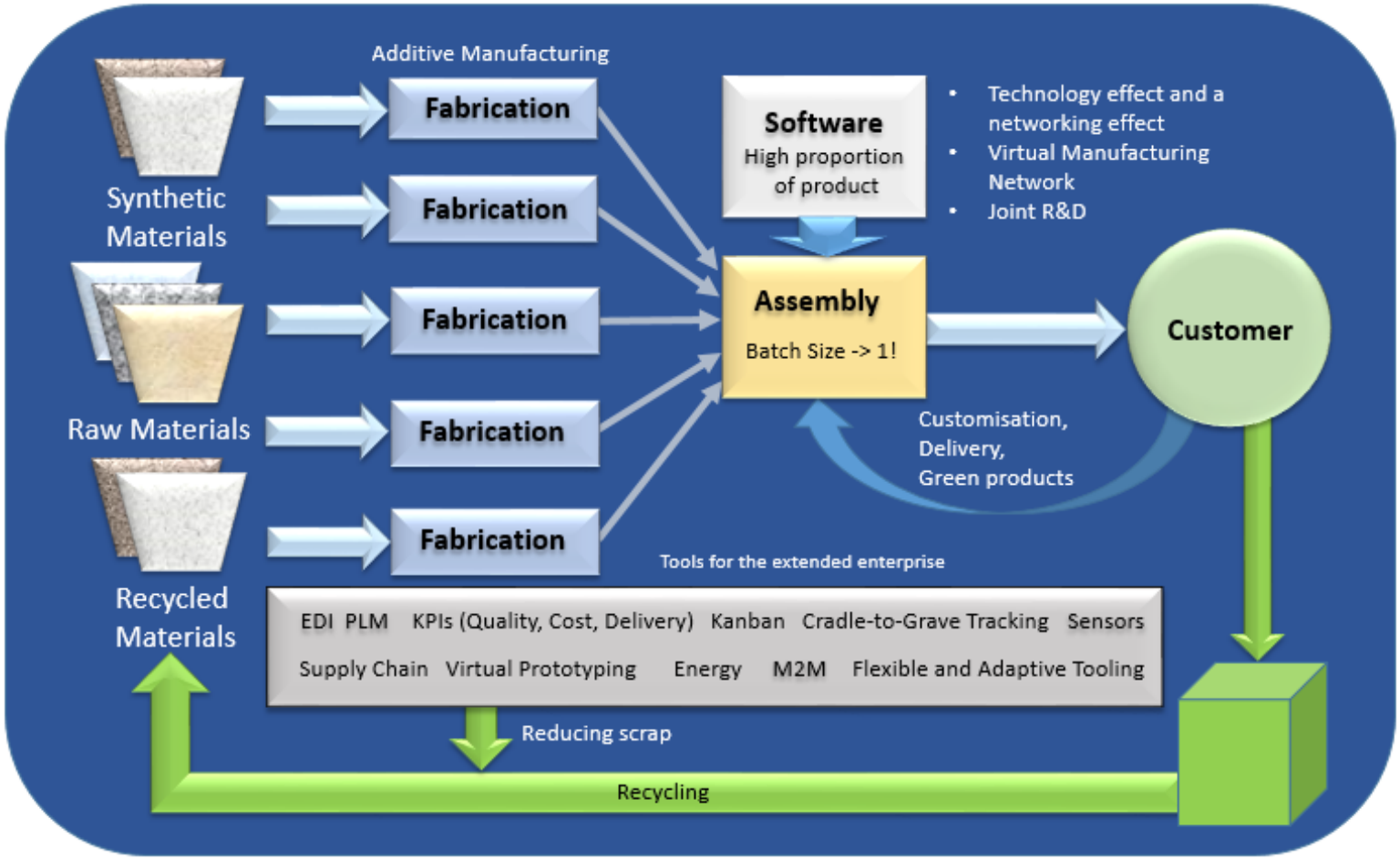
Approach of Road4FAME



How it used to be …..



Today


Additive Manufacturing
Synthetic Materials
Raw Materials
Recycled Materials
Fabrication
Fabrication
Fabrication
Fabrication
Fabrication
Software
High proportion of product
Assembly
Batch Size -> 1!
Customer
Technology effect and a networking effect
Virtual Manufacturing Network
Joint R&D
Customisation, Delivery, Green products
Tools for the extended enterprise
EDI PLM KPIs (Quality, Cost, Delivery) Kanban Cradle-to-Grave Tracking Sensors
Supply Chain Virtual Prototyping Energy M2M Flexible and Adaptive Tooling
Reducing scrap
Recycling

Recommendations for Research Priorities

Orientation Paper

Road 4 FAME

Research Recommendations

- **Scalable Cyber-Physical System architectures** for adaptive and smart manufacturing
- **Real-time** data acquisition and analysis
- **Network-centric communication and collaboration** between players, humans and systems across the entire value chain
- **ICT platform** for advanced supply chain decision support
- Modelling of **virtual enterprises**
- **Cross-cutting** challenges
  - Interoperability / Standards
  - Semantic mechanisms
  - Socio-technical issues
  - Training and education
  - Cyber security

Recommendations

Road 4 FAME

Integration

- **Integration approaches for existing ICT systems and information** (tackling the “wild garden”)
- **Integration of new smart components** (e.g. new improved low cost, miniaturised sensors) **for data collection, analysis and visualisation**
- Development/promotion of **standardization and reference ICT architectures** as well as **interoperability** and harmonization of different interfaces

Data and Information

- **Unified engineering exchange of data** considering provenance, accuracy, contextual awareness and semantic content of unstructured data
- **Big Data capture** (live streaming for situational awareness), storage (event driven databases) and analysis (data mining – ideally in real time)
- **Distributed processing algorithms** for data and systems in real time supported by resilient “industrial strength” **cloud computing** for the plant floor
- **Visualisation techniques** and specifically context-aware responsive visualisation of data
- **Decision support systems** to reduce operator load

Machine Learning and Adaptive Systems to Enable Flexible and Adaptive Manufacturing

- Environments and infrastructures for **machine learning, self-adapting and reconfigurable** manufacturing
- **Intra-and inter- machine communication standards**
- **Human-centric adaptive interfaces** to enhance usability

Multidisciplinary Modelling

- **Modelling** of factories, information modelling and work domain modelling of socio-technological systems

Security and Privacy

- **Robust Machine-to-Machine** (M2M) security protocols that guarantee operational safety and reliability
- Affordable **security for privacy,** especially within manufacturing supply networks

Demonstrators & Education

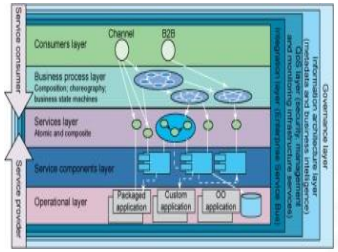
- To **convince the conservative manufacturing sector** of the cost/benefits of new ICT architectures and services
- **Education initiatives** and training materials to increase awareness

Recommendations

Road 4 FAME

Reference Architectures / Open Architectures

Many projects have generated reference architectures. These could be transformed into open architectures, which can be either implemented or further developed or adapted by other projects to improve them further.

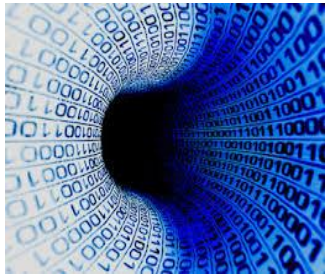


System and Information Integration Architectures

System and Information Integration Architectures are becoming increasingly important due to the growing heterogeneity, amount of information and system components available and they need to be developed to cope with this challenge.

Data Capture, Storage and Analysis

Technology to capture, store and analyze data is advancing from a technical standpoint, but specifically from a methodical and legal side further developments are needed to enable efficient sensible data and information handling, enabling business models and innovation, while protecting individuals and companies.

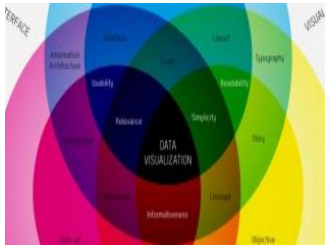


Recommendations

Road 4 FAME

Data and Information Visualization

Visualization techniques and specifically context-aware responsive visualization of data which is a major pre-condition for efficient decision support systems. Human-centric adaptive interfaces and context-centric display of only crucial information to enhance usability.

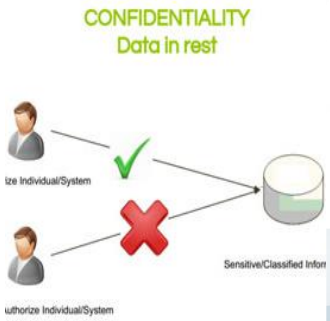


Security

Research in security strategy, protocols and tools for companies and standards to protect the networked and distributed manufacturing systems would be necessary to ensure balance between security cost and benefits to an organization.

Confidentiality

Confidentiality and know-how protection throughout the network of increasingly larger interconnected networks is essential. Therefore technological evolution of authorization, authentication and encryption mechanisms, as well as the establishment of trust among network participants, to cope with this scenario is recommended.



Recommendations

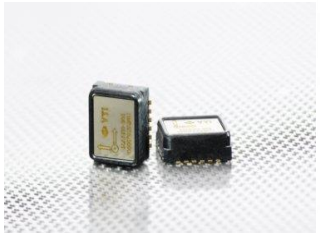
Road 4 FAME

Flexible and Adaptable Manufacturing

Self-adapting, resilient and reconfigurable manufacturing environments need to be facilitated by standardization of intra- and inter-machine communication. Wireless technologies, context awareness, human-interaction and self-learning (e.g. for production configuration) mechanisms, etc. can significantly contribute to efficiency improvements of the (re-) configuration, ramp-up, and optimization

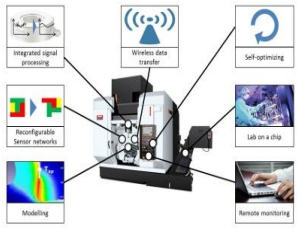
New or Improved low-cost, miniaturized smart sensors

Sensors need to become cheaper, smarter, smaller and more energy efficient, to enable new applications that until now were not possible or viable enough due to technological and economic restraints.



CPPS - Cyber-Physical Production Systems

CP(P)S concepts need to be further evaluated and implemented. Certain standards such as self-description, integration/interface, intercommunication and orchestration need to be developed for on platform and system level.

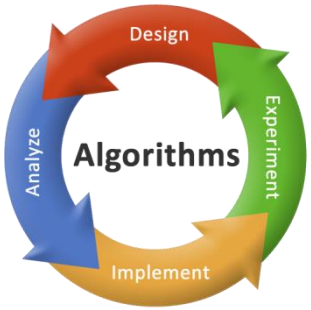


Recommendations

Road 4 FAME

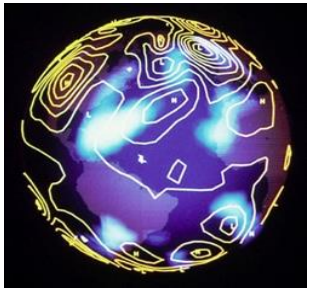
New Algorithms

The development of easy to use algorithms for analysis, and real time prediction needs to both address various manufacturing enterprises and also be time and resource efficient and cost effective, especially for SMEs. It also has to incorporate knowledge from other domains, where necessary. Furthermore, the algorithms should be able to be executed in a distributed manner to ensure their applicability in manufacturing environments.



Modelling

The development of smarter and better information and domain models can provide not only design details but also greater predictive capacity in order to reduce physical prototyping needs or construction of pilot plants. Simulations, virtual reality, tacit knowledge modelling and User eXperience (UX) of mathematical modelling potentially supports problem solving, decision support and rapid prototyping.



Recommendations for Innovation Strategies

Innovation Strategies

Road 4 FAME

Innovation Catalyst	Useful For
Competence Centres	To promote interaction between researchers, industry, and the public sector, in research topics that promote economic growth
Regional initiatives	To improve competitiveness of SMEs both locally and internationally, help with qualification, upgrading and diversification, test solutions, and carry out early implementations
Innovation Clusters	To bring together industry and researchers to address specific topics or markets with the aim of creating critical mass in technological areas
National initiatives	National initiatives can be used to engage with larger companies accelerating research and technology in areas that are considered to be nationally important, develop a technological lead and provide a strategic vision of the future
Flagship Projects	Flagship research and development projects can be used to support strategically and scientifically defined objectives and engage with many project partners across Europe
Platform Building	Platforms can be used to create ecosystems or support specific sectors. They need to be interoperable, modular, and scalable with open and standardised interfaces. Critically for uptake they need to be affordable both from applications development and operation perspectives, with clear and easy understandable business cases
Demonstrators and Large Scale Pilots	Demonstrators and Large Scale Pilots are seen as essential to show potential adopters, both SMEs and large companies, that new technologies and solutions can be exploited in the real world.
Entrepreneurship	Education via an entrepreneurship programme eliminates the fear of failure and provides guidance and support for patenting, commercialization of R&D results and business start-up.
Education and Skills	To promote holistic digital skills and training support at all levels, disseminating best practice and experience to re-skill and up-skill the workforce.

Business Models and Business Opportunities

Business Model Categorisations (100 models in 10 categories)

Road 4 FAME

Conventional
Manufacturer Model - Selling Direct
Merchant Model
Advertising Model
Information Model
Brokerage Model
Premium branding or limited availability
Licensing, franchising
Open innovation (platforms)
Hire & leasing
Razor and Blades Model
Cutting out the Middlemen
Bricks and Clicks
Subscription Business Model
Value Added Reseller
Fee in, free out – charge first client only
All in one business model
Loyalty business model
Monopolistic business model
Premium business model
Professional Open Source Business Model
Machine supplier

Customisation
Made to order
Personalisation, Identity, Provenance
Mass customization
Design and Innovation Service
Fabless manufacturing
Frugal innovation

Efficient Manufacturing
Lean manufacturing
De-materialisation (of products or packaging)
Use excess capacity
Industrial symbiosis

Economic
Build-operate-transfer (BOT)
"Patient or slow capital" collaborations

Green/Sustainable
Repair, the Circular Economy, and Collaborative Consumption
Sustainability and value
Low carbon manufacturing or solutions
Cradle-to-cradle
Reuse, recycle, re-manufacture
Take back management
Move from non-renewable to renewable sources
Green chemistry
Solar and wind-power based energy innovations
Chemical Management Services (CMS)
Dematerialised services
Collaborative consumption
Incentivised return & re-use
Collection of used products
Blue economy
Choice editing by retailers

Networking
The 'Density Principle'
Acting as a network entity
Interaction and indirect capabilities
Trans-sector collaboration
Network Architecture Business Model
Sharing assets (shared ownership and collaborative consumption)
Crowd sourcing or funding
Collaborative approaches (sourcing, production, lobbying)
Collective Business Model
Online Auction Business Model
Network Effects Business Model
Organisational form

Technology Based
Additive manufacturing
Information Technology (IT) - Infinite Bandwidth/Zero Latency
General-purpose technologies
Increased functionality
Biomimicry

Socially Aware
Ethical trade (fair trade)
Resource stewardship
Biodiversity protection
Responsible product distribution or promotion
Slow fashion
Slow Manufacturing
Product longevity
Long life
Radical transparency about eco or societal impacts
Consumer care - promote consumer health and well-being
Not for profit
Social and biodiversity regeneration initiatives ('net positive')
Hybrid businesses, social enterprise (for profit)
Alternative ownership: cooperative, mutual, (farmers) collectives
Home based, flexible working
Extended producer responsibility
Frugal business (products for low income markets)
Localisation
Bring your own device

Knowledge
Continuous innovation
Creating value through information
Incubators and entrepreneur support models
Consumer education (models); communication and awareness
Solution provider

Aftermarket/Product Service
Asset management
Product Service System
Product-oriented PSS - maintenance, extended warrantee
Use oriented PSS - rental, lease, shared
Result oriented - pay per use
Online Services Model
Demand management (including cap & trade)
Maintenance partner
Performance partner
Value partner

Business Opportunities

Road 4 FAME

Business Opportunities	Service	Status of Uptake
Knowledge	R&D	Current
	Technology Consulting	Current
	Innovation	Current
	Retired Engineer Service	New
Design	Product Customisation	New
Integration	ICT Tailoring	Current Increasing
	ICT Integration	Current Increasing
ICT Maintenance	ICT Support	Current
Supply Chain	Management & Optimisation	New
	Sourcing Raw Materials	New
	Traceability/Tracking of components	New
	CO2 Calculation	New
	Data broker between stakeholders	New
Simulation	Factory	Current Increasing
	Product	Current Increasing
Financial	Accounting	Current
	Product Costing	Current
Customer Focus	CRM	Current
External Computing	Data Centre	New Increasing
	Cloud Computing	New Increasing
Monitoring	Wireless Sensors	New Increasing
	Big Data Management	New Increasing
	Data Mining	New Increasing
	Visualisation	Current Increasing
	Decision Support	Current Increasing
	Energy Management/Brokering	New Increasing
Product Services	Servitization Support	New
	Aftermarket Support	New
	Available Hours Contracts	New Increasing
	"Photocopier" Contracts	New Increasing
	Monitoring Own Equipment -maintenance	New
	Providing process optimisation (based on own machine monitoring)	New
Sales	Marketing	Current
	Demand Prediction	Current
	Customer Polling	Current
	Renting Showcase Products	New
Spare Capacity	Renting Machinery	New
Security	Providing guaranteed security	New

Transversal View Converging Themes

Conclusion for Converging Themes

Road 4 FAME

- Seamless **integration** of systems and components
- Acquisition and use of **big data in real time** & handling of complexity
- Visualisation, virtualisation, situational awareness, **decision support**
- **Interoperability**, standardisation, **reference architectures** and tools
- **Platforms** (organisational, technological, operational, customer,..)

- Security, privacy, trust
- Regulatory issues, IP
- Demonstrations, living labs
- Business models

- De-fragmentation, cross-fertilisation
- Raise awareness & education
- Commitment of large industries
- Enhance involvement of SMEs

Thank you