NORWAY – NATIONAL REPORT

FAME O1/A1 - National/Transnational Phase

Fostering the Adoption of ICT-enabled AMTs by European SMEs

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Lead organization
[CCSDE]

Revision History

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[1.0]	15/01/219	CCSDE	Creation	C	16

(*) Action: C = Creation, I = Insert, U = Update, R = Replace, D = Delete

Referenced Documents

ID	Reference		Title
1	2018-1-FR01-KA202-04780		FAME Proposal
2			

Applicable Documents

ID	Reference	Title

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0. Introduction

a. Scope of the project

While Advanced Manufacturing Technologies (AMT) are widely recognized as key to industrial competitiveness, growth and job creation in Europe, various barriers and low-readiness factors in EU lead to low levels of adoption in companies, especially those of the SME Sector.

FAME, by fostering the adoption of ICT-enabled Advanced Manufacturing Technologies by European SMEs, will assist them to exploit the benefits of AMT including: product cost reduction, products and services quality improvement, employees' productivity improvement and the reduction of production lead time.

b. Target group

In general, all SMEs and micro-SMEs lack the knowledge and resources (human & financial) to break through the AMT barriers. There are though some sectors in which EU SMEs can benefit the most, and also sectors in which SMEs need to be supported the most, in order to ensure their financial viability, as a Directorate-General study shows.

Following these results FAME will focus on the below sectors:

- Food and Beverages
- Wood industry
- Metal industry - NACE 24 25
- Electronic and Electrical Equipment

c. Project Objectives

FAME aims to:

- Design a training program and supporting tools for addressing the barriers (especially the skilled human resources barrier and access to technology services) in ICT-enabled intelligent manufacturing (environmental, organisational, technological barriers)

- Emphasize the main drivers for investing in AMTs

- Personalise the training based on company type (barriers and drivers addressed at company type)

d. The State-of-Play in Norway

Overview

Norway is historically a strong manufacturing nation, rich in natural resources and innovative in its approach. The export-oriented manufacturing sector accounts for approximately 14% of the country's GDP and the main subsectors include food and beverage, machinery for offshore installations and ocean vessels, process industry including petroleum products, pharmaceuticals, pulp & paper, chemicals, metallurgy and aluminum processing. The sector is highly digitally developed, but in the older paradigm, has strong clusters and networks, and a skilled workforce.

The manufacturing sector is so under transformation in Norway and there is demand for technology advancements around process digitalization, disruptive technologies and use of IoT applications that will gradually replace the more traditional manufacturing methods and, to some extent, modify the sectors, as well. Norway is taking advantage of this development and combining new materials and automated processes, new value chains and new business models with the traditionally strong industrial skills base to create new industrial opportunities.

Key Subsectors

Subsectors with strong technology-related interest include digitalization solutions for the whole manufacturing value chain, Big Data analytics tools, advanced robotics that enable remote management, additive manufacturing models and materials, and offshore mechatronics and automation.

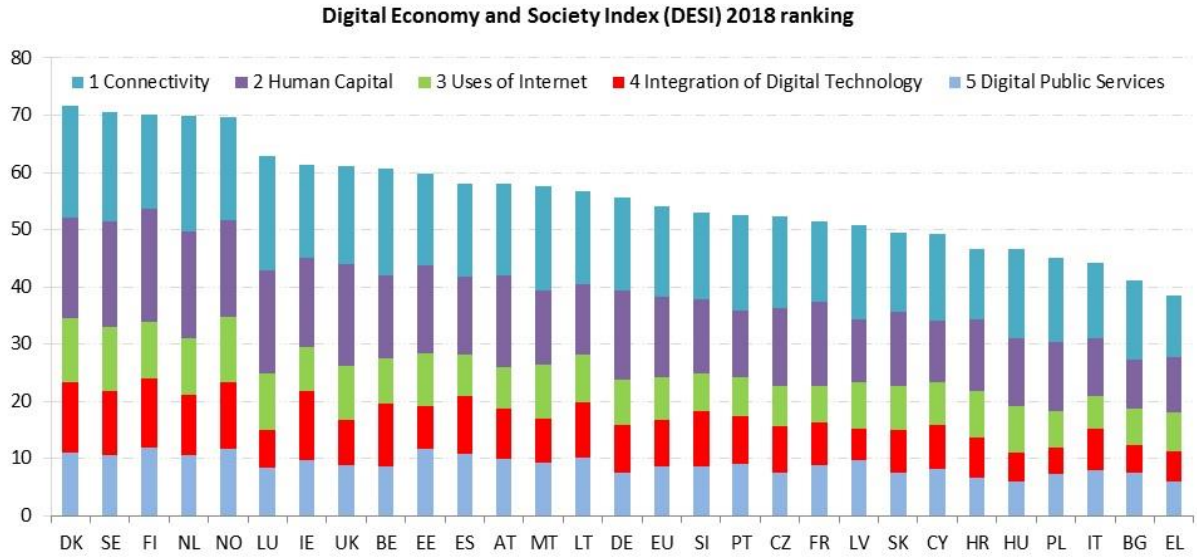
Government Initiatives and Funding Sources

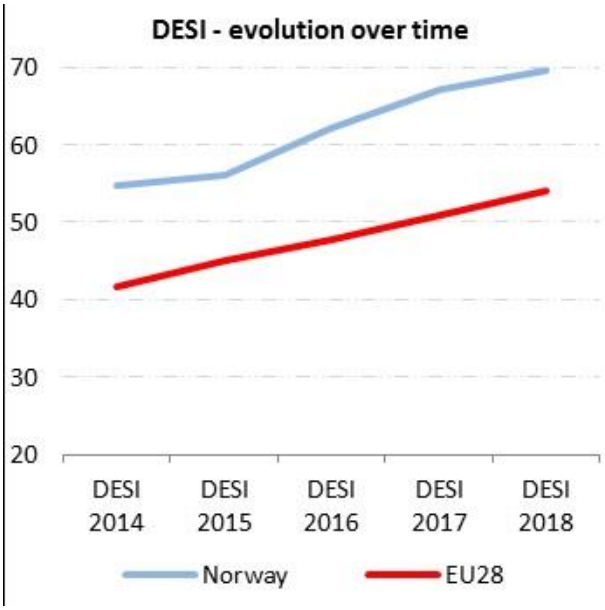
In 2017, the Government of Norway launched a White Paper on greener, smarter and more innovative Industry, aiming to make Norway a world leader in industry and technology. The government's vision is for the industry to achieve highest possible value creation, while remaining sustainable and lean. Initiatives stemming from the White Paper include Digital21 and Norwegian Catapult program.

Digital 21 will provide industry and government guidance, cooperation opportunities to facilitate the creation of new business models and methods of production. The Digital21 steering committee, consisting of public and private sector participants, submitted, on September 2018, 64 proposals to the government on how the business sector can be digitized. Digital21 believes that areas of priority should be artificial intelligence (AI), big data (Big Data), the Internet of Things (IoT) and autonomous systems, so strong research centers should be established for business-oriented digitization in these areas. Norwegian Catapult test centers provide companies opportunities and funding to test, verify and simulate new technologies to speed up innovation and technological disruption. The program is managed by the Industrial Development Corporation of Norway – SIVA.

The Digital Economy and SMEs in Norway

At a high level and based on the Digital Economy and Society Index (DESI), 2018 Norway was and remains at the top group of countries together with the rest of the countries in the Nordic region.





In order to understand though the State-of-Play in Norway, especially regarding Industry 4.0-related technology adoption focused on SMEs of the desired groups, we need to have a closer look at the Norwegian Economy.

In 2015 there were roughly 450.000 enterprises in Norway where almost 310.000 of them were non-employer firms. Enterprises with 1-249 employees were accounting for the 99.5% of firms with employees and those with no more than 49 employees represent the 97% of the entities with employees.

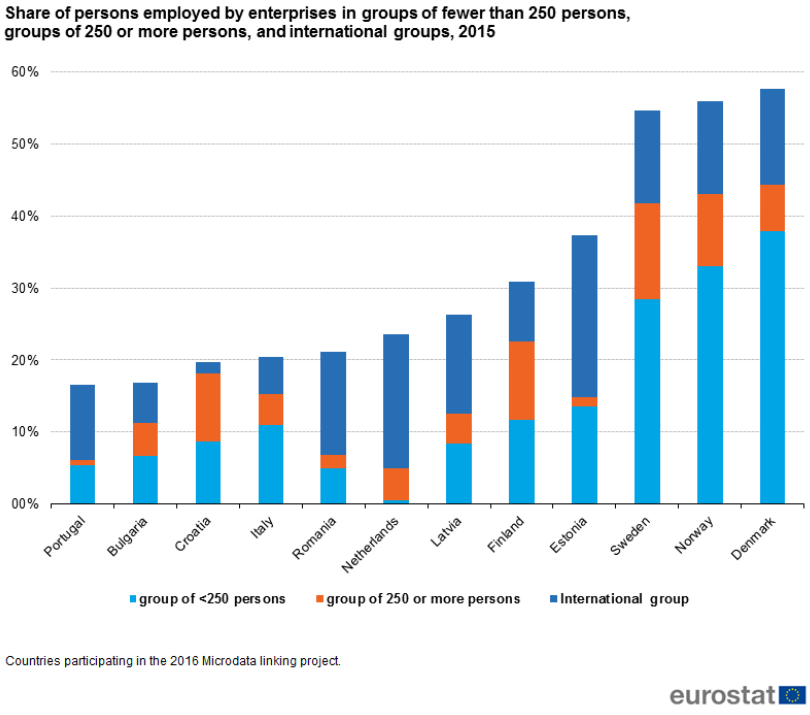
Table 29.2. Distribution of firms in Norway, 2015

By firm size

Firm size (employees)	Number	%
Total firms	453 762	100
Firms with 0 employees	308 558	68
SMEs (1-249)	144 507	31.8
01-09	117 365	25.9
10-49	23 647	5.2
50-99	2 227	0.5
100-249	1 268	0.3
Large (250+)	697	0.2

Source: Statistics Norway.

To make things a little more blurred, around 11.000 entities of the above SMEs are members of a group ('dependent') with more than 250 persons or belong to an international group and may not be considered as SMEs.



After the definition of SMEs we have also to estimate their contribution in the Norwegian economy and if possible of those sectors in our target group.

We selected as a major indicator the country's exports. Norway shipped US$123 billion worth of goods around the globe in 2018, and that represents 35.5% of total Norwegian economic output or Gross Domestic Product. http://www.worldstopexports.com/norways-top-10-exports/. Given Norway's population of 5.4 million people, its total $123 billion in 2018 exports translates to roughly $22,900 for every resident in the Nordic country.

The following top 10 product groups are accounted for 86.1% of the overall value of Norway's global shipments.

1. Mineral fuels including oil: US$76.5 billion (62.2% of total exports)
2. Fish: $11.7 billion (9.5%)
3. Machinery including computers: $4.6 billion (3.7%)
4. Aluminum: $4.2 billion (3.4%)
5. Electrical machinery, equipment: $2.7 billion (2.2%)
6. Optical, technical, medical apparatus: $1.4 billion (1.1%)
7. Iron, steel: $1.3 billion (1.1%)
8. Nickel: $1.2 billion (1%)
9. Organic chemicals: $1.2 billion (1%)
10. Ships, boats: $1.2 billion (1%)

A more granular research for the 200 most in-demand goods shipped from Norway during 2018 that represent by value the 94% of exports, will show that they mostly come from non-SME companies.

The oil sector is accompanied by a very strong service and supply sector so we have also to take into account that many, if not the majority, of SMEs are suppliers to the oil and gas, fishery and maritime industries (with the latest sharing also a strong bond with the oil and fisheries).

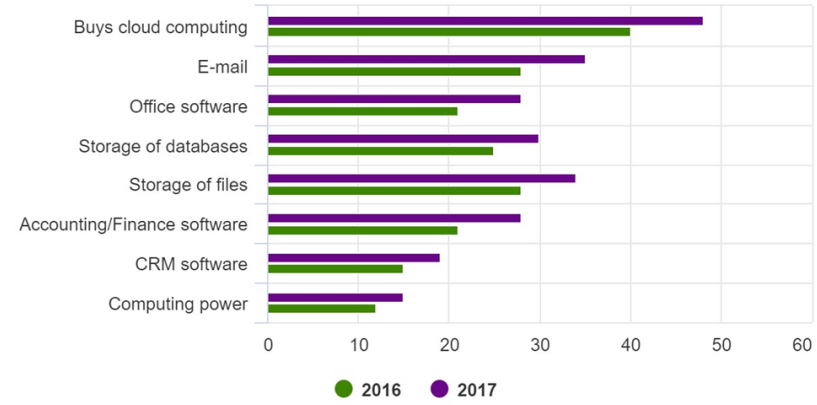
The above results show a rather low diversification in the Norwegian economy (or at least a specialization) and are followed by some, maybe unexpected, findings:

- Certain IoT-related technologies fall below EU average. E.g. RFID use is at 3,2% vs 4,2% of EU average (and 9,2% of Bulgaria!).
- Certain Management-related technologies show a decline. (4a1 includes ERP)

	Norway					EU
	DESI 2018			DESI 2017		DESI 2018
	value		rank	value	rank	value
4a1 Electronic Information Sharing	**30%**	↓	**NA**	**32%**	**NA**	**34%**
% enterprises	2017			2015		2017
4a2 RFID	**3.2%**	↑	**NA**	**2.6%**	**NA**	**4.2%**
% enterprises	2017			2014		2017

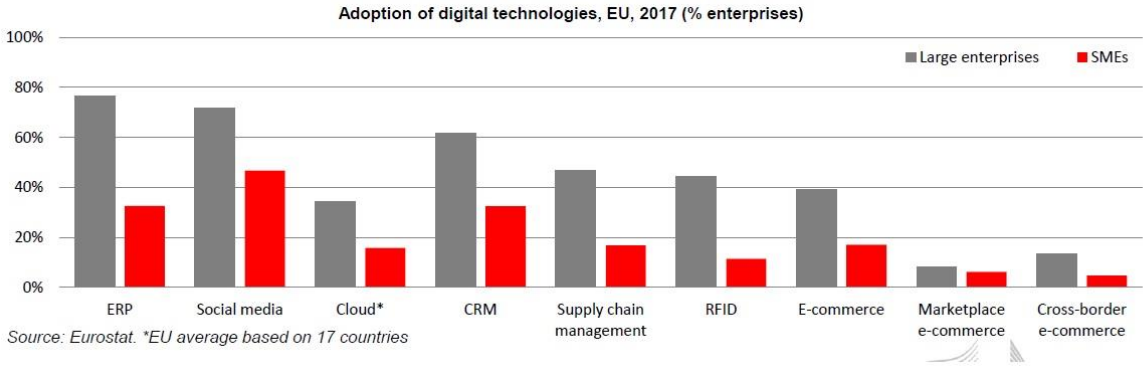
Still cloud use is strong and increases significantly year-over-year. It was 48% on 2017 up from 40% in 2016 and 29% 2014.

Figure 1. Share of enterprises with 10 or more employees buying cloud computing services.



Source: Statistisk sentralbyrå.

The above 'mixed-bag' indications may show that, while larger companies are at a better state of readiness, adaptation and adoption of technology in order to stay competitive in the international marketplace, ICT-enabled AMT may not be so prevalent in Norway's SMEs, especially of the targeted sub-sectors, following the EU pattern:

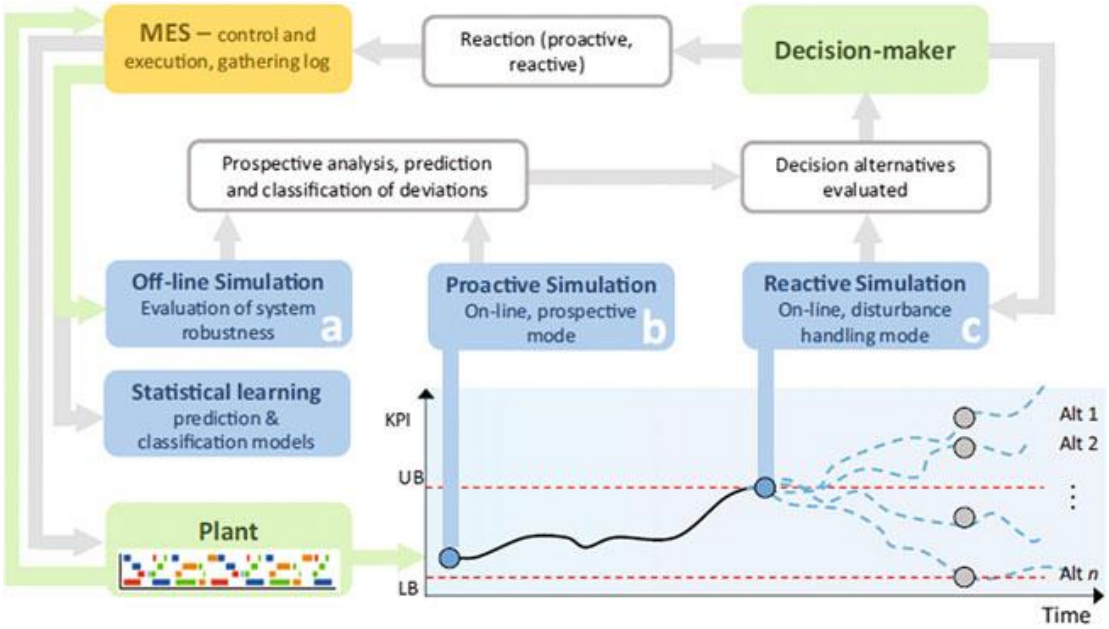


*Source: Eurostat. *EU average based on 17 countries*

e. Initiatives for the adoption of Industry 4.0 in Norway

As we enter the Industry 4.0 area, which is actually in its infancy, we have to note the very important role clusters, independent R&D organizations and initiatives (either state-, industry-, or science-origined) play in the Norwegian Economy. In years of rapid evolution like these, even the stronger enterprises struggle to synchronize with the accelerating pace things seem to change and come-up, how much more the weaker ones like the SMEs.

This was also highlighted by the results of a survey [1] that included managers in the sectors of mass , customised and small series production of electrical components, machine and metal parts. More than 34% of the responders were declaring that had neither planned any Industry 4.0 project nor created a new business models for their company. Many of them were confident for their operational skills but although they could see the innovation potential, they were not able to implement this into a product. Main hurdle to that is the lack of product design and production planning skills. One more issue in the country is that the Lean manufacturing standard followed intensively there, has quite different characteristics than the Industry 4.0 and Cyber Physical System. The research concludes that in Norway also implementation of Industry 4.0 has certain barriers particular in small companies. Most of these barriers lies in the educational and managerial area, where the managers often focus on the operational day-to-day activities. More extensive researches reach to comperable results [3].



A CPS model, based on prediction and simulation of lead-time

One of the R&D organizations in Norway to assist Industry 4.0 adoption is SINTEF, one of Europe's largest independent research institutes. Manufacturing Technology Norwegian Catapult Centre (MTNC) is a so-called catapult or testing centre where industrial companies can test new technology and new solutions. The centre is lead by SINTEF Manufacturing. This type of centres will help companies with developing ideas from the concept stage to market launch in a faster, more cost effective and more skilled way. They will provide facilities, equipment and expertise that companies can use for testing, simulating or visualizing technologies, products or services. MTNC will develop and demonstrate innovative production processes and enabling technologies in mini-factories, in cooperation with industry and research- and educational institutions. The centre has the ambition to

be a driving force in stimulating the Norwegian industry to become greener, smarter, more innovative and more productive. The Norwegian Catapult MTNC will be a world-class technology centre, consisting of several mini-factories, with industry 4.0 standard, for developing and testing new production technologies and new ways of working. The centre will be a new and important learning arena for both large and small businesses across different industries in Norway.

The first mini-factory will focus on Additive Manufacturing, which is popularly called 3D printing, which is a process where objects are build layer on layer from a 3D model. In total, MTNC will consist of four to six advanced, modular and flexible mini-factories.

The other major initiative is the SFI (Centre for Research-based Innovation) scheme under the Research Council of Norway (RCN). The main objective for the SFIs is to enhance the capability of the business sector to innovate by focusing on long-term research based on forging close alliances between research-intensive enterprises and prominent research groups. Following the scheme SFI Manufacturing is a cross-disciplinary centre for research based innovation for competitive high value manufacturing in Norway that does research in the areas of: Multi-Material Products and Processes, Robust and Flexible Automation and Innovative and Sustainable Organizations. Here is the list and a short description of the Industrial partners.

Beyond these institutions and initiatives there are also private consulting companies that provide such 'holistic' services to customers who wish to take part in the new industrial era. On top of experience and expertise lacking from SMEs (and even larger companies) consulting companies like BearingPoint Norway can also provide a Smart Factory and Internet of Things Lab that smart sensors with machine-to-machine communication and the integration of PLM, CRM and ERP provide Industry 4.0-based prototyping for new products and procedures and extensive knowhow with the smaller possilbe overhead.

Although the huge resources of the Nowergian economy (due to oil production mainly) and the relevant freedom from the EU framework (whenever this is possible or usefull) cannot be automatically replicated to the other countries, the paradigm of clusters, R&D that is strongly attached to production and reality and outsourcing remains by all means valid.

Most of the aforementioned Industrial partners are important and rather large companies that implement for years various ICT-enabled Advanced Manufacturing Technologies but more in the essence of an 'Industry 3.0+' model, if we were allowed to call it like that, meaning that although they are heavily automated and digitized the cannot fall in the category of solutions where e.g. a single customer order or product reconfiguration through a cloud-based CRM will inform the ERP and PLM systems that will lead in an automated change in production sequence by the production systems alone without any human intervention.

In the following table we see summarized what characteristics can be categorized as Industry 3.0 or 4.0 [2]. The solutions described later are either 'towards Industry 4.0' or components of an Industry 4.0-era solution.

Type	Today's factory	Factory with CPS
Production System	Semi-automated, Manual control, Productivity, Quality, and Lean: waste reduction etc.	Networked manufacturing systems, Remote control, Flexible production line, Automation, In built quality systems and Collaborative production
Working Style	Individual machine operations, Not possible to track product life cycle, Manual maintenance, and Condition based monitoring	Cooperative machines, information transfer and troubleshooting through network, Smart products and possible to track the product life cycle, Self-detection – Self regulation – Self Control systems, and predictive health monitoring
Components	Use of sensors is to have the precision and fault detection, Controllers are to increase production and performance of the machine	Use of smart sensors to self-aware, self-regulate and self-control systems, Smart controllers for predictive health monitoring systems (early warnings and regulations)
Flexibility	All the designs are controlled by design department and once the production is started it's not recommended to change the design, Product services manual are time consuming	Customer can optimize the design whenever wanted and can alter the next production steps through network, Product services are networked and instantaneous
Production Cost	Suitable for mass production, production of small quantity of items is expensive	Cost and material for each product is same
Real-Time	Products are produced by enterprises	Customer can locally print the product using 3D printing with the support of manufacturer on internet
Data	Data from machines are stored in log books and not available for customers	Data is stored in cloud using big data and is available for customers and interested parties for future analysis, preventive maintenance and services

1. VR/Simulations

a. VR/Simulations in design and reconfiguration of products and technologies

The main subsectors of the economy like the machinery for off shore installations (e.g. Citec), are very keen in adopting first-line technology to facilitate their design, testing, instalation, use, maintenace, for their products (e.g. an underwater pump). The same stands for major exporting enterprises like Benteler Automotive Norway, GKN Aerospece Norway that produces jet engine components for the world's largest aircraft engine manufacturers and others. The subsector of companies supporting aquaculture with equipment and machinery, the wood industry when designing objects and structures (like the 18-stories Mjøstårnet!) , electronic and electrical equipment manufacturers, they all have been the early adopters (if not testers) of advanced VR/Simulation technologies.

For the users that cannot justify the financial and the technical specialty overhead of in-house design facilities, either these are local SMEs or large international customers, and ecosystem of design houses exists in Norway that include older/bigger companies that adopt the new technology and newer players who enter directly in the VR/AR 3D Simulation area like: Haptiq, Pivot, Design Container, Impact Reality, Konfigai, VR Oslo Business Cluster, KRAFT Engineering and EkerDesign with the most extended set of services. EON Reality, a major world player in AR/VR is the technology provider at the Norwegian Interactive Digital Center that provides access to state-of-the-art Virtual Reality showroom, development lab, and a VR Innovation Academy.

2. Management

a. Supply chain management with suppliers/customers, mnetwork-centric production

Customer-facing enterprises of the fresh-food sector, like TINE, Norway's largest producer, distributor and exporter of dairy products, were the first to realize the challenges related to supply chain management. TINE challenges included: difficulties in balancing supply and demand throughout supply chain network, while employing a total cost perspective, difficulties in accounting for constraints: production capacity, storage capacity, aging requirements for products like cheese, and shelf life and limited support for planning across all affected stakeholders in the organization. To address the challenges of long term planning they Supply Chain Guru from LLamasoft, complemented with a BI solution from Tableau Software. For the daily business TINE uses Quintiq's (a Dassault Systèmes company) route optimization technology will enhance its existing tactical planning solution and expand its scope to include day-of-operations planning by incorporating and managing

disruptions through real-time feedback and increased supply chain visibility for providing fresh, quality products to customers. Other international players in the supply chain solutions market like Blue Ridge provide solutions in the retail market (SPAR KJØP and Gausdal Landhandleri AS).

b. Optimization, lifecycle and data Management systems

Product Life Cycle Management solutions are implemented by producers in some sectors (e.g. in the textile market -Varner implemented US-based solution Centric Product Lifecycle Management). From the solution supplier side companies like Jotne IT provide PLM solutions through the use of intelligent data management, but outside the scope of FAME (in the areas of Defense, Aeronautics, Oil & Gas, Built Environment and Aerospace).

c. Entreprise Resource Planning

In the ERP area and beyond World players like SAP, Microsoft and Infor that do have market share in y and in sectors covered under FAME (e.g. Infor in Glamox lighting solutions) a dominant player in business S/W in all the Nordic area and parts of N. Europe is Visma (an 8.000 employees company with its origins in Norway that claims 800.000 installations through the years in all the above areas).

Many also producers, mostly SMEs and from the Metal sector (the site lists 24 companies), have selected the local ZIGMA360 cloud-based total business system that covers functionalities such as: ERP – Enterprise Resource Planning, EPM – Enterprise Project Management, CRM – Customer Relation Managemen, PLM – Product Lifecycle Management, EAM – Enterprise Asset Management, EQMS – Enterprise Quality Management System, MPS - Material and Production Management, HRM – Human Resource Management, SCM – Supply Chain Management, BPM — Business Process Management

3. ICT-tools

a. Cyber-physical systems and networking, sensing and intelligent components

Examples of companies offering already solutions in this field are: Kezzler that deploys its serialisation technology to help clients meet challenges from counterfeit goods and unauthorised distribution, to changing regulatory requirements, traceability concerns and building consumer trust. Realtime Aquaculture that enables precision, data-driven aquaculture with underwater wireless sensors that deliver real-time data to the cloud, and why not, Shiip your sheep, the newest and easiest way of keeping track of your animals! Powered by Narrowband IoT mobile technology, Shiip gives customers lower prices, more possibilities, longer battery life and better coverage.

b. Mass customization (3-dimensional printing, direct digital manufacturing)

Innovative companies do exist, either as start-ups or as spin-offs/daughter companies of establised enterprises. As an example Fieldmade, that designs mobile container-based Additive-Manufaturing facilities that produce in-field spare parts in near real time, belongs to the group of design company Eker Design.

Norsk Titanium, with its patented RAPID PLASMA DEPOSITION technology, produces already A-M components that are certified for the aviation industry.

c. Intergrated Solutions

Following is an example that combines design virtualization and simulation, ERP integration, intelligent sensors, a Norwegian electronics producer and a Norwegian solution provider. In this case ClampOn which designs and produces world-leading ultrasonic intelligent sensors for the oil and gas industry, has turned to PLM Group and its Solidworks solution (https://plmgroup.eu/success-story/clampon-as/).

More towards the Industry 4.0 era are the solutions used in the very important aquaculture sector that we can include ourthe targeted food sector. There, either through Merger & Acquititions (InnovaSea Systems Nortek Akvakultur) or through solution integration (https://bit.ly/2Unrbp4 & https://www.lillebakk.com/en/home) smart wireless sensors, connectivity solutions and automatic data exchange between machinery (e.g feeding systems) and the monitoring and process management software and the cloud bring new levels of productivity, safety and product quality.

d. The Norwegian green and sustainable solutions

A very interesting group of solutions is exhibited at The Explorer, being the same time ethical, modern and from rather small companies in sectors included in our targe group.

Solution include:

Autonomous robots for farming

Irrigation sensors

Digital farming tools

Automated forest monitoring

References:

[1] : Industry 4.0 and Cyber Physical Systems in a Norwegian Industrial Context *(Ragnhild J. Eleftheriadis and Odd Myklebust -Feb. 2018)*

[2]: CARVING FUTURE MANUFACTURING IN NORWAY *(Sri Sudha Vijay Keshav Kolla NTNU -May 2016)*

[3]: Digitalisation and automation in the Nordic manufacturing sector *(Nordic Council of Ministers -2015)*