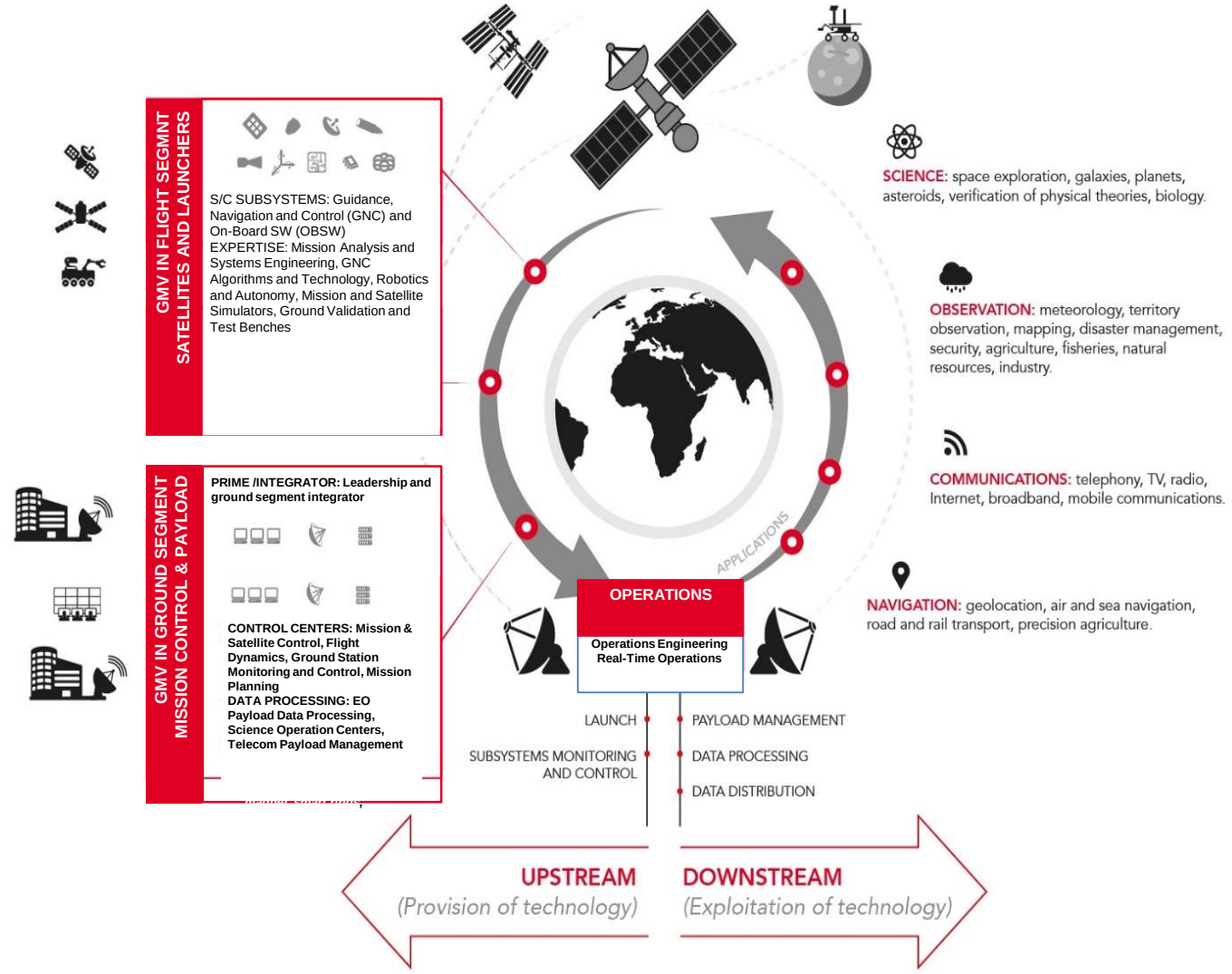
A Holistic Maintenance Strategy for Satellite Control Centers based on the International procedure specification for Logistic Support Analysis (LSA)

Name of Presenter: **Ms. Isabel BACHILLER**
Rank/title of presenter: Head of RAMS and ILS Section
Company/Organization: **GMV Aerospace and Defence S.A.U.**

Abstract-No: **A#21**

Maintenance approach por Satellite Ground Segments: GMV in Space



Objective: Reduce Maintenance Time and High Service Availability

- **HW upgrades:** No impact on operations. Ensure safety of mission
- **Mainteance Strategy:** Reduce failure occurrences
- **Interface with ILS Tools:** Ensure maintenance and Integrity of Data
  - *Logistics Management (material ref data, inventory, suppliers, etc.)*
  - *Maintenance management (plan and coordinate work order execution, collect data)*
  - *Decision Support System for analyzing and viewing collected data and plans*
  - *Common shared database as per ECSS-E-TM-10-10A*
  - *Ticketing tool (TBD incorporate into a single ticketing tool)*
- **Monitoring Strategy:** Nominal/Action needed/Down
- **Planning**: Synchronisation of operations-maintenance
- **Spare configuration**

Maintenance Concept as part of the ILS Concept

- **Levels of Maintenance** for all tasks to be performed on the system and system components in order to restore the functionality and/or resilience/redundancy lost.
- **Preventive / On-Condition Based Maintenance (CBM)** and interaction with the **FDIR system,** reducing failure occurrences.
- **Repair policy,** specifying the extent to which a repair of a component will be accomplished.
- **Organizational responsibilities,** identifying all the stakeholders and functions involved.
- **“Impact to” Vs. “Dependencies from” in operations.**
- **Maintenance Support Elements:** identify spare parts and repair pool, test and support equipment, facilities, personnel and training, in accordance with LSA activities [FDIR]).

S3000L V2.0 updated

S3000L v2.0 Supportability

LSA & In-Service Support

In-Service (IPS) product (S3000L v2.0)

The Logistics Support Analysis (LSA) process is considered a subset of Integrated Product Support (IPS). IPS has overall responsibility for the development of technical information and the support environment used to support a Product throughout its intended life cycle. It is necessary to harmonize the different disciplines in the context of supportability. The main disciplines are:

- design influence
- product support management
- supply support
- support and test equipment
- technical data/technical publication
- personnel and manpower
- IT/software support
- facilities and infrastructure
- maintenance planning
- preventive maintenance program
- Packaging, Handling, Storage and Transportation (PHST)
- training and training devices

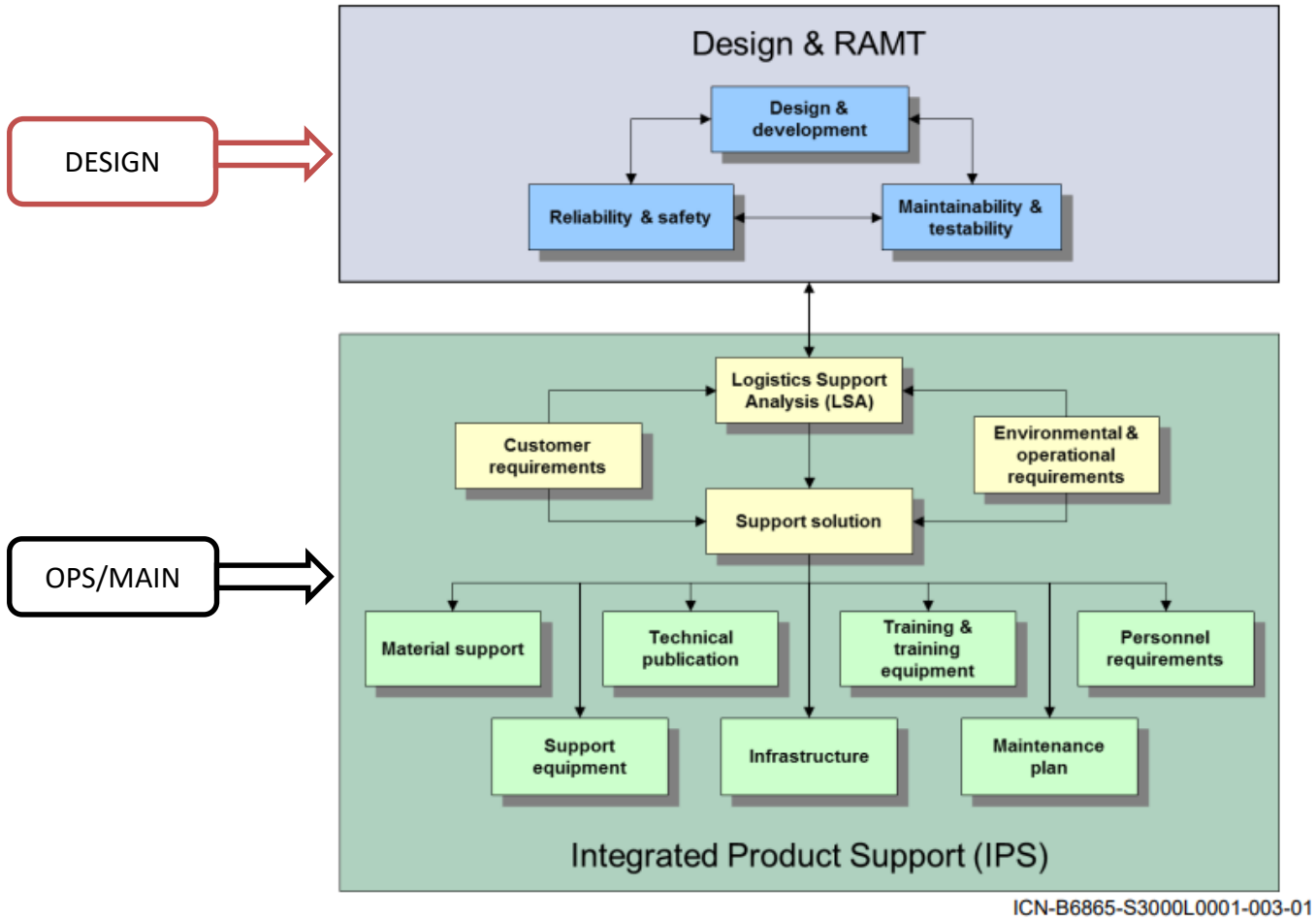


Fig 1 Functional elements of integrated product support

Maintenance Tasks Analysis (MTA)

Traditional Maintenance Tasks improved with MTA from S3000L

CORRECTIVE MAINTENANCE

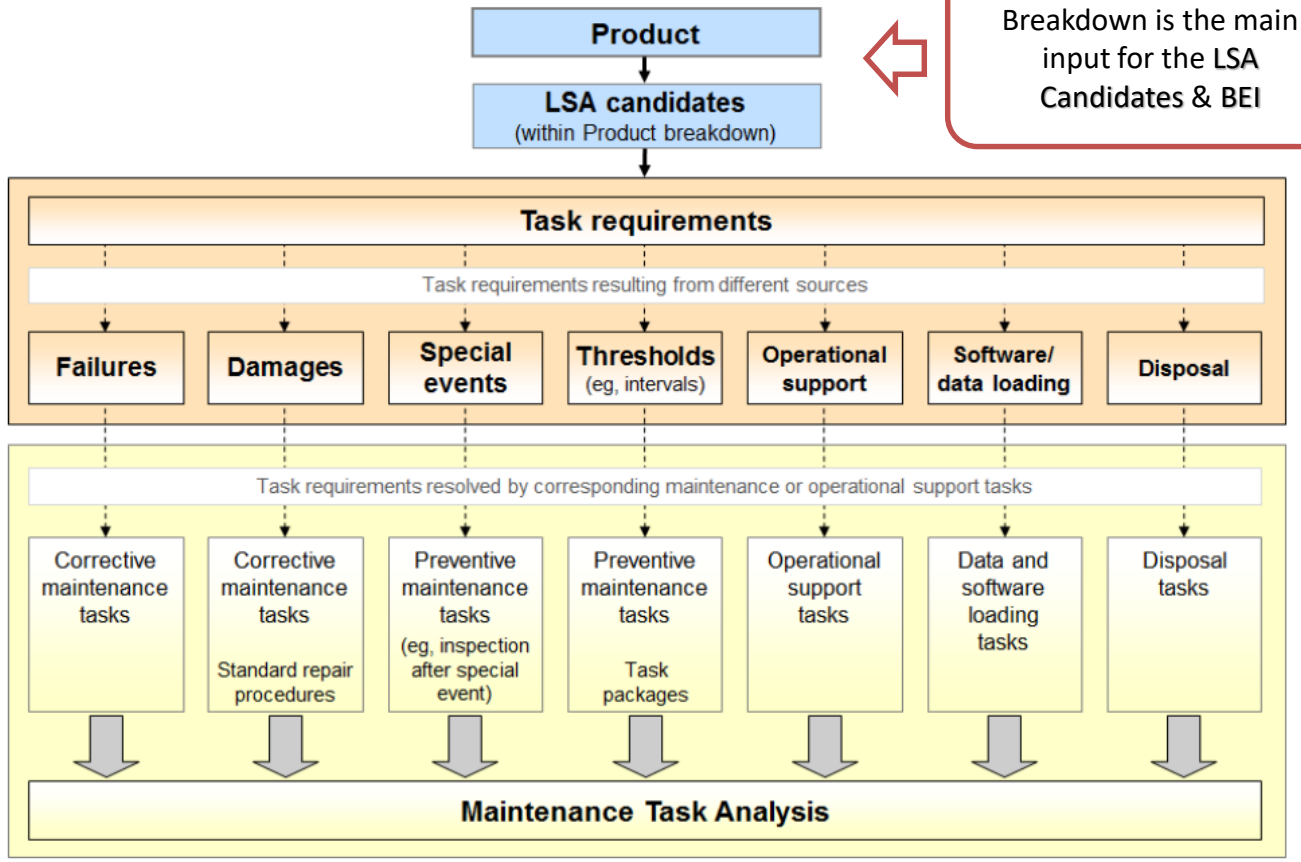
- Improved with a Condition Based Maintenance

PREVENTIVE MAINTENANCE

- Improved with prediction Models

MAINTENANCE TASKS:

1) Failures & events requiring maintenance taks
2) Tasks Identification
3) Tasks classification
4) Tasks Definition



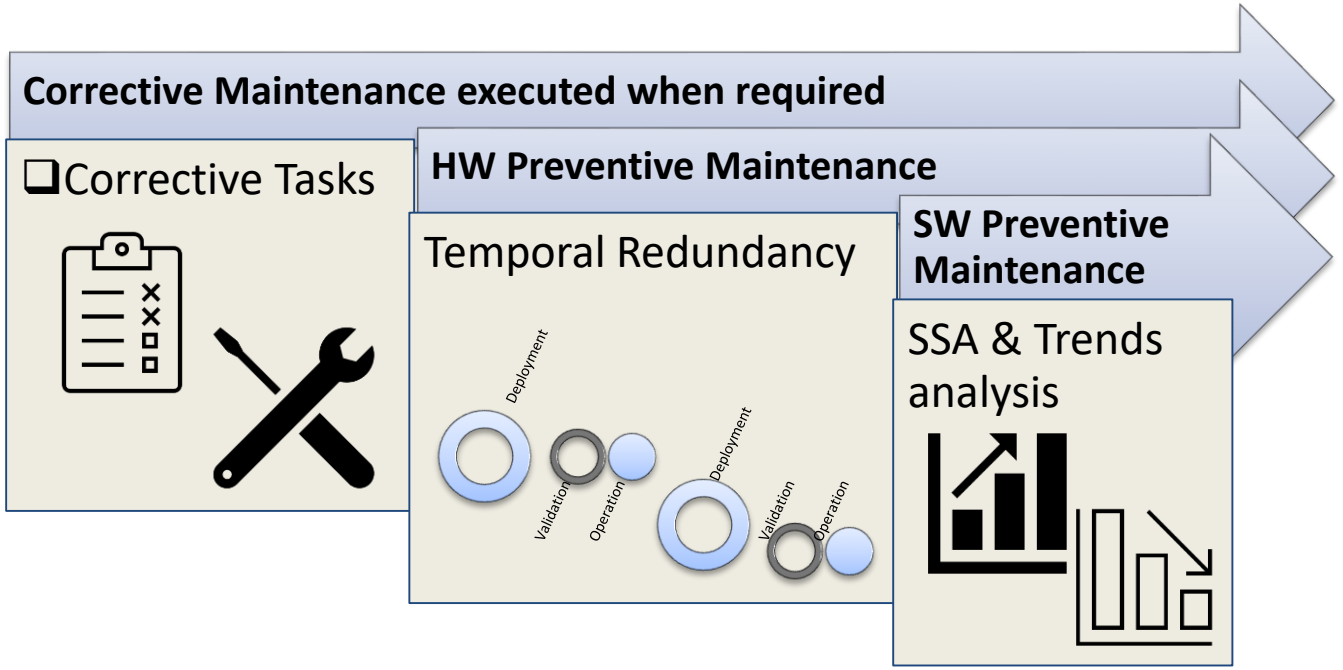
ICN-B6865-S3000L0049-003-01

Fig 1 Relationship between task requirements and support tasks

S3000L V2.0 TECHNIQUES

Preventive Maintenance tasks based on the Operator Maintenance Plan (OMP)

- **HW preventive maintenance**
  - Planned according to the Scheduled Maintenance Analysis (SMA)
  - Based on trend analysis of component behavior and Real-time monitoring
  - Identification of components that need early maintenance
  - Linked to related maintenance procedure
- **SW preventive maintenance**
  - Planned according to the Software Support Analysis (SSA)
  - Based on trend analysis of component behaviour and their real-time monitoring
  - Time intervals
  - FDIR outputs



Failure Mode Effects and Criticality Analysis (FMECA) and Failure Catalogue (FC)

- **Key Objectives:**
- → Propose DESIGN/DEVELOPMENT RECOMMENDATIONS to avoid unavailability/loss of systems

FMECA (Failure Modes Effects Criticality Analysis) To identify failures at different System Levels (requirements, design, implementation).

FC (Failure Catalogue): To trace the Failure Modes to test implemented in monitoring and control.

- **Statement:** Failures as Events  , WARNINGs  & ERRORs  are stored in logs.

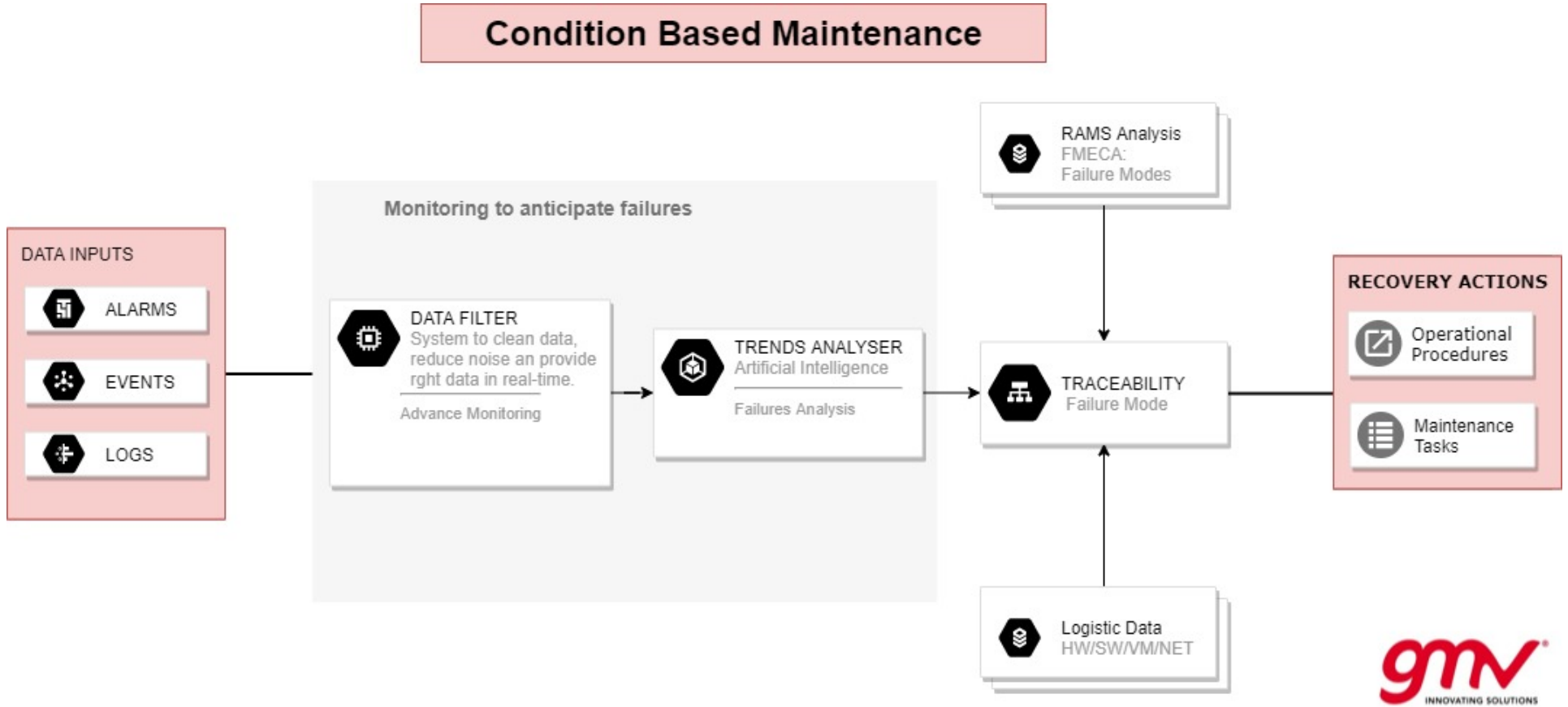
PROBLEM: Operators and/or Maintainers find ➔

EVENTS and ALARM Storms

Maintenance Procedures are defined in a PDF file of hundreds of pages

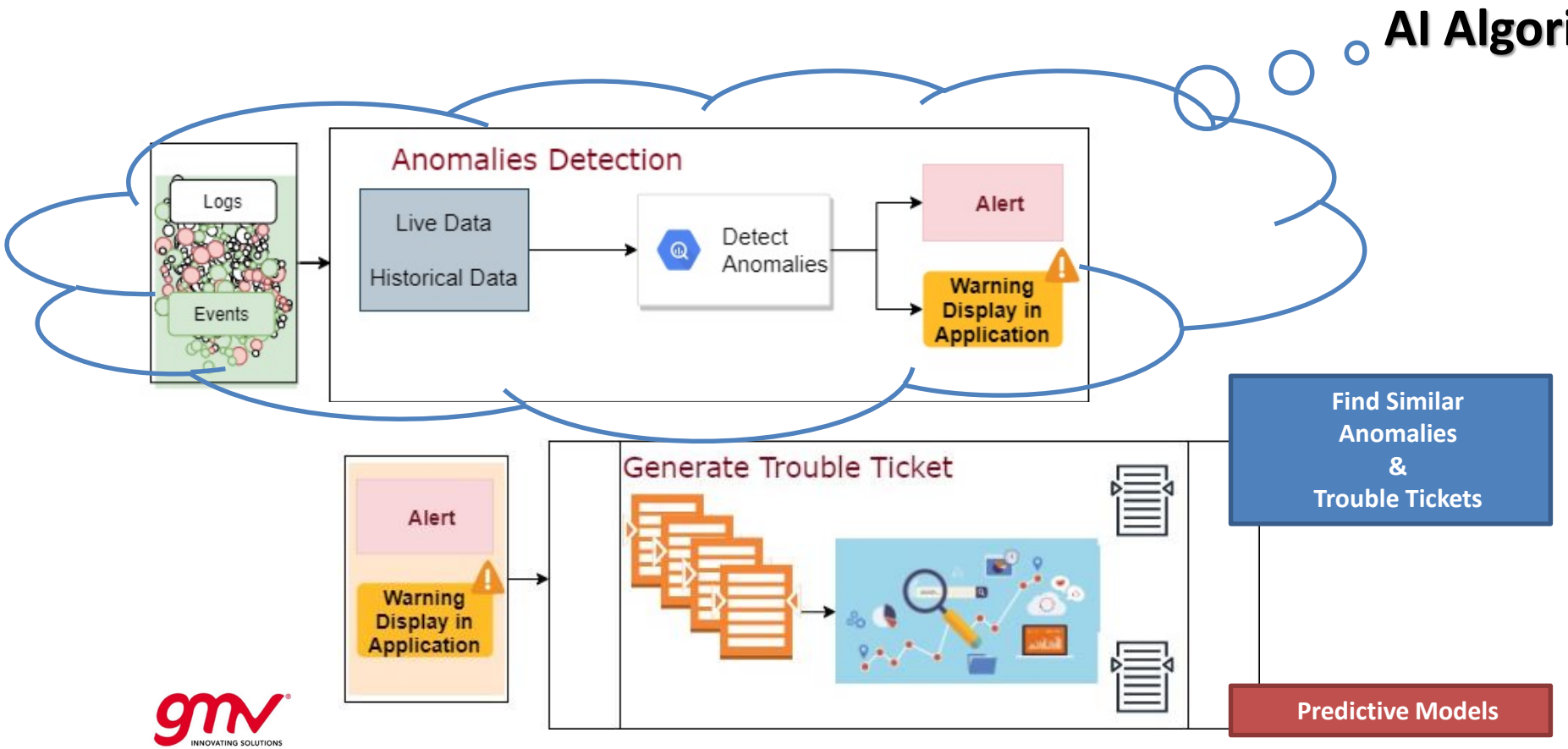
RAMT Traditional Techniques

Predictive/On-Condition Maintenance tasks



Artificial Intelligence based algorithms to identify alarms and failure events

Prediction Model



Prediction Model

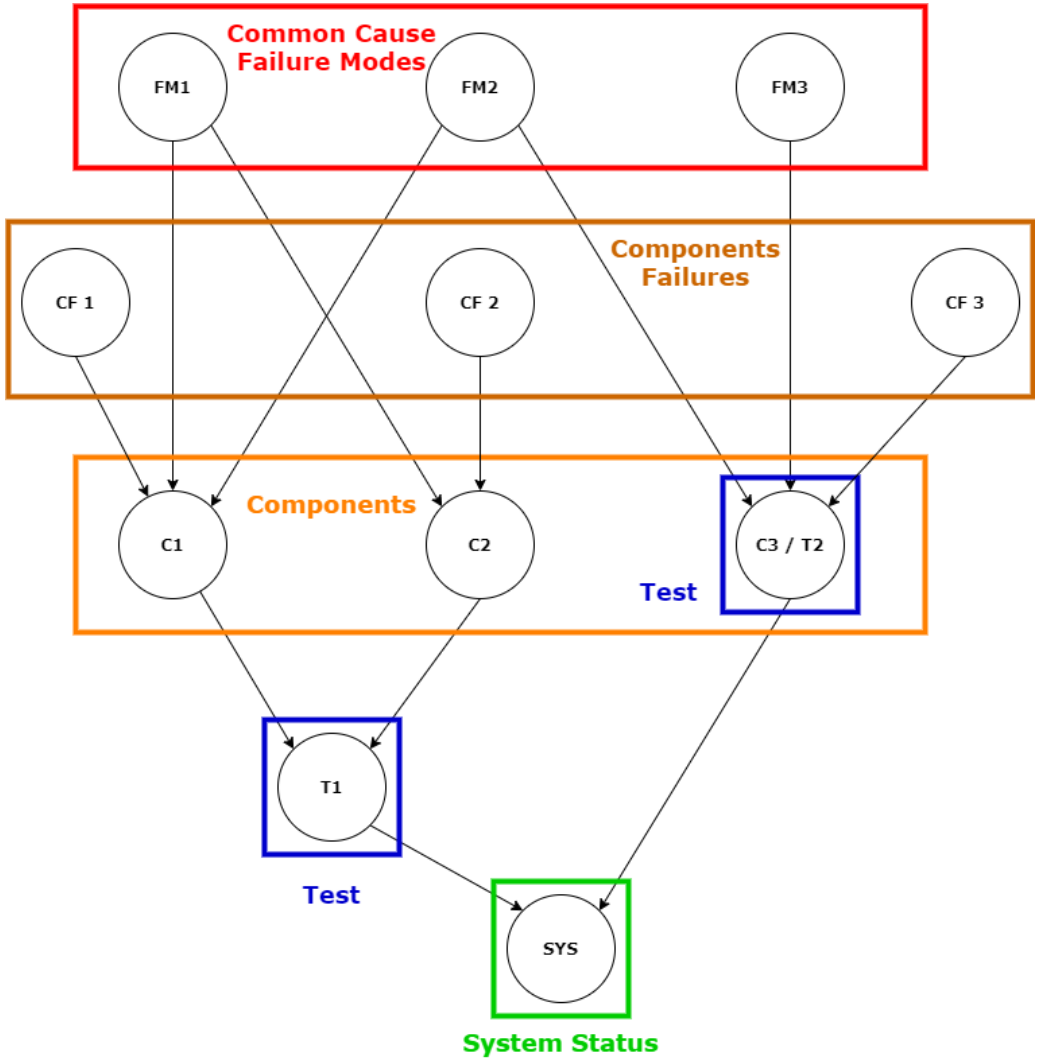
Root Cause Analysis for known failure: Bayesian Networks

System is represented as a Bayesian Network:

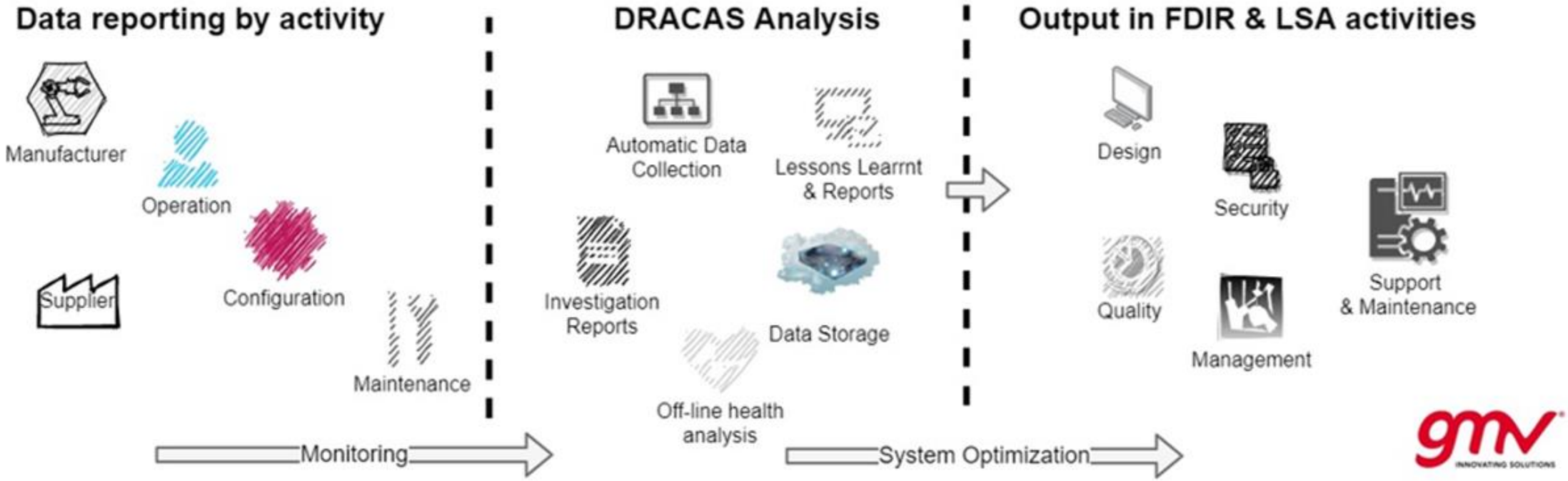
- ❑ Both common cause failure modes, and component failure modes are represented as root nodes.
- ❑ Components are the direct child nodes of the failure modes.
- ❑ Test and monitors of the system are represented as nodes which can give information about the network, called evidence.
- ❑ The network has only one leaf node, which represent the whole system status.

The operation of the known failures RCA is the following:

- ❑ The analyzer is activated when detects changes in tests and monitors.
- ❑ Information of test and monitors is introduced in the Bayesian Network as evidence.
- ❑ Using the evidence provided by test and monitors, inference is performed, calculating the probability of occurrence of each failure mode.
- ❑ Failure modes with not null probability are shown to the operator ordered from most to least probable.



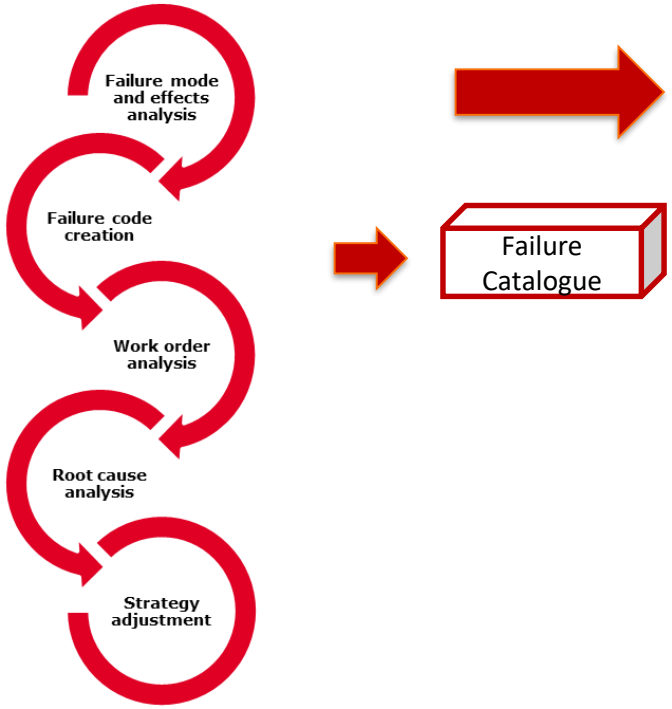
Data and failure analysis based on operational field data

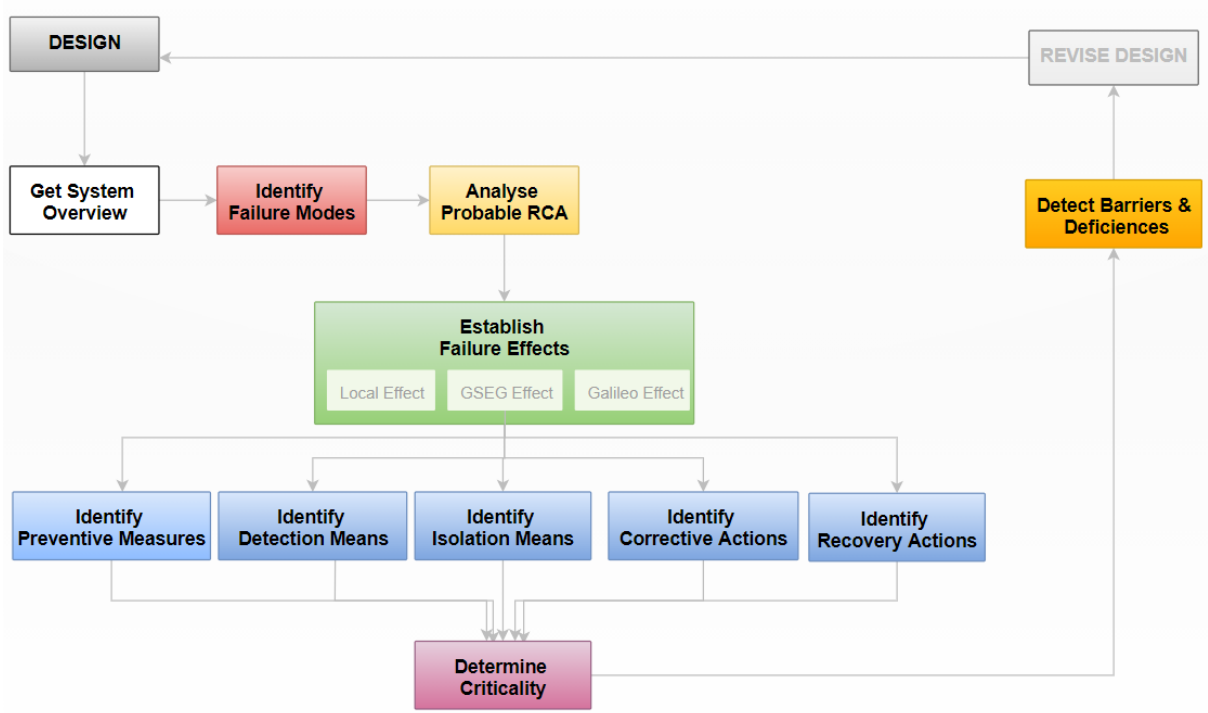


FRACAS / DRACAS

Conclussions

CONCLUSSION





Abnormal behavior to anticipate failures are identified using FMECA and Failure Catalogue complemented with prediction algorithms based on Artificial Intelligence and Machine Learning.

When the failure is detected and its cause identified, the recovery/corrective maintenance tasks will be executed with a minimum system downtime.

Monitoring mechanisms and prediction models will be updated with operational field data

CONCLUSSION

- **Maintenance strategy is based in S3000L**
- **Failures can be identified: FMECA + Failure Catalogue + Prediction algoritms**
- **Mainteance Strategy reduces system downtimes**

  Failure detection → Analysis of Cause → Execution of Recovery / Corrective task

Thank You

for your attention!

Questions?

Isabel Bachiller
Head of RAMS and ILS Section