R2B
RESEARCH TO BUSINESS

Trend in Machining for Aerospace

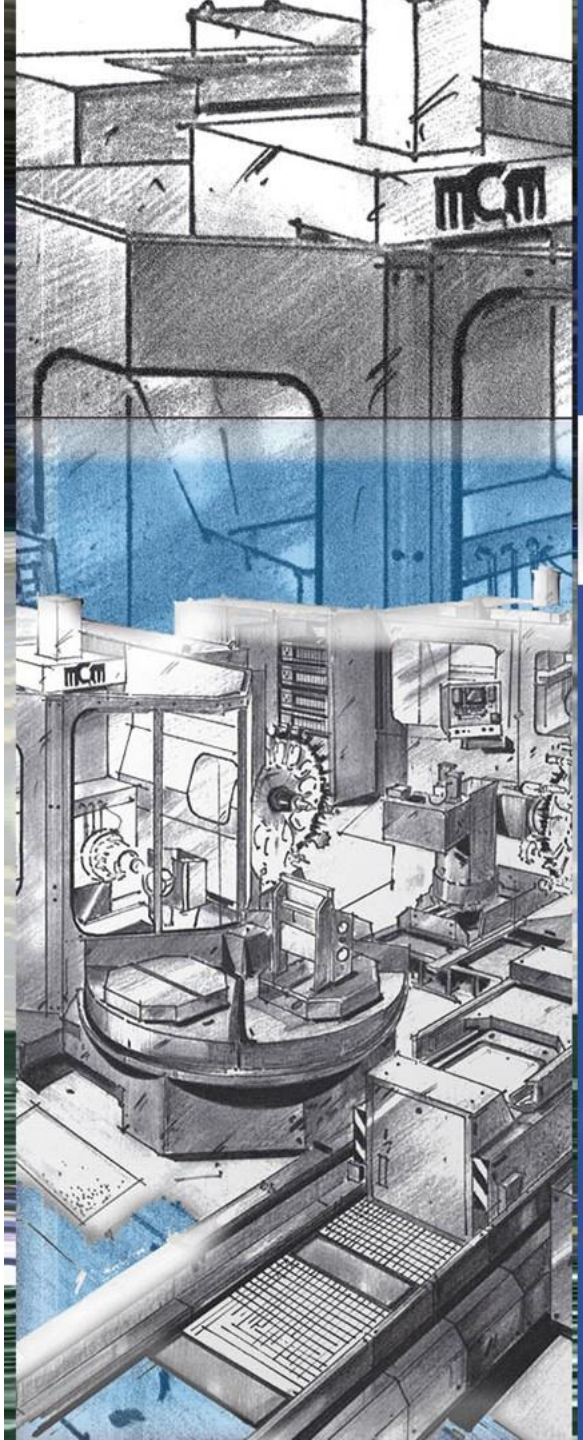
Bologna

7th of June 2012

Giuseppe Fogliazza

Responsabile Software e Architetture

(g.fogliazza@mcmspa.it)



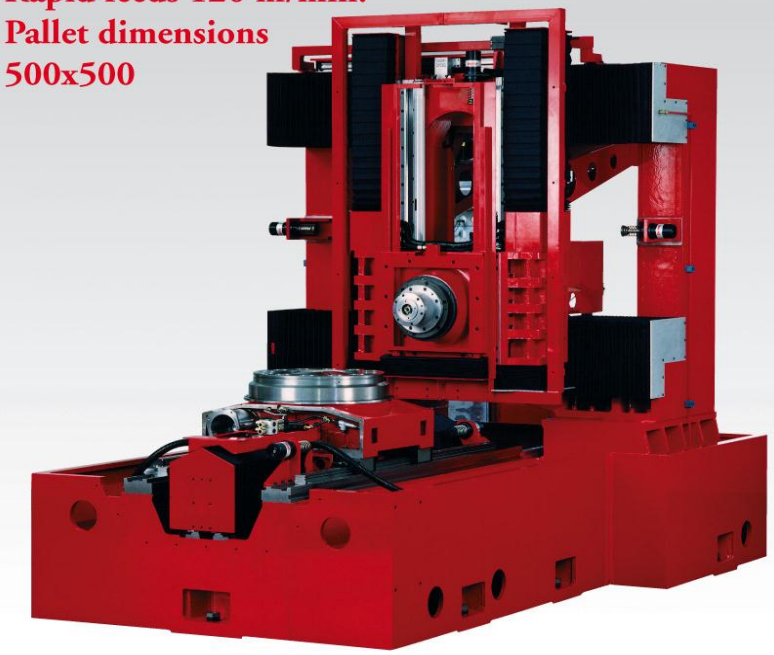
30 years of continuous innovation

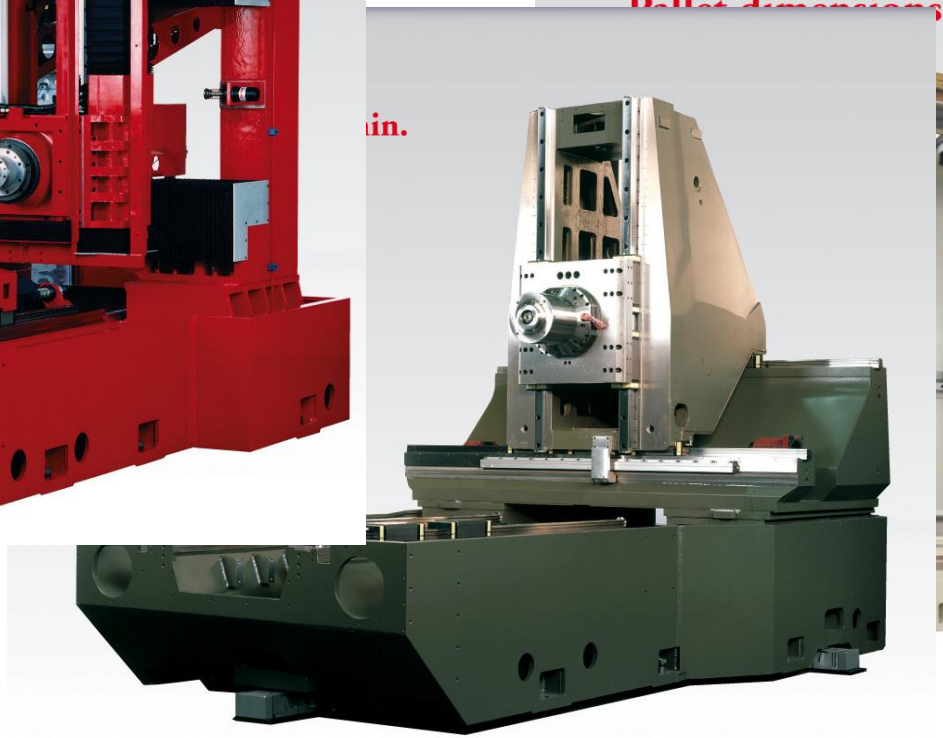
Presentation Outline

- Company Introduction
- Trends in company evolution
- Trends in machining (for aerospace)
  - Past: Structural part dimension
  - Present: Machining of “difficult” materials
  - Future: From machine tool to machining system

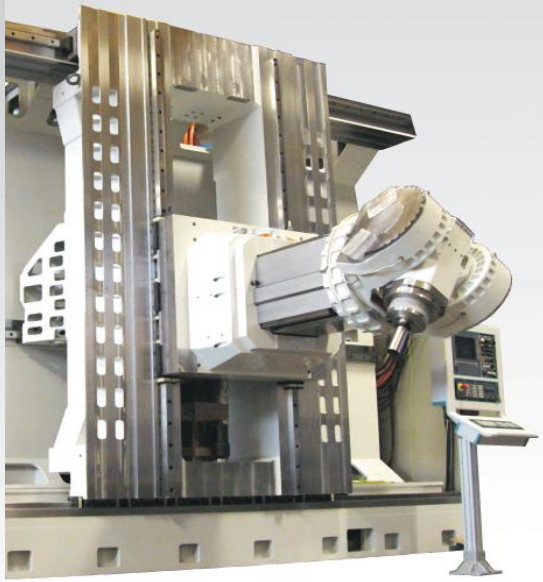
MCM Product: Horizontal axis machining centers

HSK-A63
Rapid feeds 120 m/min.
Pallet dimensions
500x500

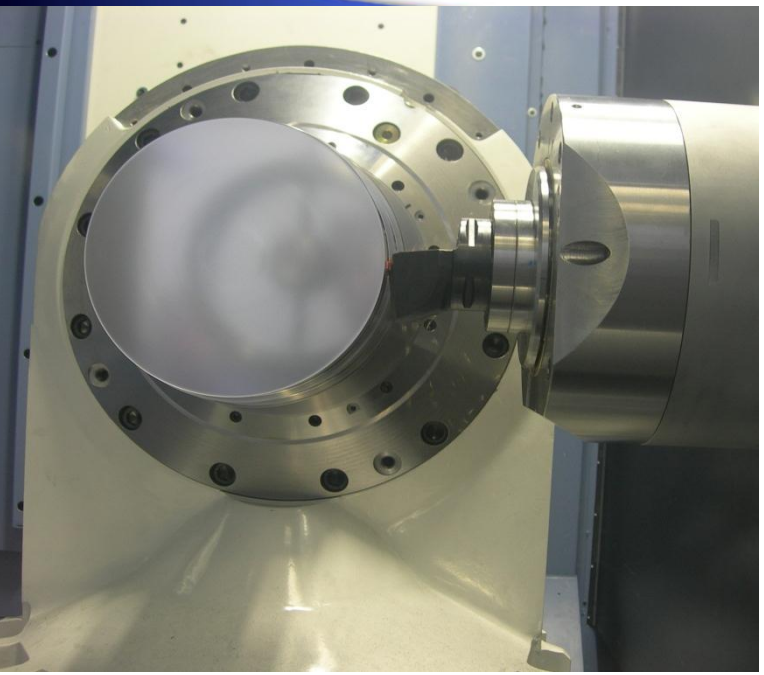


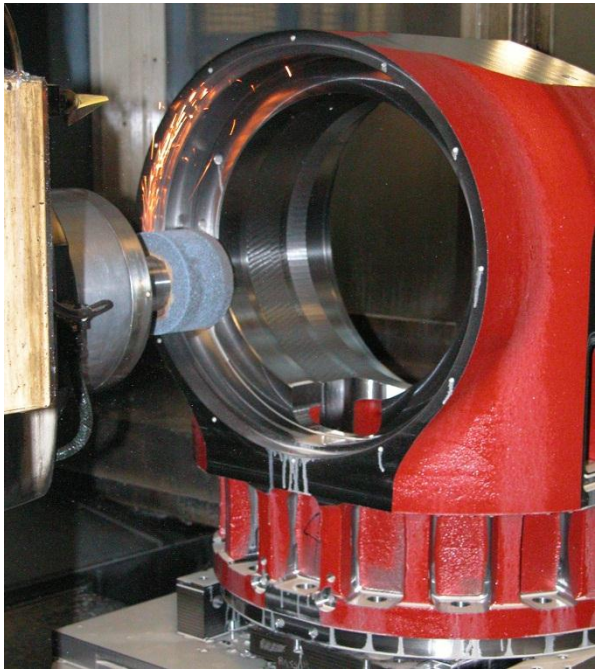


A-C axes 22,000 degrees/min.
HSK-A80 / HSK-A63
Linear axes rapid feeds 70 m/min.
3,000x2,000



Five axes Multi-Tasking





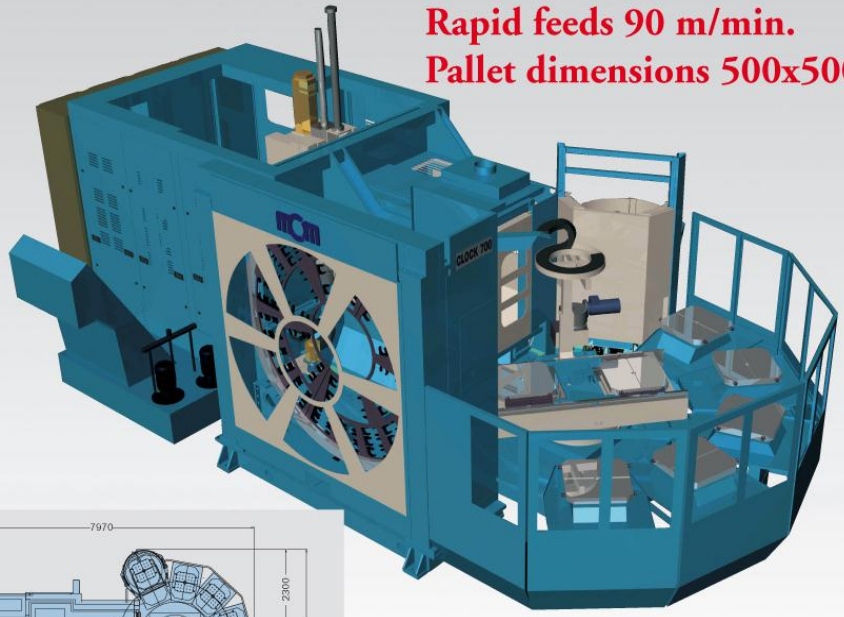
HIGH PRECISION COMPLEX PARTS MACHINING

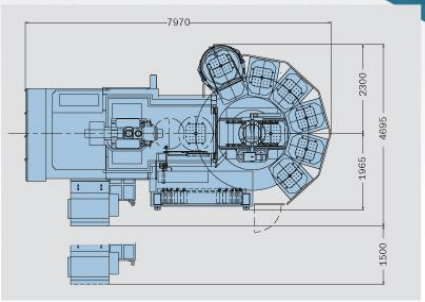
MILLING – TURNING - GRINDING

jFMX level 2

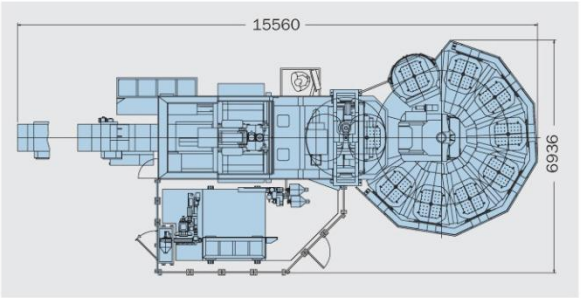
Flexible Automation:
Multi-pallet flexible machining cells

HSK-A100 / HSK-A63
Rapid feeds 90 m/min.
Pallet dimensions 500x500



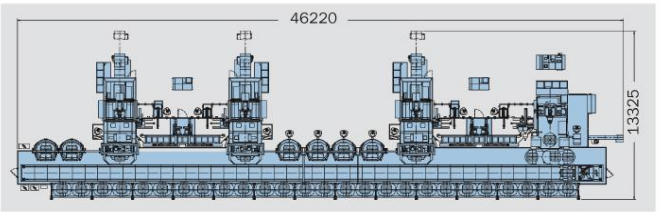


HSK-A100
Rapid feeds 60 m/min.
Pallet dimensions 630x630/800x800

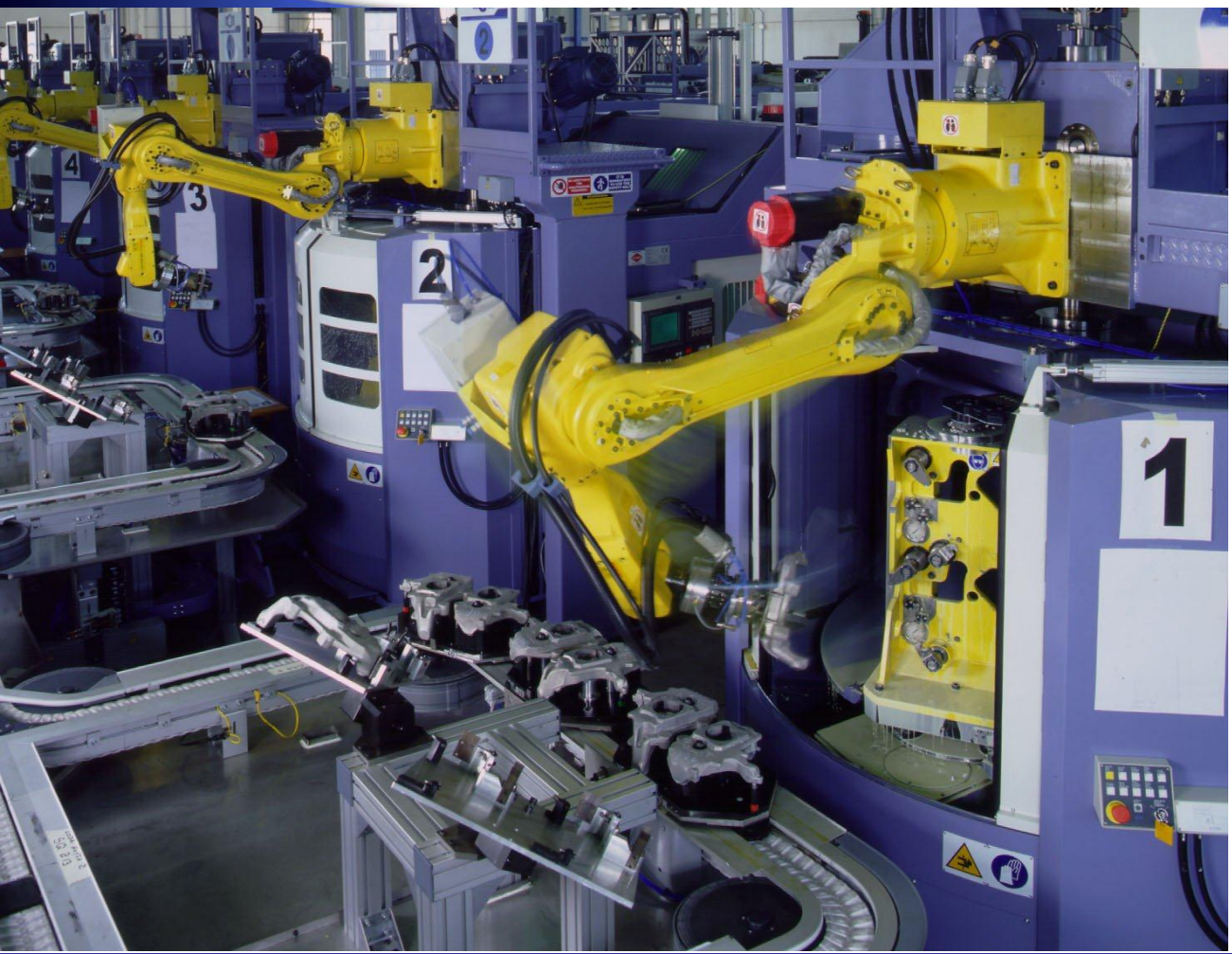


Flexible Machining Systems

Shared mirror type tool magazine	
Super tool	
Number of tools HSK-A100	291-999
Number of tools HSK-A63	343-2258
Tool regeneration with buffer	
+ washing + tool check	12 s
Number of pallets	14-100
Pallets automation on 3 different levels	



Focused Flexibility Mfg. Plant



- Designed to deal with a specific production problem
- Configured to provide the exact amount of flexibility
- Re-configured to adapt to changing requirements

jFMX level 2

Highly Customized Solutions for

Autonomous and Flexible Machining

jFMX level 2

Supplier

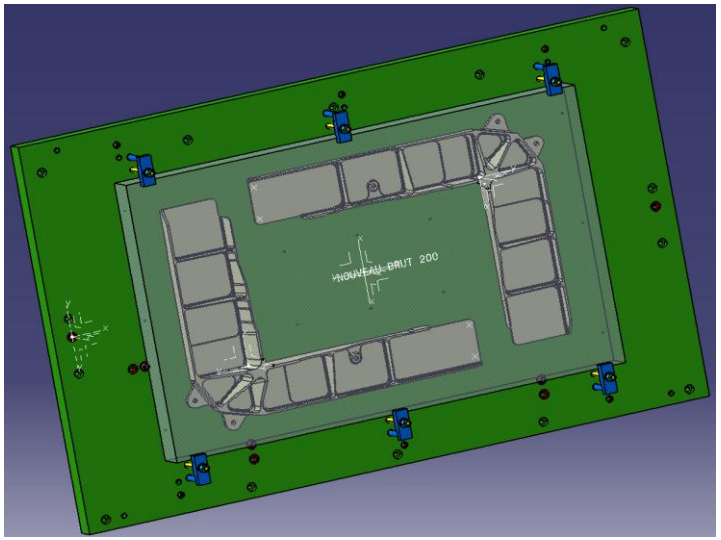
Customer

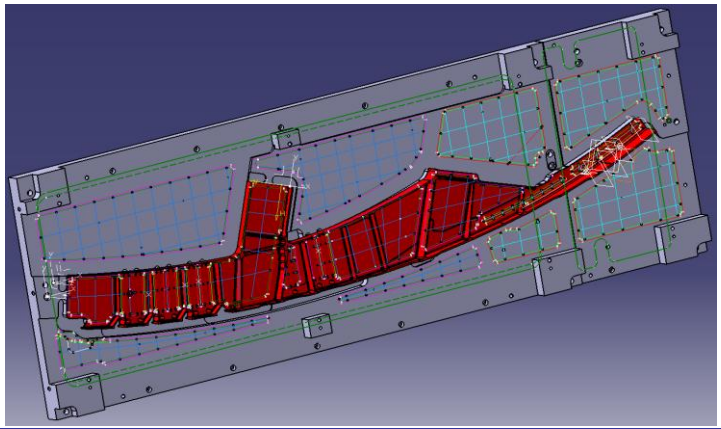
Machining flexibility

Company evolution as a supplier of autonomous flexibility in machining

- Company DNA and research on product innovation:
  - Multi-disciplinary integration
  - Advanced control architecture
  - Continuous product development
  - Long term relationship with customer
- Research on strategic innovation:
  - Methodologies to develop reusable components
  - Models, methods and tools for *flexibility engineering*
  - Service orientation
  - New business models

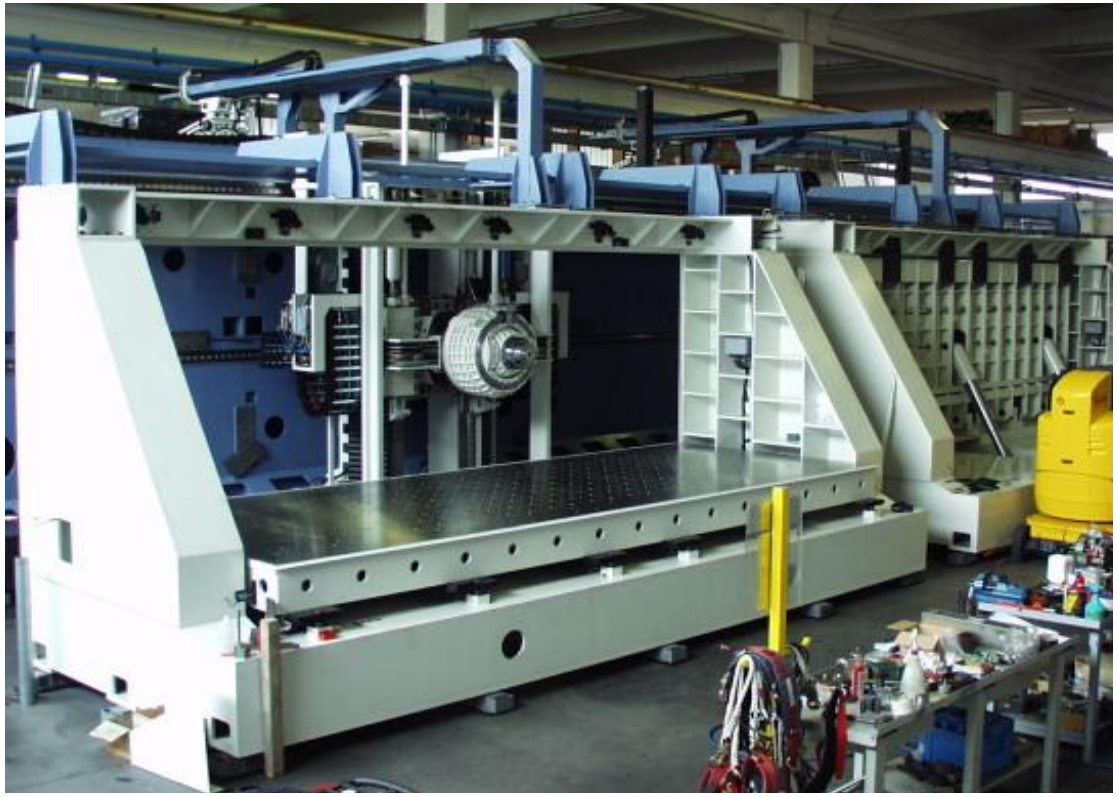
Machining of aeromobile structural part





- Structural part dimension increases
- Removed material volume increases
- Machining time should decrease

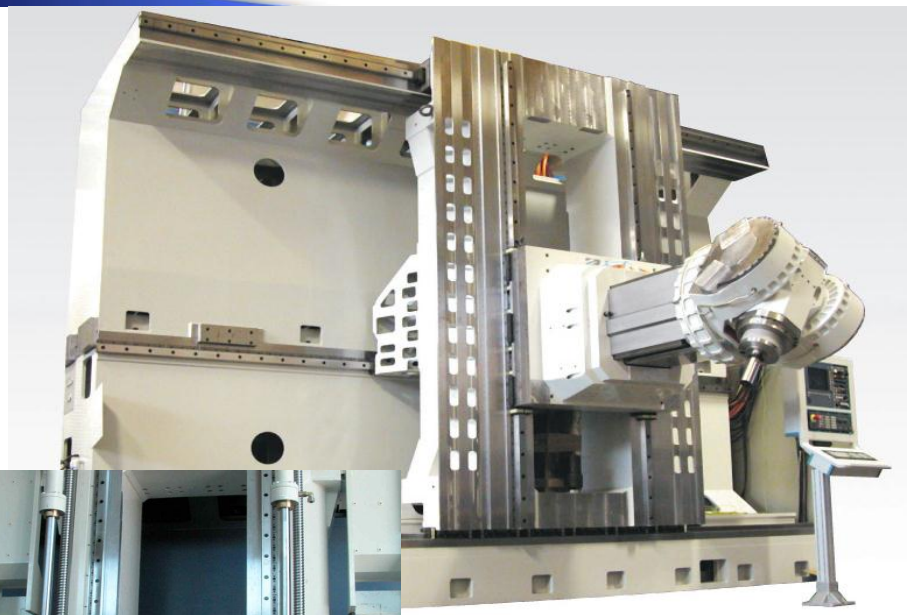
Machine Structure : JetFive (Eureka project 2267/E)

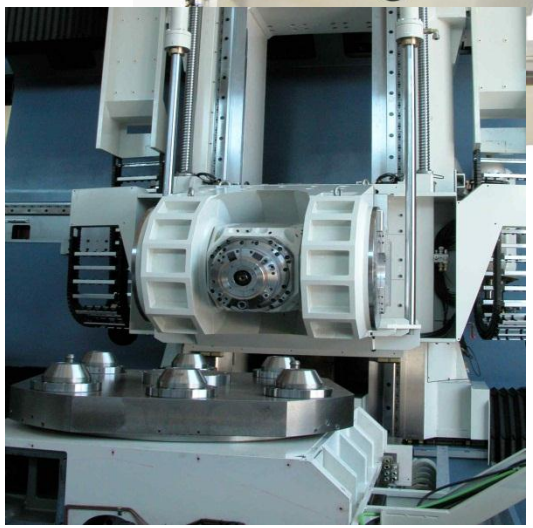


- Linear motor 5 axes machining center
  - Gantry control on all axes
  - Axes strokes motors and thrusts
    - X 14.000mm 2+2 Fanuc L15000/C2
      Max Thrust 60.000N
    - Y 2.000mm 2 Fanuc L15000/C2
      Max Thrust 30.000 N
    - Z 500mm 2 Fanuc L9000/B
      Max Thrust 18.000 N

- Universal tilting head prototype
  - A axis +/- 30 degrees
  - C axis +/- 180 degrees
- Tilting table with integrated vacuum clamping system

JetFive/L





- Linear motor 5 axes machining center
- Gantry control on all axes
- Work Area Dimension:
  - X from 3.000 to 19.000 mm
  - Y 2000 mm
  - Z 600 mm

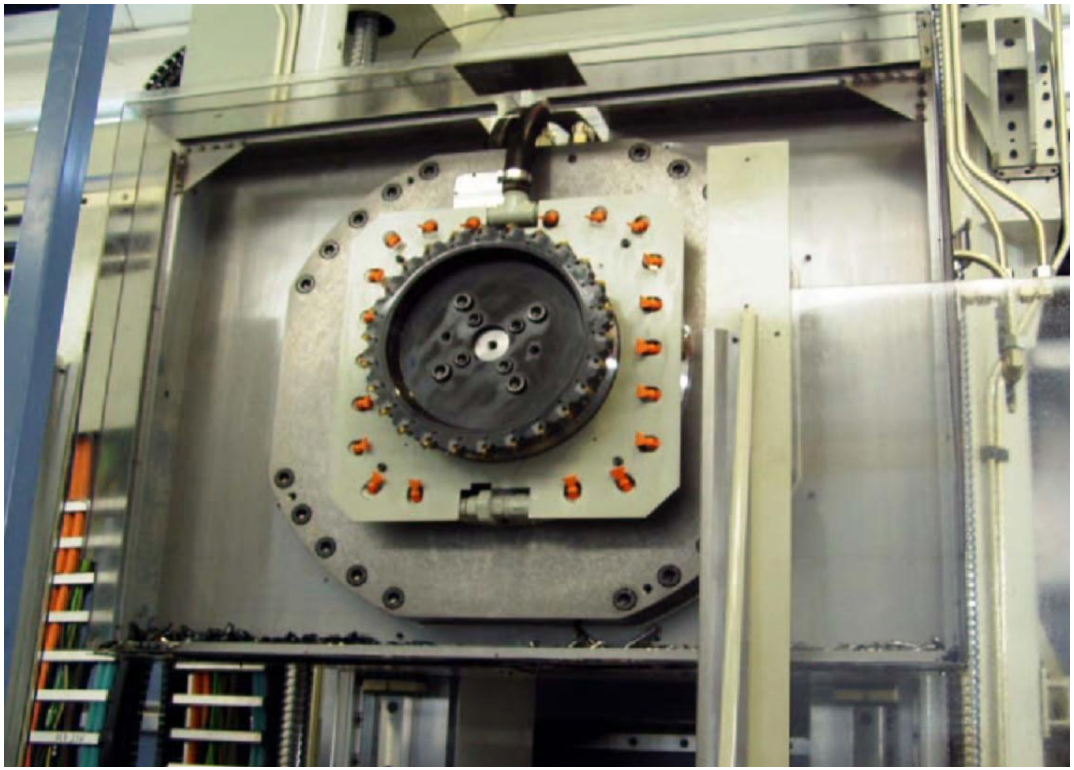
- HSK-A80/HSK-A63 Spindle
- Speed 20.000rpm
- Power up to 75kW
- Torque 200Nm
- Forward bearing 100mm

- HSK-A100 Spindles
- Speed 6 / 8 /14.000rpm
- Power up to 75kW
- Torque fino a 1000Nm
- Forward bearing: 130mm

Machining of titanium alloys

- Roughing at low speed and maximum depth
- Special tool development
- High torque electrospindle (beyond 3.000 Nm)
- Machine structure with high dynamic and static stiffness
- 5 Axes, high speed finishing milling, boring and drilling

Adaptation of JetFive Process Unit



- High stiffness, stable structure, balancing on Y axis for heavy heads
- Electrospindle providing 7.640 Nm torque at low speed (up to 500 rpm)

Modern Mfg. Industry: Uncertainty

- Modern industry is operating in a context of nearly continuous technological change
- Industrial decision-makers must select technologies and implement production strategies even in the face of known-to-be-incomplete information
- Results of a business decision can therefore be uncertain even in cases of mature technology implementation

Increasing information and adopting flexible strategies

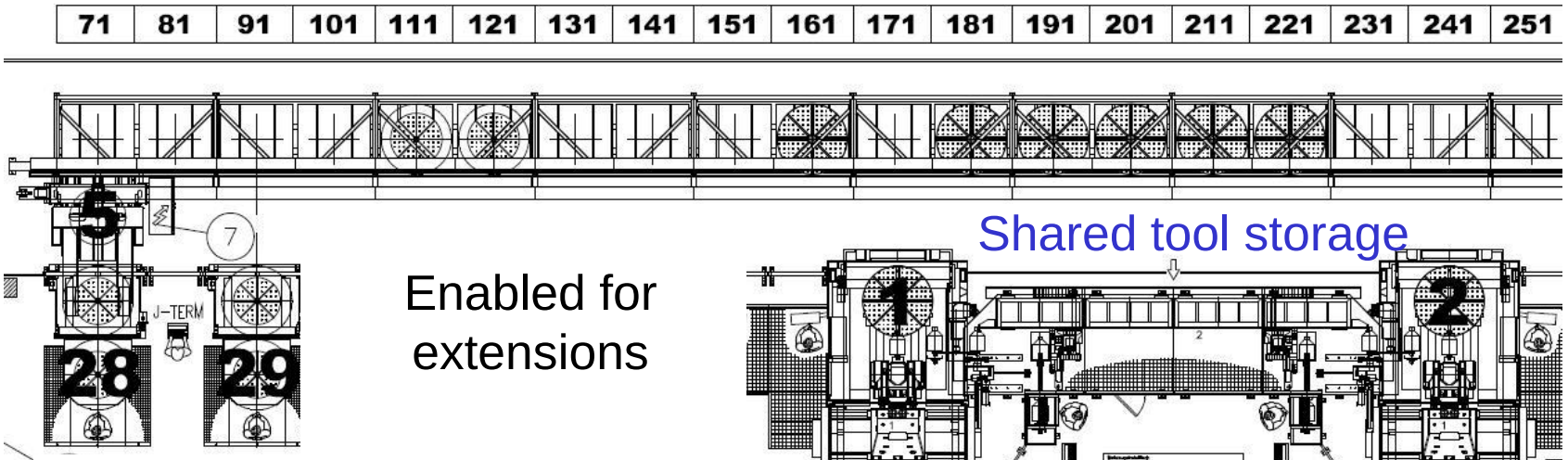
- To address this issue, decision-makers can adopt two distinct approaches, or a combination of them:
  - implementing flexible strategies to reduce the negative impacts of uncertainty or enable improvements as uncertainties are resolved.
  - improving the quality and quantity of the information currently available

Flexibility Engineering

- Focusing: being capable to rationalize the flexibility embedded in manufacturing plant
- Embedded flexibility can be rationalized with better information of production needs
- Strong relationship between user and supplier can lead to the correct solution
- Reconfigurability: A system can acquire new abilities already having the enabler

Mirror Flexible Machining Cell

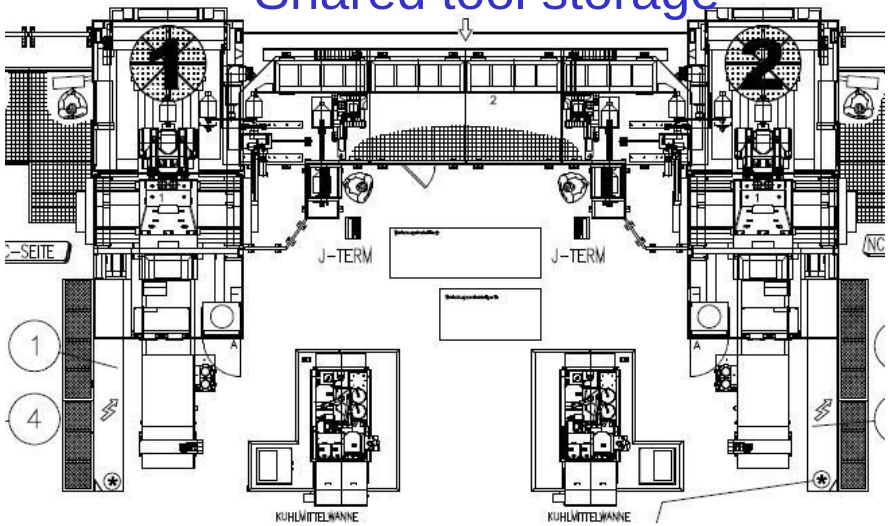
Shared pallet storage with shuttle



Load/Unload Stations

Enabled for extensions

Shared tool storage



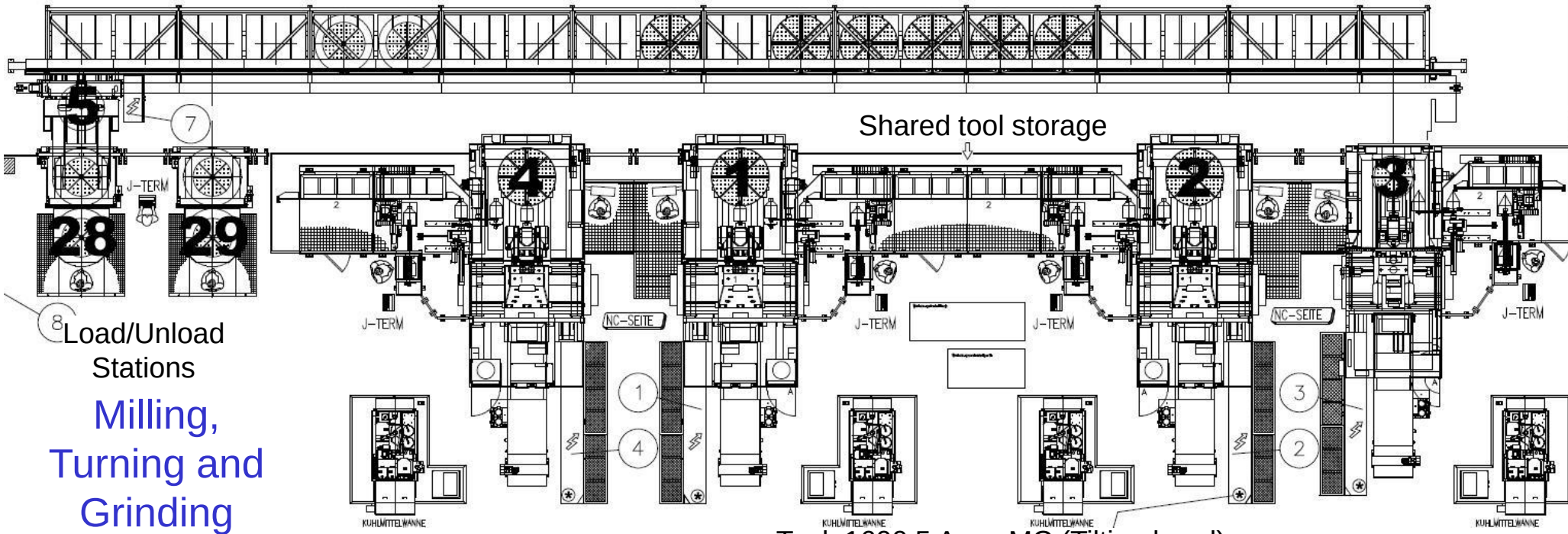
Milling of aircraft engine components

Tank 1600 5 Axes MC (Tilting head)

Focused Flexibility Machining Plant

Shared pallet storage with shuttle

71	81	91	101	111	121	131	141	151	161	171	181	191	201	211	221	231	241	251	261	271	1. EBENE



Milling, Turning and Grinding of aircraft engine components

Tank 1600 MultiTasking MC

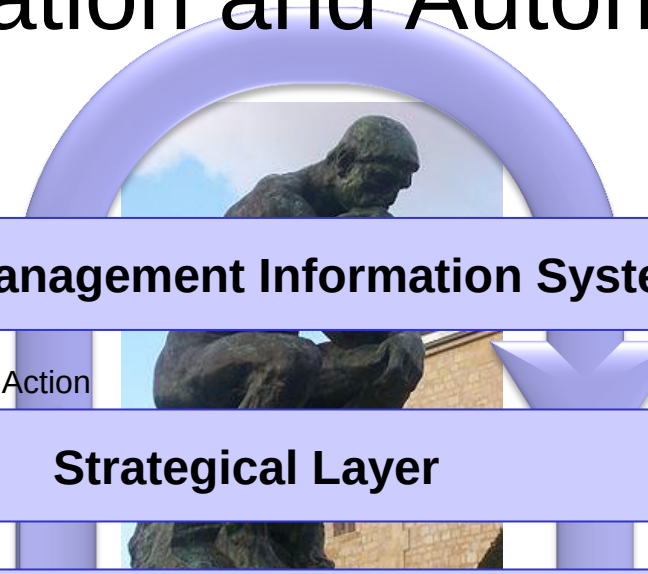
Tank 1600 5 Axes MC (Tilting head)

Tank 1300 MultiTasking MC

Machining : Knowledge intensive activity

- Process Knowledge
  - Extensive use of virtual mfg. tools
  - Reusing knowledge from shop floor in future projects
- Production plan
  - Beyond scheduling and setup minimization in finite capacity operative planning
- Resource monitoring
  - Real time efficiency indicators
  - Pattern discovery from sensor data analysis for predictive maintenance and strategic decision support

Integration and Autonomy



Process data

Process Knowledge

Management Information System

Level2

Perception

Action

Optimization

Strategical Layer

hours-day

Level1

Plan Execution

Tactical Layer

mins-hour

Reactiveness

Operational Layer

secs-mins

Level0

Conventional control

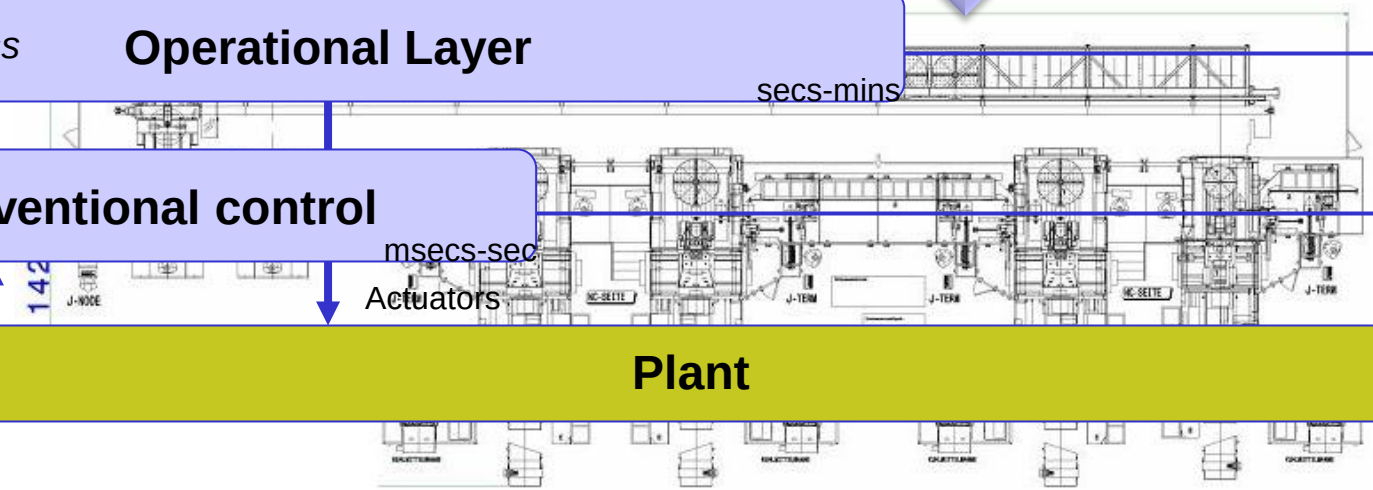
msecs-sec

Sensors

Actuators

Plant

Operator Interface



Conclusions

- Flexibility
  - From machining centers to multi-task machines
  - From flexible automation systems to reconfigurable systems
- Integration
  - Capacity to build production **systems**
  - Closing control loops from sensors to production plans
- Autonomy
  - Economic advantage of unattended production
  - Changing the relationship between man and machine:
    - Performance (process, productivity)
    - Safety
    - Reusable knowledge
  - Making complexity as transparent as possible

Questions ?

Thanks !

Manufacturing Flexibility

- … as the ability to change or react with low penalty in time, effort, cost or performance (Upton 1994)
- It is the strategic answer to protect from risks related to market change
- With a strong impact on competitiveness of both producer and user of mfg. systems

R&D Role

Technological Innovation:

- Development of new machining and automation modules
- Development of new services
- Continuous product improvement
- Support to customer process innovation

Strategic Innovation:

New internal production methodologies, enabling the **reuse** of existing modules to reduce costs and to improve productivity

Relationship with University and Research Institutions

- Strategic relationship since 1990
- Stages and thesis
- PhD programme support
- Joint participation to European and National programmes

Industrial Partner (1997)

MUSP
Macchine Utensili e Sistemi di Produzione

- PRRIITT – Regional program for industrial research
- HiMec: Advanced Mechanics District
- Co-Founders (2005)

jFMX level 2

Participation to research programmes

Mod Flex Prod

Brite Euram BR-0440 (5/1997 - 6/2000)
new MODular production system architecture to combine FLEXibiliy and PRODuctivity

SPI
Sistemi di Produzione Innovativi

PNR SPI-1 Rif. 1381/525-209401: (7/1999 - 12/2003)
Metodologie innovative per la realizzazione di stazioni di lavoro meccaniche

Jetfive

Eureka Σ!2577 (11/2001 - 10/2003)
High Speed, Five-Axis Manufacturing Module For The Aerospace Market

TORERO

FP V IST-2001-37573 (7/2002 - 1/2005)
Total life cycle web-integrated Control

KoBaS

FP VI IP NMP 505339-2 (6/2004- 6/2007)
Knowledge Based Customized Services for Traditional Manufacturing Sectors Provided by a Network of High Tech SMEs

jFMX level 2

MCM

Participation to research programmes

FP VI Strep IST-016649 Pabadis Promise (9/2005 –9/2008)

PABADIS based Product Oriented Manufacturing Systems for Reconfigurable Enterprises

FP VI IP IST/NMP-016969 VAN (10/2005 –10/2009)

Virtual Automation Networks

National Research Project (1/2007 –10/2009)

NetPP

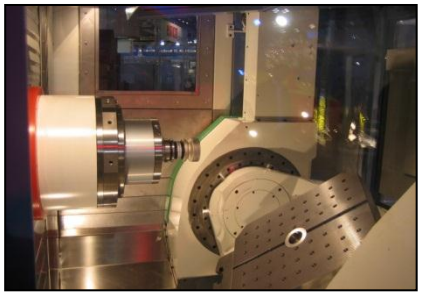
Development of Network Part Programs for the machining of prismatic components

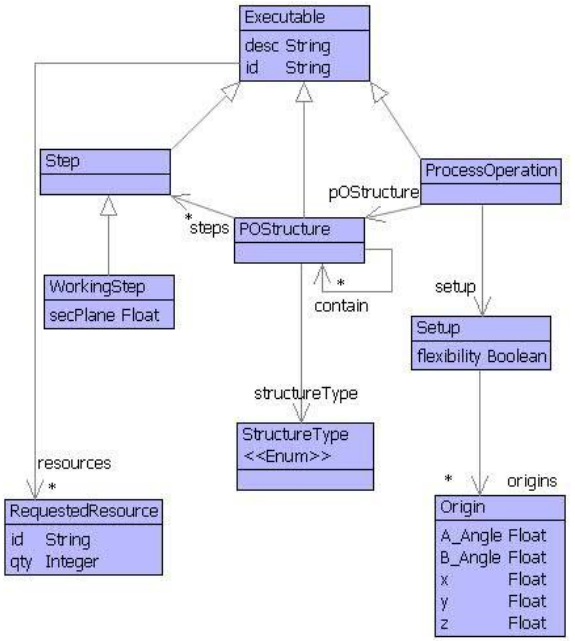
FP VII Strep ICT-2007-1-211448

Model-Driven Embedded Systems Design Environment for the Industrial Automation Sector

Network Part Program and Model Driven Process Plan Execution

- Dated DSL ISO 6983
  - needs to improve and to raise abstraction level in modelling machining operations to perform advanced control of the machining process
- Network Part Program method
  - explicitly based on the development of a new DSL, its supporting tool and its run-time environment
- Influenced by the Step-NC project
  - association between *machining operation* and *manu-facturing feature* creates a *machining working step*
- High level of abstraction to represent process plans provides support:
  - to control process cycles step by step
  - to manage unexpected events
  - to automatic restart and to execute incomplete cycles
- Italian national research project (NetPP 1/2007 – 12/2009)





NetPP Abstract Syntax Fragment

DEMAT

Dematerialised Manufacturing Systems

A new way to design, build use and sell European Machine Tools

Participants

TECNALIA	CECIMO - The European Committee for the Cooperation of the Machine-tools	IBARMIA INNOVATEK S.L.	MICROMEGA DYNAMICS SA
Ce.S.I. - Centro Studi Industriali Di Taddei Simona Maria Ec Sas	Nicolas Correa Service SA	INTELLIACT AG	D.ELECTRON SRL
MISSLER SOFTWARE	ITIA-CNR Consiglio Nazionale Delle Ricerche	Katholieke Universiteit Leuven	Ecole Polytechnique Federale De Lausanne
Fraunhofer-Gesellschaft Zur Foerderung	University of Bath	University of Stuttgart	Machining Centers Manufacturing SpA

SIGI-X
BUSINESS SOLUTION PER COMMESSA SINGOLA

Programma Industria 2020
Made in Italy

Significa attenzione alla qualità, al servizio ed alla soddisfazione dei clienti nella produzione di pezzi unici di elevato pregio e personalizzazione.

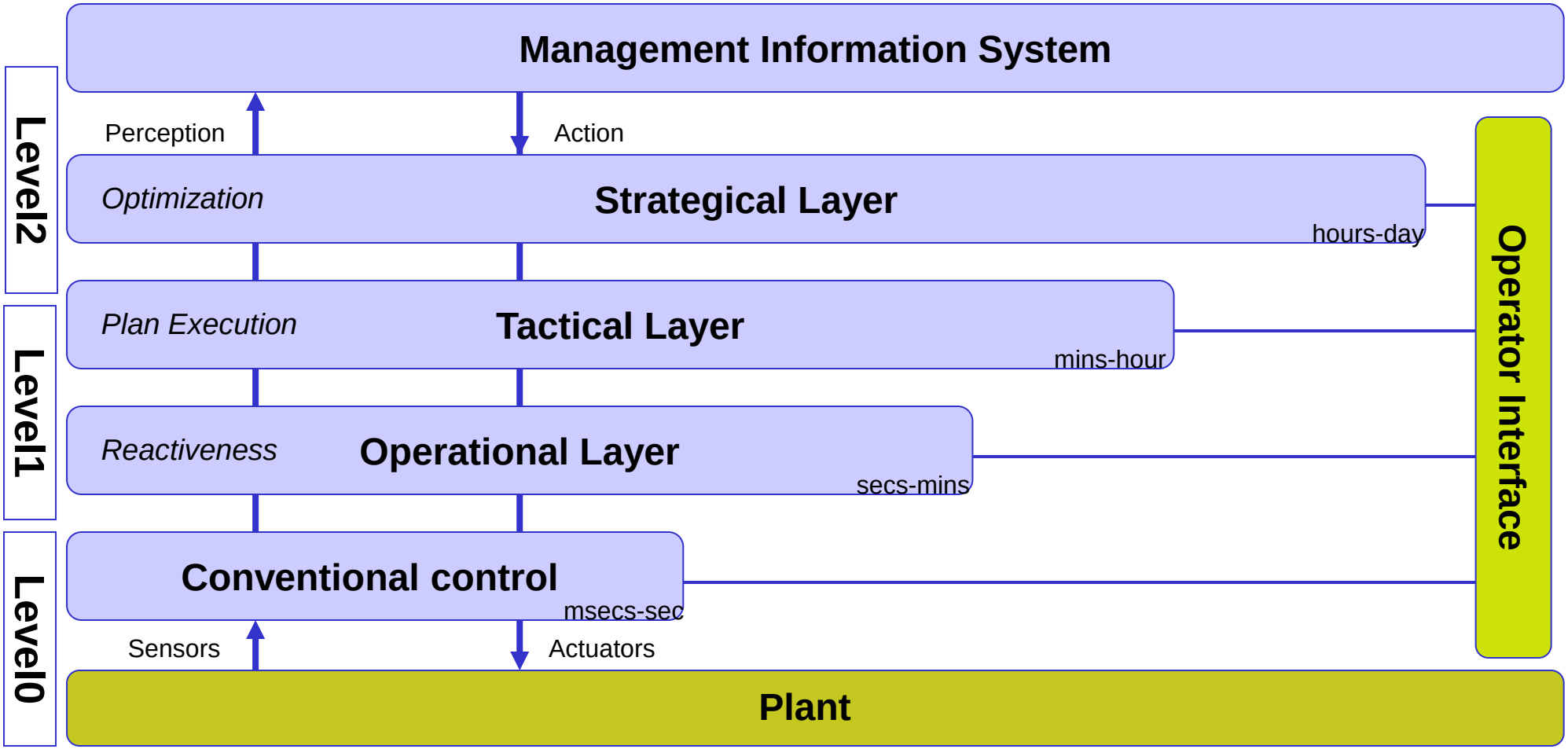
Che per competere a livello planetario devono organizzarsi in filiere per mettere in rete le proprie competenze e conoscenze

Occorre quindi supportare, prima di ogni altro i processi industriali, legati alla concezione, allo tutto sviluppo, alla produzione ed alla vendita dei prodotti

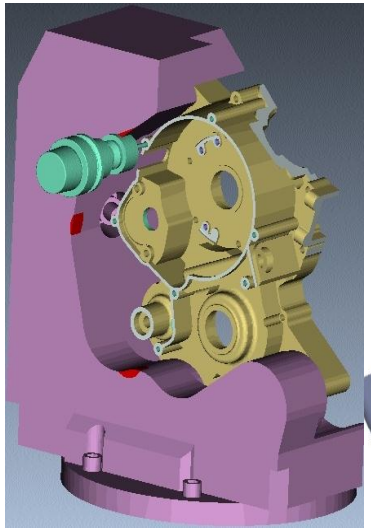
jFMX level 2

MCM

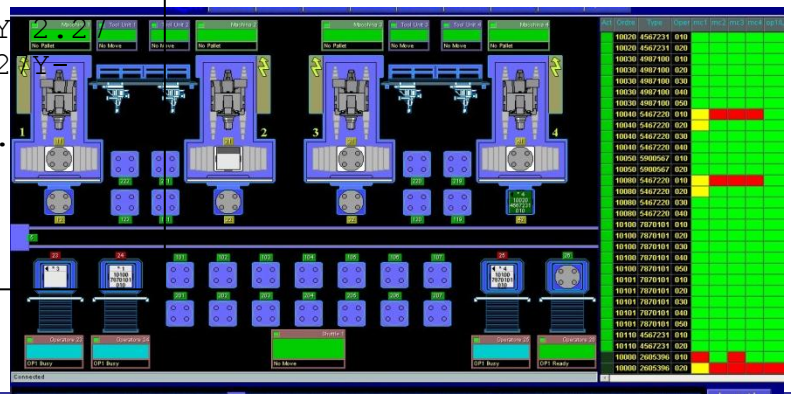
Integrated hierarchical control



jFMX: Flexible Cell Supervisor



```
M3S10000F7200
G0X7.Y65.
G0Z0.
G1X-
16.19Y2.2
X-38.2
24.15
G1X15.
Y20.
X-38
Z-38
```

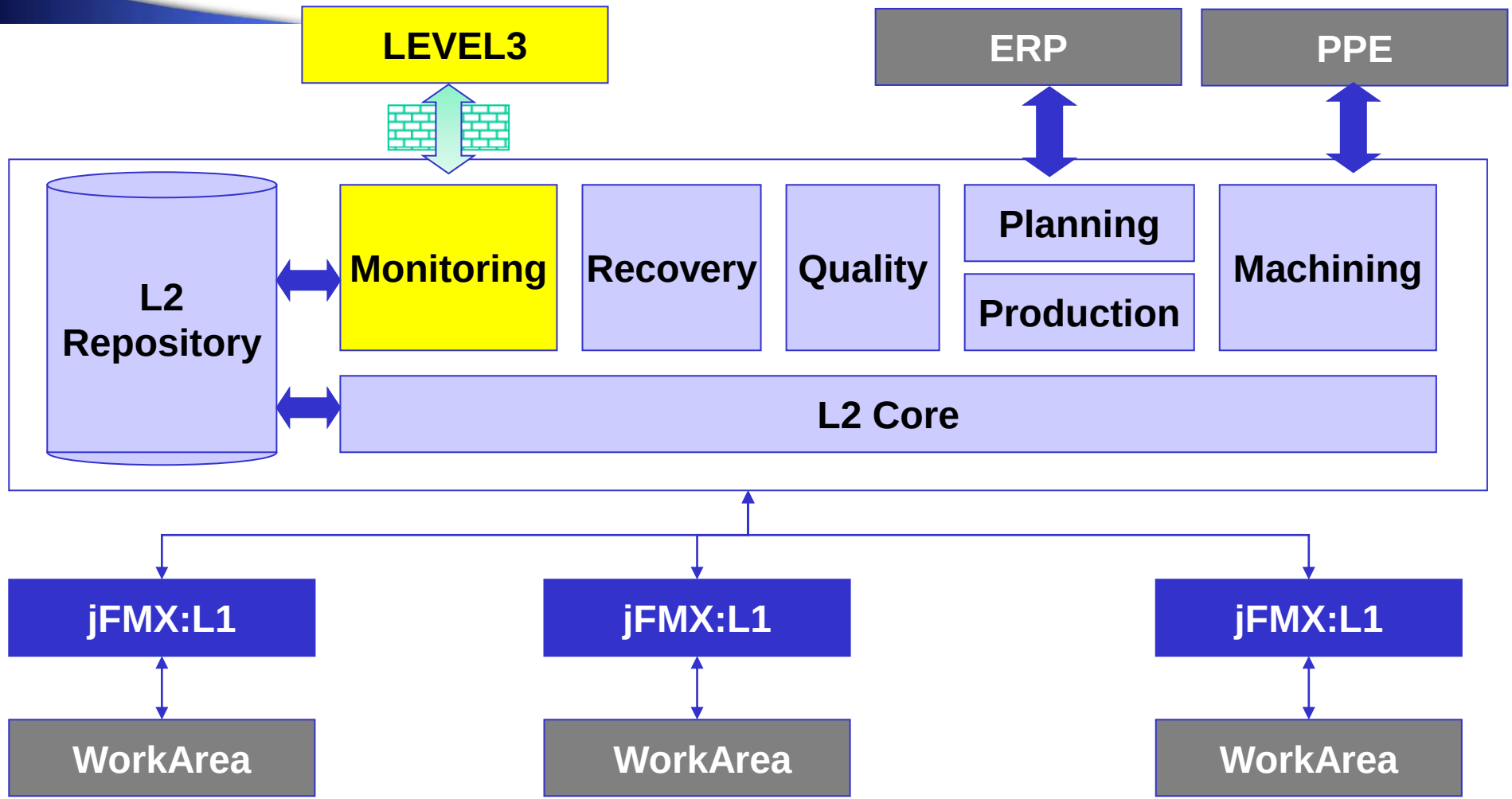


- Flexible automation coordination
- Real time monitoring of resources status:
  - Units
  - Pallets
  - Fixtures
  - Parts
  - Tools

- Operation description and part-program management
  - Dynamic management of CNC memory
- Execution of a production plan
  - Real time dispatching of part to machines
  - Priorities and balancing of production orders

jFMX level 2

jFMX:Services for a Flexible Shop Floor



Disclaimer

- Questo documento è stato redatto dallo staff MCM
- Le informazioni in esso contenute hanno valore solo con il commento orale degli autori.
- La proprietà intellettuale del documento appartiene ad MCM
- L'utilizzo e la riproduzione di questo materiale sono consentiti solo con il consenso scritto di MCM.
- Ogni abuso potrà essere perseguito secondo quanto stabilito dalle vigenti leggi.