The SAMANTA platform

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Snecma and Health Monitoring

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Snecma, Key figures

Revenue in Billion €* 5,9

Employees worldwide * 14 662

Sites worldwide 35






* *As of 2013 December 31st*

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Thrust: from 9 grams to 135 000 kilograms

(1) PowerJet (50/50 Snecma-NPO Saturn)
(2) CFM International (50/50 Snecma-GE)
(3) EPI (ITP, MTU, Rolls-Royce, Snecma)
(4) En coopération avec GE

Satellites
PPS ® 1350
90 mN

Ariane 5
HM7B
64,8 kN

Ariane 5
Vinci
180kN

Ariane 5
Vulcain ® 2
1340 kN (main stage)

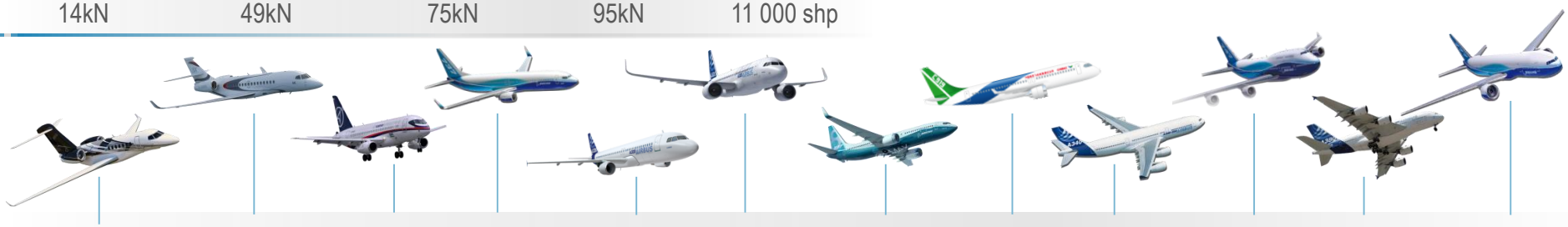
Alpha Jet
Larzac ®
14kN

Mirage F1
Atar
49kN

Rafale
M88
75kN

Mirage 2000
M53
95kN

A400M
TP400 (3)
11 000 shp



Citation Longitude
Silvercrest ®1C
9 500 to
12 000 lb

Falcon 5X
Silvercrest®1D
9 500 to
12 000 lb

SSJ100
SaM146(1)
15 400 to
17 800 lb

737
CFM56-7B(2)
19 500 à
27 300 lb

A320
CFM56-5B(2)
21 600 to
33 000 lb

A320neo
LEAP-1A(2)
21 500 to
33 000 lb

737MAX
LEAP-1B(2)
21 500 à
28 000 lb

C919
LEAP-1C(2)
21 500 to
30 000 lb

A340
CFM56-5C(2)
31 200 to
34 000 lb

747
CF6(4)
52 500 to
72 000 lb

A380
GP7200(4)
70 000 to
85 100 lb

777
GE90(4)
93 700 to
115 300 lb

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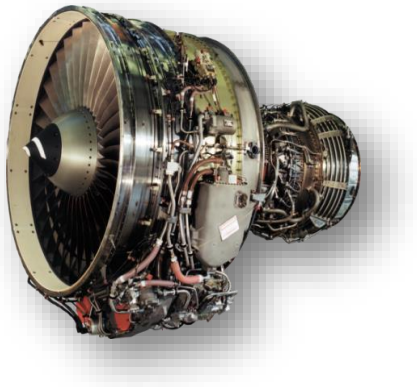
CFM56, THE worldwide civil engine aircraft best-seller



CFM56-5B

Nearly 105 millions of cumulative flight hours

More than 5 895 engines in service at 198 operators

Thrust range: 21 600 to 32 000 lb

Applications : Airbus Family A318, A319, A320, A321

A320

CFM56-7B

More than 195 millions of cumulative flight hours

9 801 engines in service at 265 operators

Thrust range : 19 500 to 27 300 lb

Applications : Boeing Family 737-600, 737-700, 737-800, 737-900

Boeing 737-800

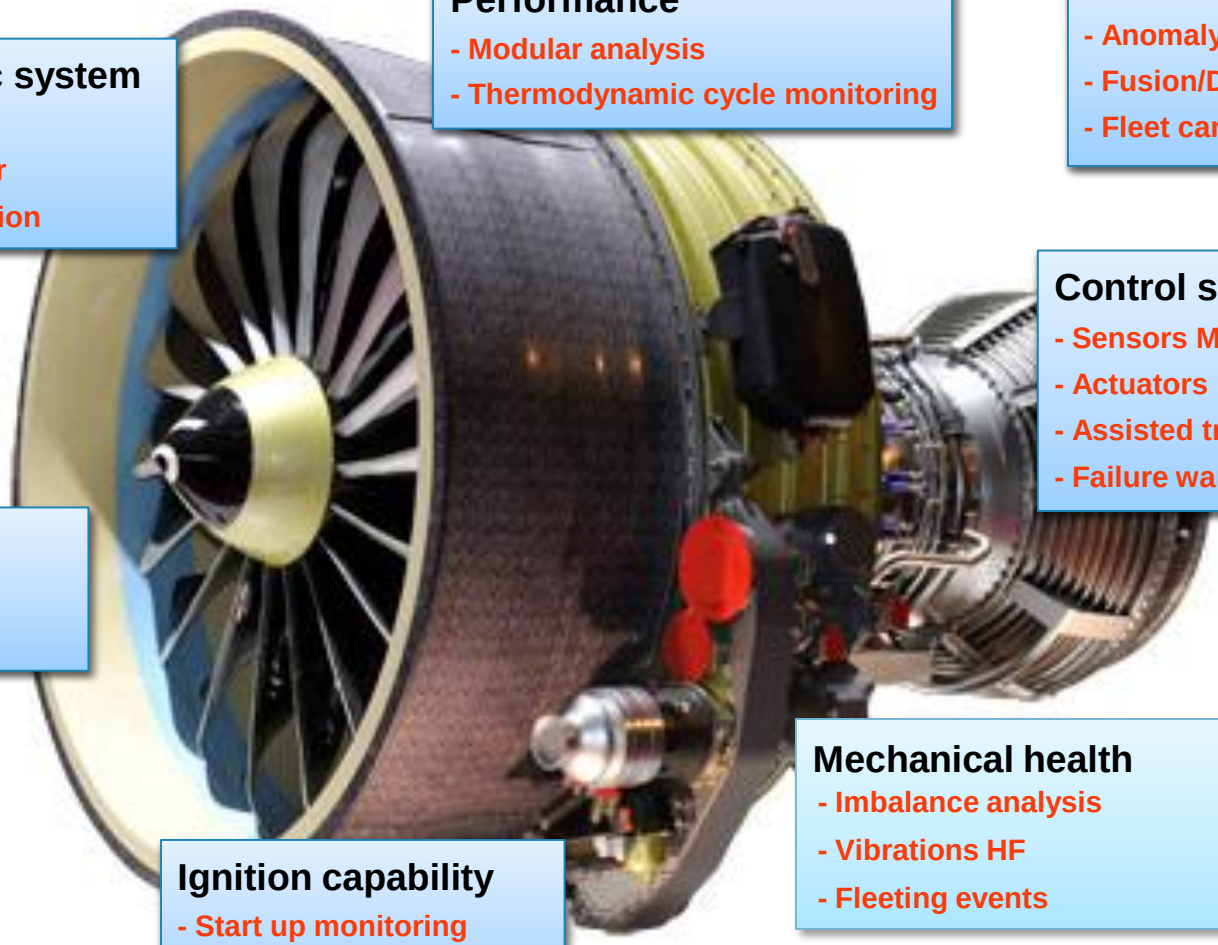
As of 2013 Agust 31st

CFM a 50/50 joint company of Snecma (Safran) and GE.

Health Monitoring

- **Health Monitoring is a nearly real-time monitoring of system parameters in order to:**
  - Detect signs of failure
  - Predict the remaining time before a required intervention (inspection or maintenance)
  - Identify faulty components
- **Improve operational aircraft availability**
  - Aircraft takes off on time, lands on time at destination
  - Reduction of operational events
  - Planning and optimization of maintenance
  - Reduction of stopping time engine
- **Reduce maintenance costs**
  - Assisted troubleshooting (isolating the faulty element)
  - Limit secondary damage
- **Note: The health monitoring is a maintenance function, no impact on the current flight and aircraft safety**

Engine systems monitored



Performance
- Modular analysis
- Thermodynamic cycle monitoring

General
- Anomaly detection
- Fusion/Decision making
- Fleet cartography

Hydraulic system
- Debris
- Smart filter
- Consumption

Control system
- Sensors Monitoring
- Actuators Monitoring
- Assisted troubleshooting
- Failure warnings

Fuel system
- Smart filter
- Fuel pump

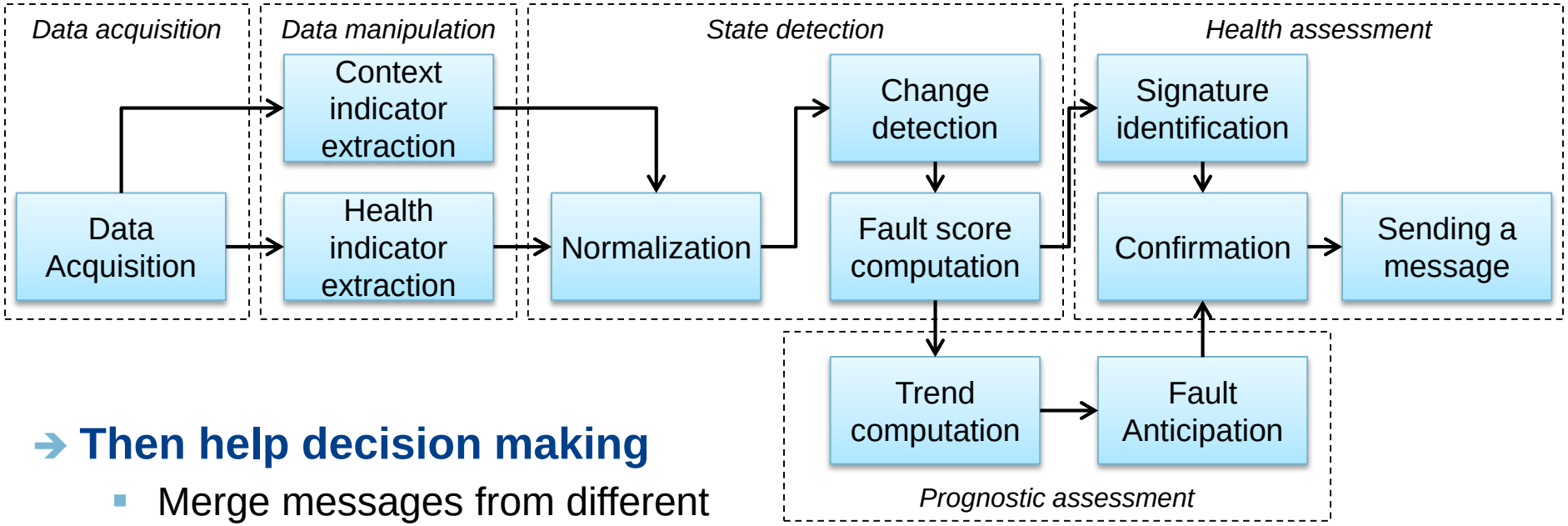
Mechanical health
- Imbalance analysis
- Vibrations HF
- Fleeting events

Ignition capability
- Start up monitoring
- Sparking plug monitoring

Faults diagnose

➔ Building alert messages from acquired measurements

- Using physical models
- Learning behavior using mathematical models
- Identification of fault signatures, drifts detection, component targeting



➔ Then help decision making

- Merge messages from different diagnose sources

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Introduction to SAMANTA

Snecma Algorithm Maturation ANd Test Application

Introduction to SAMANTA

➔ What is SAMANTA ?

- SAMANTA (Snecma Algorithm Maturation ANd Test Application) is an environment for **Design, Development** and **Maturation** of algorithms based on 3 items

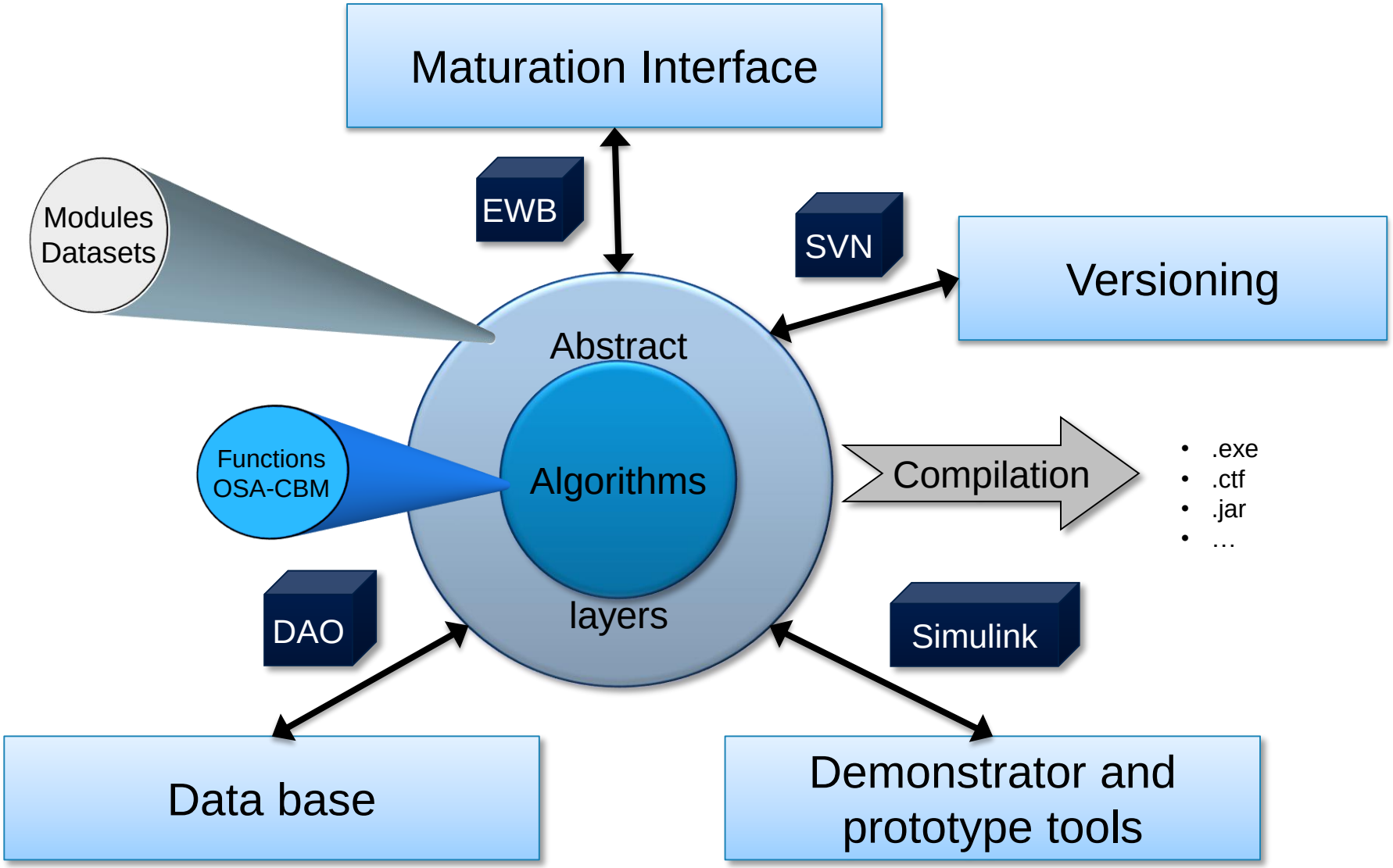
➔ Why develop this platform ?

- To enable engineers to quickly and easily lay out algorithms without special knowledge in mathematics or computer science
- To facilitate exchanges between algorithm designers through scripts/displays/ common and consistent operations
- To capitalize on algorithms
- To create a complete interface between algorithms, data and associated documents

➔ Why with MATLAB?

- To quickly and easily create a platform giving the freedom to design algorithms through written code or through connecting blocks in Simulink

SAMANTA environment



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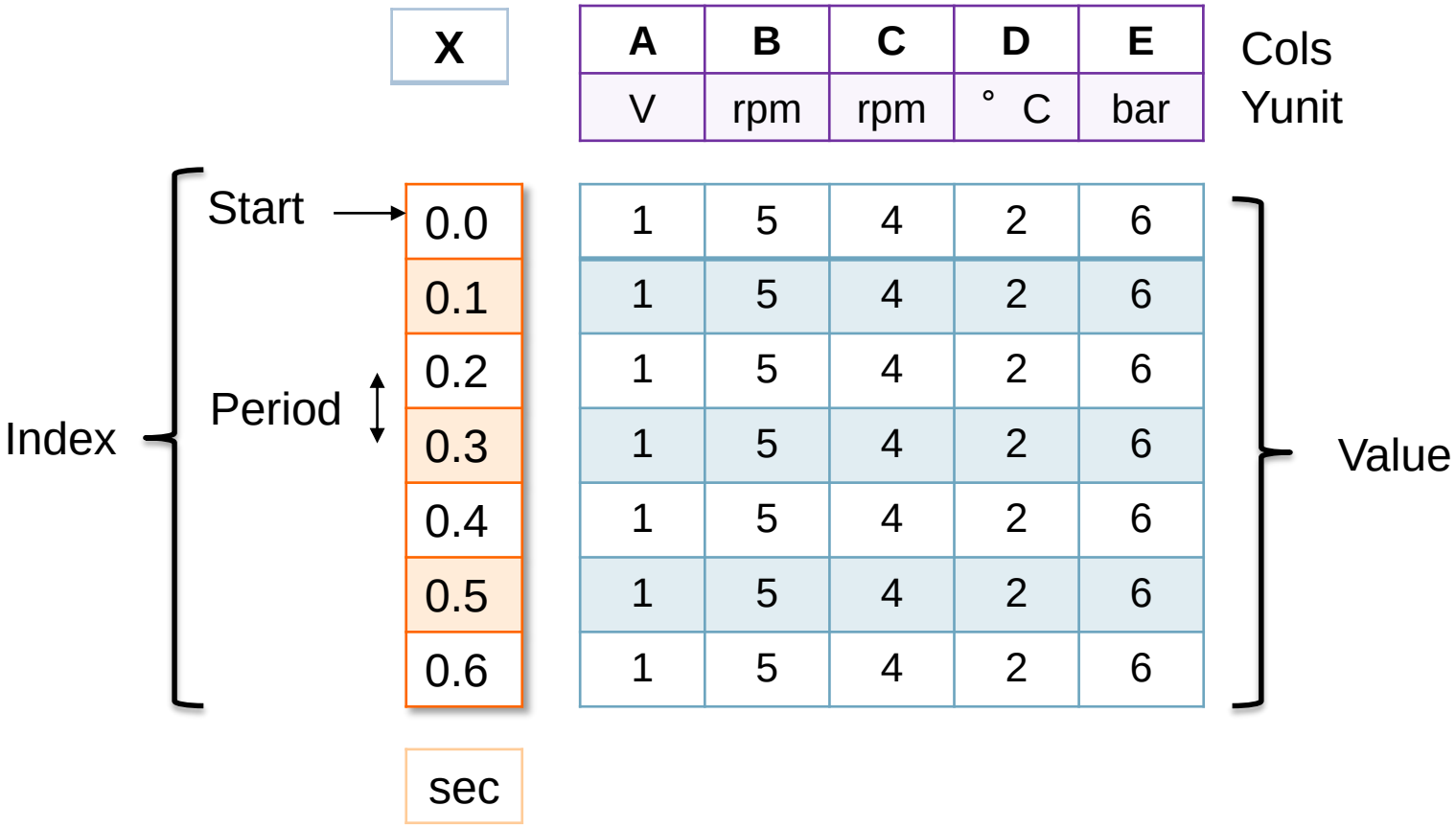
Presentation of SAMANTA objects

Signal, Opset, Mnode

SAMANTA objects – the signal

- **Algorithms process input data and produce results. These data come from:**
  - Flight measures or flight tests
  - Intermediate results produced by other algorithms
- **The SAMANTA *signal* is a structure containing and formalizing data through a standard:**
  - Table of values
  - Associated properties

SAMANTA objects – the signal



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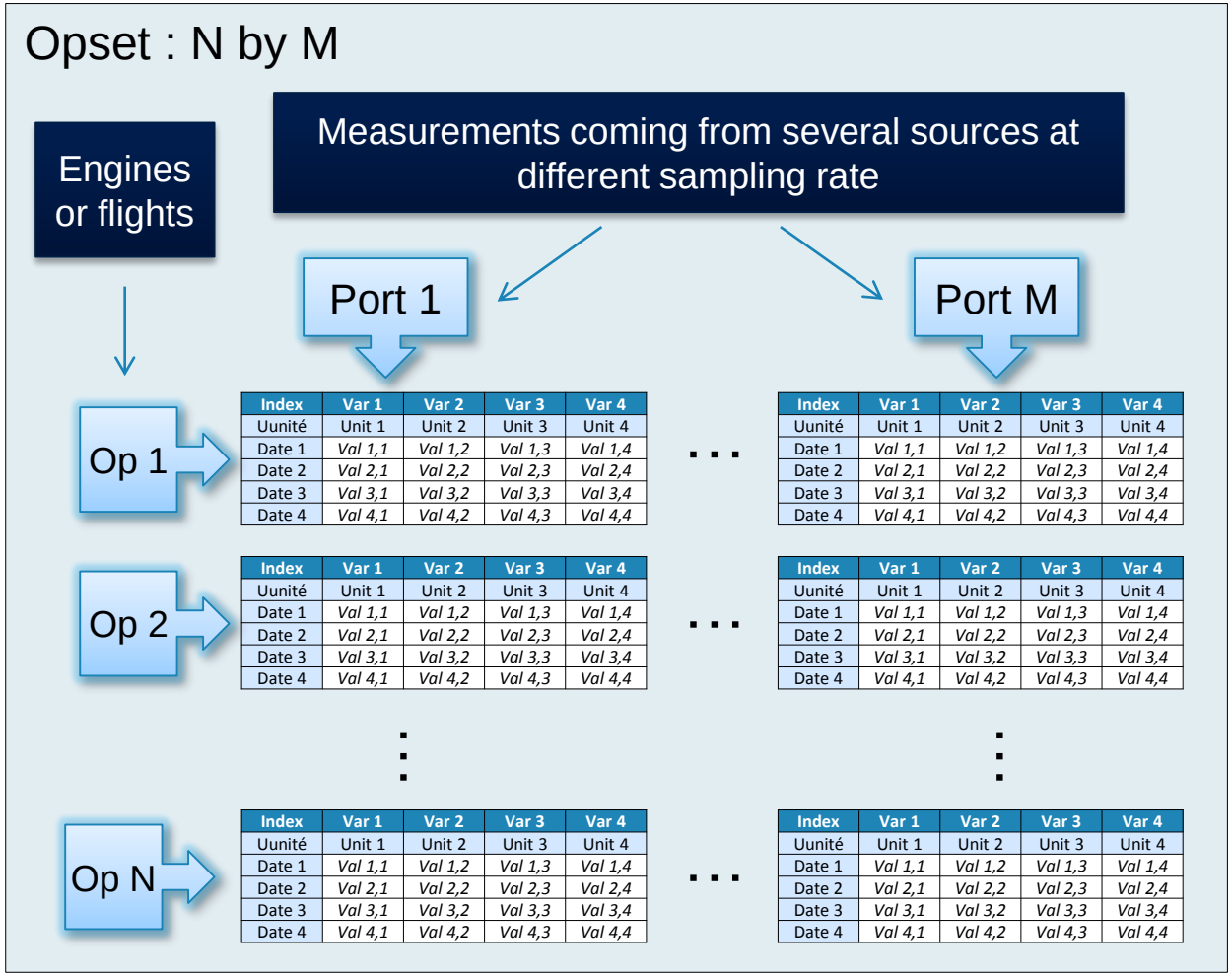
SAMANTA objects – the opset

- **It is necessary to store the signals in MATLAB files: the SAMANTA object *opset* defines a list where to store the signals.**
  - Pointer to a backup file (.mat)
- **The *opset* is a sheet with n leaves, called operations**
  - Each operation comprises a series of signals
  - Signals must be similar from one operation to another
  - Easy access to all the information stored in the structure of the opset
- **The *opset* is serializable**
  - It is suitable for any method of execution of the algorithm

SAMANTA objects – the opset



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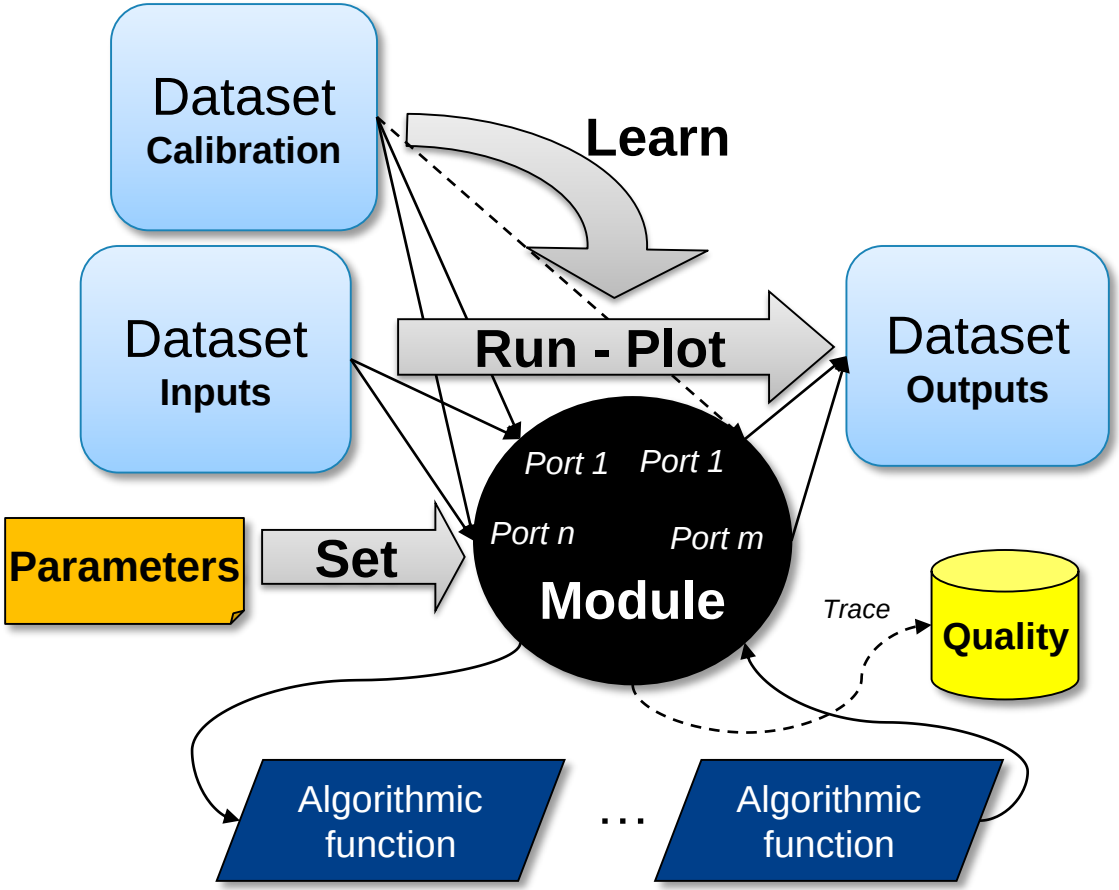
SAMANTA objects – the mnode

- **The SAMANTA *mnode* (short for "module node") is intended for data algorithmic processing.**
- **It allows the wrapping of any kind of algorithm**
  - Uniform interface
  - Standard handling through a graphical interface
- **The module operation is a sequence of several tasks:**
  - Initialization, parameter validation, data accumulation, learning from accumulated data, processing performance on the inputs, display, ...
- **The user also has different methods to use *mnode* including:**
  - **Set** for parameterization
  - **Run** for execution
  - **Learn** for learning
  - **Plot** for display

SAMANTA objects – the mnode

➔ Summary of the *mnode* operation:



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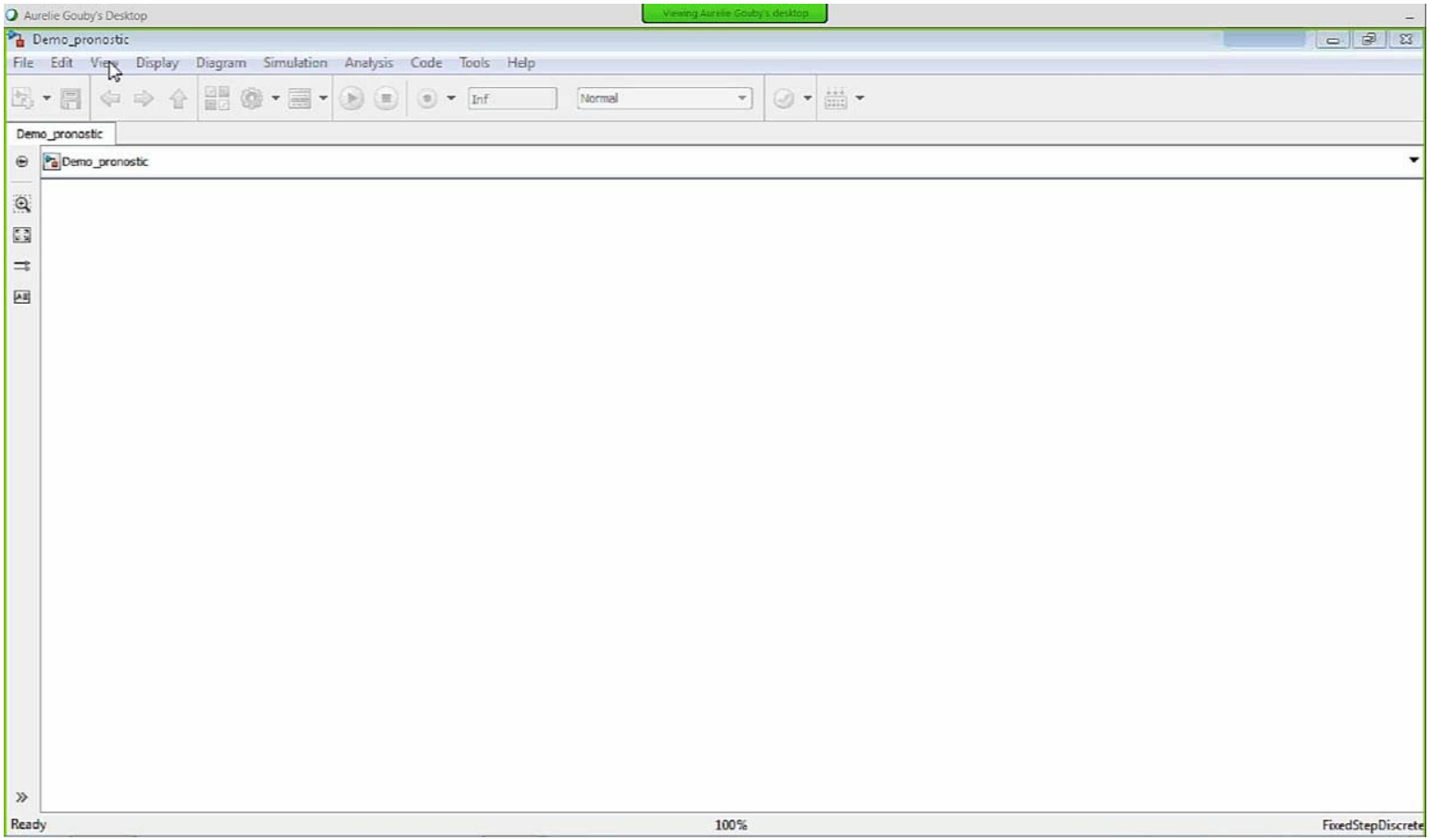
Utilizations

With MATLAB or Simulink

SAMANTA utilization with Simulink

- **SAMANTA platform can be used via SIMULINK**



SAMANTA utilization with a MATLAB script

- **The SAMANTA platform can be used through MATLAB**
  - Create SAMANTA objects you want to use:
    - Treatment Module: *mnode*
    - Input: *opset*
  - Set treatments:
    - Set modules
  - Run treatments
    - Depending on the execution mode selected: run, learn
  - Show results:
    - Via module: plot run mode
    - Via the generated data (*opset*)

- **In 'SCRIPT' mode, execution is a sequence of treatments, each one playing successively its entire *opset* input set and generates an output *opset***

SAMANTA : methods used for the PHM

- **The SAMANTA platform makes use of following MathWorks toolboxes:**
  - Control System Toolbox
  - Database Toolbox
  - Fuzzy Logic Toolbox
  - MATLAB Compiler
  - Optimization Toolbox
  - Robust Control Toolbox
  - Signal Processing Toolbox
  - Stateflow
  - Statistics Toolbox
  - System Identification Toolbox
  - Wavelet Toolbox

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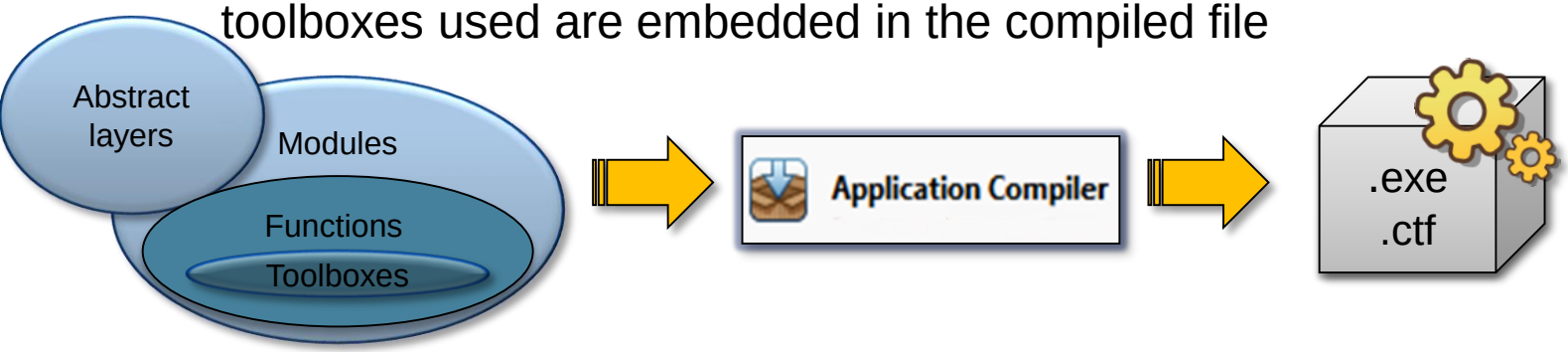
Algorithms compilation and MPS usage

Next steps

Algorithms compilation

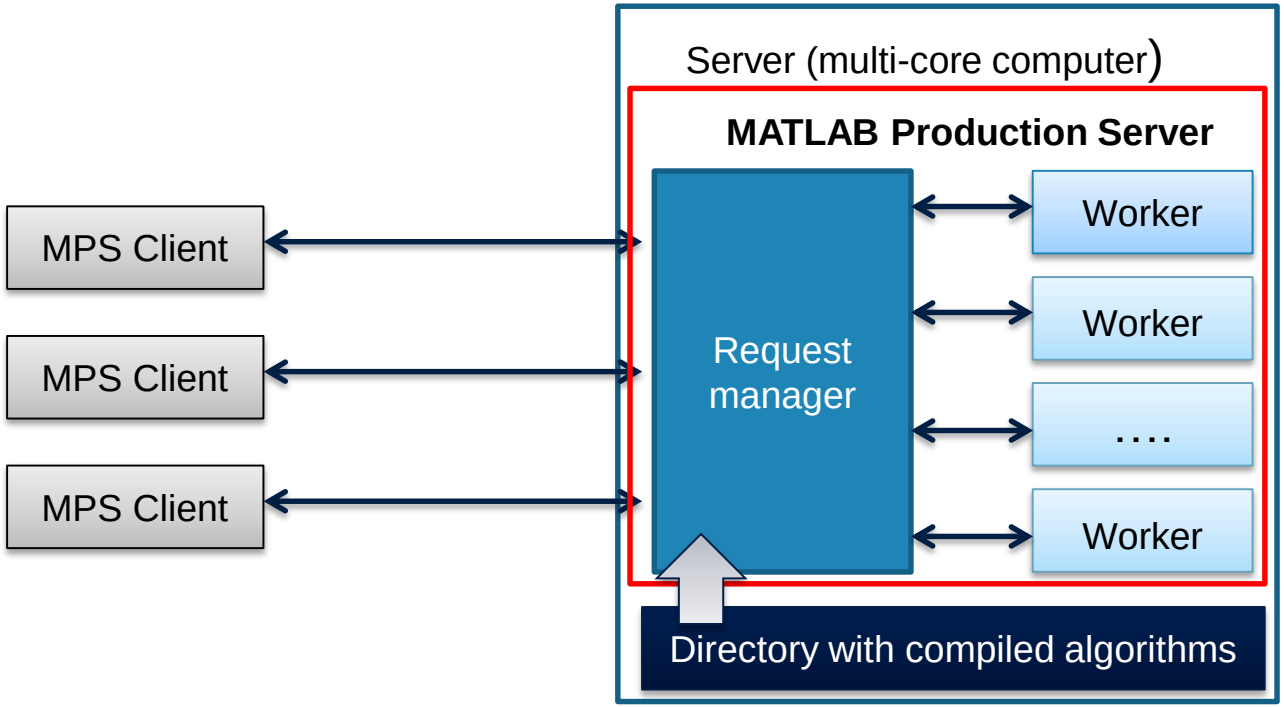
- **SAMANTA algorithms can be compiled to be easily run in an environment without MATLAB.**
  - We use the MATLAB Compiler to create a compiled file from a SAMANTA application (.exe .ctf, .jar, ...)
  - Abstract layers, codes of underlying modules and functions as well as toolboxes used are embedded in the compiled file



- **Once compiled, the SAMANTA algorithms can be used in the same way as in MATLAB thanks to the MCR (Matlab Component Runtime):**
  - Opset reading / processing/ writing
  - Graphic displays specific to modules

Use of compiled algorithms with the MPS

➔ Example of using MPS to deploy SAMANTA algorithms



Manager

- Distributes client requests among the Workers depending on availability (load balancing)

Worker

- An instance of MCR that treats a client request at a time

Directory

- MPS readable directory where the compiled algorithms are deployed

MPS Client

- Client application to be developed with MPS client API available in Java or C #

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Conclusion

Conclusion

- **The SAMANTA platform was created in 2007 and about 160 modules were designed since then**
  - Today about 15 engine monitoring algorithms have been developed, tested and matured through this platform and modules
  - The next step for Snecma is to compile these algorithms to be able to export them and use them in an operational environment thanks to the MPS
- **Thirty people are now using this platform in several companies of the SAFRAN Group**
  - Snecma, Turbomeca, Safran Engineering Services, Sagem,…
  - Among all regular users of the platform, only 1/3 have a computer science background

Thanks for your attention

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