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A Value-Based Approach for the Evaluation of Investment Options in Oil & Gas Plants

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Arthur D. Little and eni versalis have established a collaboration aimed at developing a structured multi-year Process Safety Management program

eni versalis

- Versalis is a leading multinational Chemical and Petrochemical Company part of the eni Group
- Versalis owns Production Plants all over Europe in plastics, rubbers and bio-based business
- 5.7 million tons of petrochemical products and polymers in 2016

Arthur D. Little

- As the world's first consultancy, Arthur D. Little (ADL) has been at the forefront of innovation for more than 130 years
- Arthur D. Little stands out for its Side-by-side approach with Clients at all levels
- We leverages on a solid experience with companies and governments in complex business and social contexts

Process Safety Management Program

Process Safety Management is a strategic process related to the business performance and in particular to asset integrity, business continuity, safety of personnel, contractors and population, environmental protection and reputation of the Company

In the recent past years, the Oil & Gas sector faced several challenges due to limited resources, assets ageing and stringent standards…

Oil & Gas Issues

Oil prices reduction: after the 60% drop in the second semester of 2014, the Brent price has not gone above US$60 since

Assets ageing: many assets are operated beyond their originally designed lifespan

Stricter Industry Standards and **Regulations**, required by Companies' stakeholders

Challenges

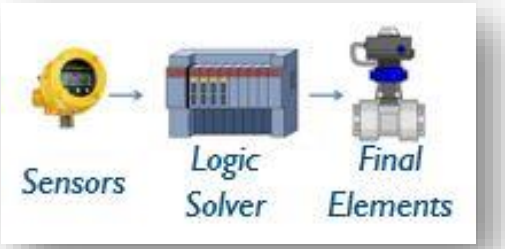
- Oil & Gas Companies face now a choice regarding old assets and compliance with Industry Standards and Regulations:
  - complete decommissioning / shut down
  - large investments into **plant upgrade** and/or **revamping**

… making it essential to adopt structured approaches to support Management decision-making process in **selecting and prioritizing investment options,** so as to create value in the future

A Safety Integrity Level (SIL) initiative was executed as part of the overall PSM program in order to ensure effective management of process risks

SIL Analysis

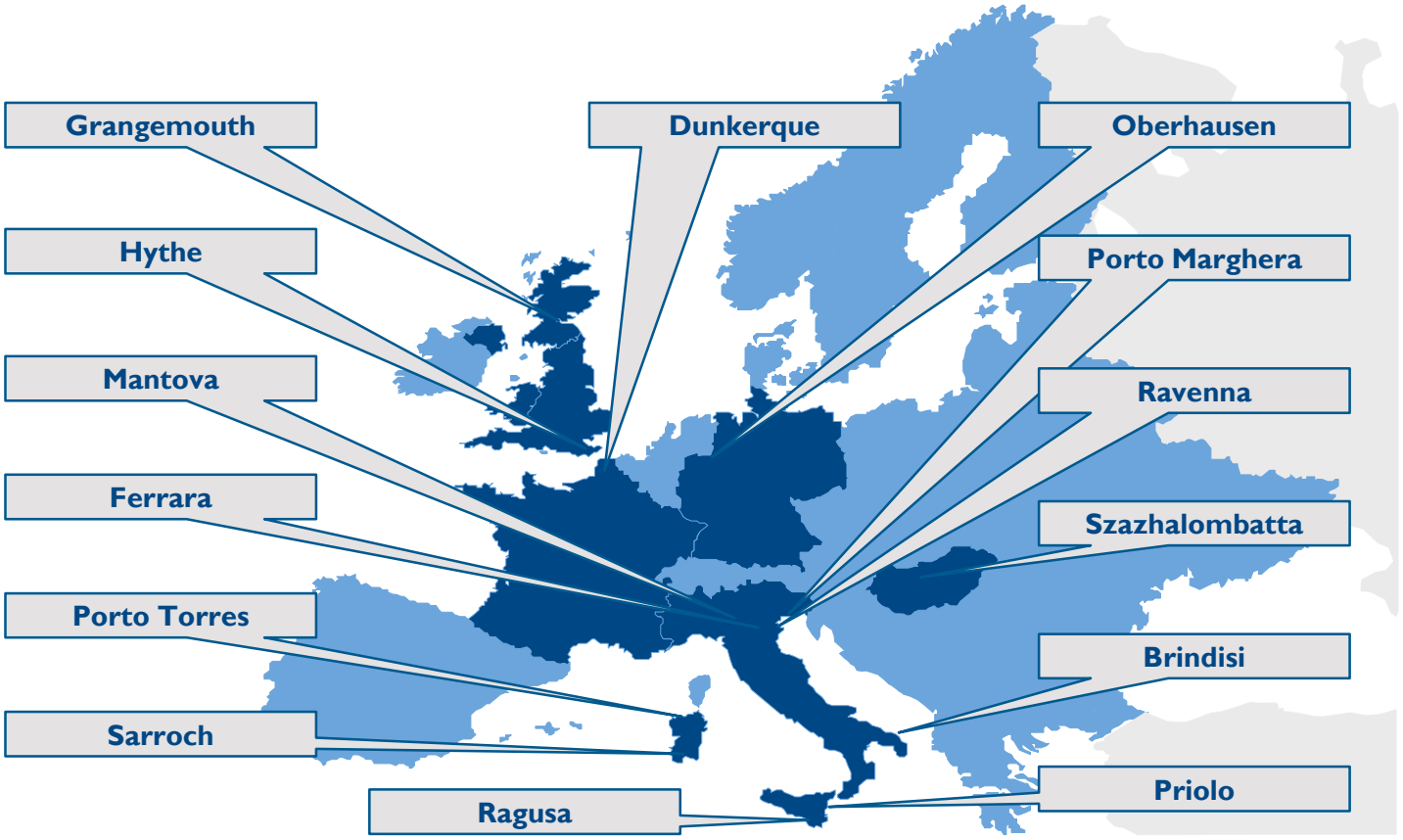
- Safety Integrity Level analysis assesses risks due to the failure of **Safety Instrumented Functions (SIF)**
- Each SIF is assigned a **Safety Integrity Level (SIL)**, which represents an average Probability of Failure on Demand



1. **SIL Allocation** identified the reliability requirements for each SIF
2. **SIL Verification** determined the current reliability provided by the installed components
3. **SIL Optimisation** was applied to SIFs presenting a reliability gap (i.e. SIL allocated greater than SIL verified), determining the improvement actions needed to close each gap

The SIL initiative involved 14 Versalis' Petrochemical Plants: 9 in Italy, 2 in UK e 1 respectively in France, Germany and Hungary

Overall Results of SIL Analysis

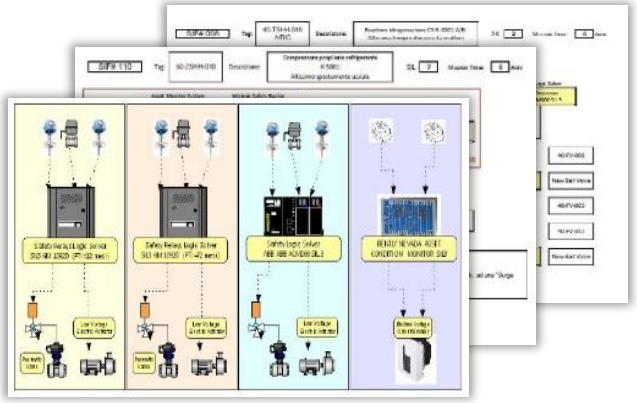


1. **SIL Allocation**
   - 5500 SIFs analysed
2. **SIL Verification**
   - 3000 SIFs analysed
   - 1700 SIFs in Gap
3. **SIL Optimisation**
   - 1500 SIFs analysed
   - 1000 SIFs in Gap
4. **Cost Benefit Analysis**
   - Selection of the most feasible improvement actions to close the reliability Gaps

Improvement actions needed to close the reliability gaps include both technological and organizational measures

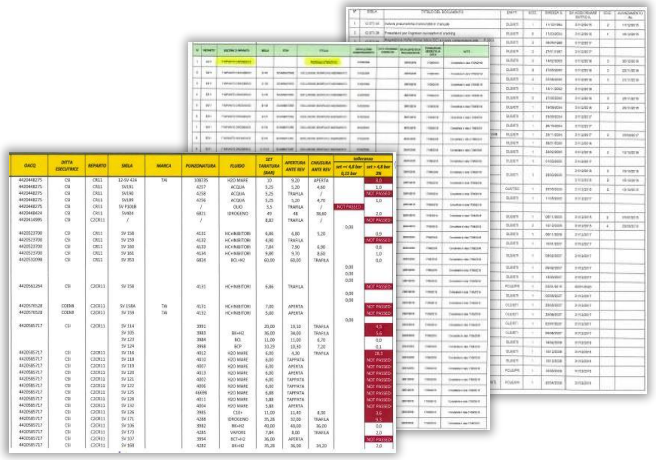
Technological and hardware changes

- Integration or replacement of installed components with **more reliable devices**
- Modification of existing **protection layers** or implementation of additional ones
- Installation of **new alarms** granting enough time for the operator to perform remedial actions



Organizational / procedural measures

- Increase of **maintenance frequency** of installed components
- Revision or introduction of **operating procedures**, **emergency plan** (internal or external)



For each improvement action, required investments involve both implementation and maintenance of adopted measures

$$\textbf{Annual cost of the improvement action} = \frac{\text{CAPEX}}{\text{Depreciation period}} + \text{OPEX}\ (^{€}/_{year})$$

- Following the identification of the improvement actions for each SIF, costs have been evaluated considering:
  - The cost for the **action implementation**, CAPEX (CAPital EXpenditure) (e.g. new safety equipment, new certified instrumentation)
  - The cost related to **maintenance** of the adopted measures, OPEX (OPerating EXpenditure); (e.g. periodic tests / safety studies, equipment maintenance)
  - **Synergies** arising from the implementation of more than one specific improvement action (e.g. the cost of a new Logic Solver which can be distributed on every SIF which will benefit from it)

Note: the depreciation period for the CAPEX is spread over10 years in equal instalments

The application of improvement actions generates benefits in terms of prevention of impacts affecting production, safety and environment

Benefits considered…

… for Production [a)]

… for people Safety

… for Environment and Reputation

Steps for Benefits evaluation

01 **Current risk (R_C)** calculation (before the investment) considering the SIL Verified

$$R_C = \frac{\mathrm{W \cdot M}}{10^{[\mathrm{SIL_V} + \sum_i IPL_i]}} \cdot \varphi_{\mathrm{EF}} \left(\text{€}/\text{year}\right)$$

02 **Mitigated Risk (R_M)** Calculation (after the investment) evaluating the implemented actions

$$\mathrm{R}_M = \frac{\mathrm{W \cdot M}}{10^{[\,\mathrm{SIL_V} + \sum_i IPL_i\,]}} \cdot \varphi_{\mathrm{EF}} \cdot \alpha \left(\text{€}/\text{year}\right)$$

03 Evaluation of **Benefits,** stemming from the risk reduction

$$\mathrm{Benefits} = \mathrm{R}_C - R_M = \frac{\mathrm{W \cdot M}}{10^{\left[\mathrm{SIL_V} + \sum_i IPL_i\right]}} \cdot \varphi_{\mathrm{EF}} \cdot [1 - \alpha]$$

Note: a) Business interruption and Asset damage

b) **W**: Process upset frequency; **M**: magnitude of the accidental scenario; **SILv**: SIL value verified; **IPL**: independent protection layer; φ_{EF} = risk reduction coefficient given by the enabling factors of the scenario; **α** = risk reduction coefficient given by the improvement action

In addition, the SIL program activities can generate relevant indirect benefits

Indirect Benefits

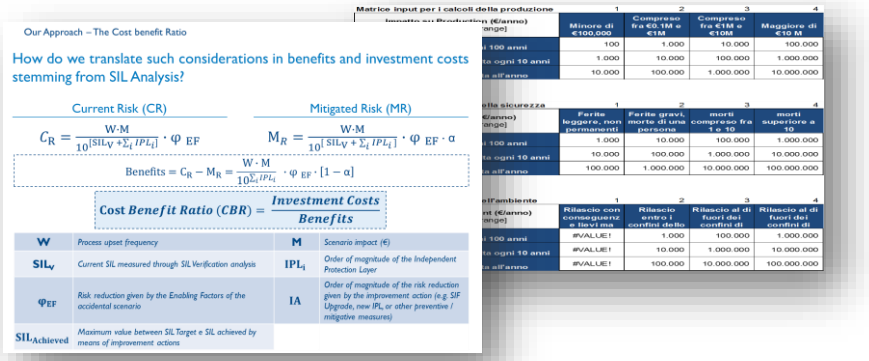
- Mapping of critical SIFs and optimisation of resource allocation
- Optimisation of predictive maintenance planning and replacement of obsolete components
- Certification of the correct application of international standards (IEC 61511 and IEC 61508) through accredited tools
- Encouragement of economies of scale for supplies and maintenance plans
- SIL analysis as proof of solid risk management to external verification bodies (e.g. fire departments, insurance and authorities)
- Improvement of Company's reputation
- Additional value can be generated if all relevant data and documentation developed and retrieved during the SIL program activities are accompanied and supported by digital transformation initiatives

To help select and prioritize investments, two quantitative parameters have been determined during the Cost Benefit Analysis

Cost Benefit Ratio (CBR)

$$CBR = \frac{Costs}{Benefits}$$

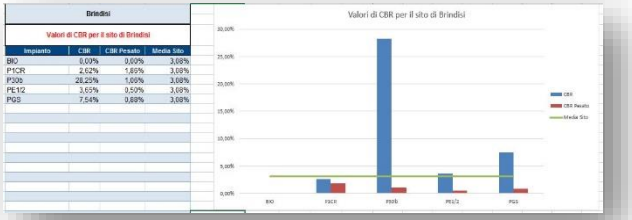
- It represents a dimensionless indication of the **investment convenience**
- Calculated for **every SIF, Plant** and **Site**
- The lower the CBR, the more justifiable the investments



Weighted Cost Benefit Ratio (WCBR)

$$WCBR_{Plant} = CBR_{Plant} * \frac{Plant\ investment}{Site\ Investment}$$

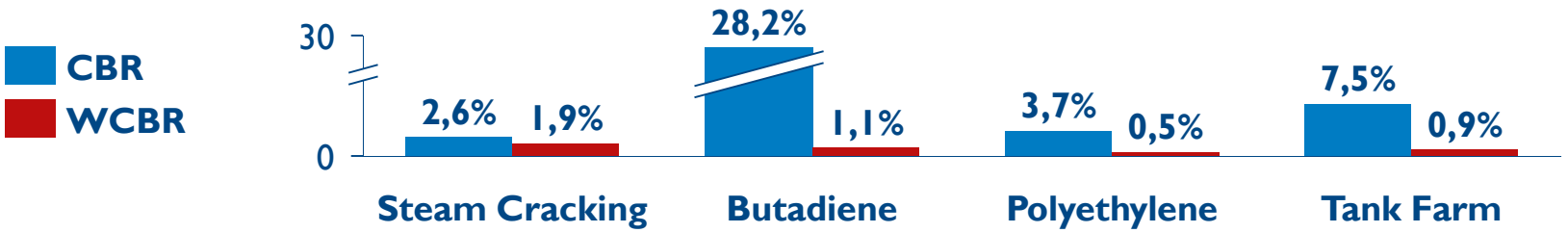
- **It weighs the Plant CBR** considering the fraction of the Site investment required
- Calculated at **plant-wide level**
- Low WCBR indicates that the Plant requires limited investments compared to the overall Site investments



As shown in the example, taken from Brindisi Site, the Cost Benefits Analysis helps Management compare investments and plan resource allocation

Illustrative – Brindisi Site

Total Number of SIF	158	30	273	181
No. SIFs requiring investments	39	2	35	7
Plant Investment (k€)	1,128	60	208	187
Plant investment (% compared to Site investments)	70%	4%	14%	12%
Plant Benefits (k€)	42,988	212	5,955	2,475



- In the given example, the calculated **WCBR**s are lower than 2%, showing that investments are balanced in all of the four Plants in the Site
- Based on Plant **CBR**s, a reasonable resource allocation would be achieved starting to invest in Steam Cracking and Polyethylene Plants, followed by Storage facility and Butadiene Plant

Once Resource Allocation Plans are provided by each Site, the Client Headquarter will consequently develop a structured Investment program

Illustrative

Site	Plant	Year 1	2	3	4	5	6	7	8	9	10
Brindisi	Steam Cracking	1,128 k€									
	Polyethylene				208 k€						
	Tank Farm					187 k€					
	Butadiene									60 k€	
Dunkerque	L52	803 k€									
	Steam Cracking		1,786 k€								
	S & L				1,240 k€						
	Utilities						522 k€				
	Pyrolysis								403 k€		
Ferrara	GP10	549 k€									
	GP26					2,085 k€					
Mantova	PGS	1,114 k€									
	ST40			606 k€							
	ST17				3.6 k€						
	PR7				2,796 k€						
	ST20					2,253 k€					
	ST18						564 k€				
	ST16							546 k€			
	PR11								48 k€		
	ST15								29 k€		
	ST14										55 k€
TOTAL (k€)		792.7	1,149.9	1,301.4	2,201.7	3,334	3,290.1	2,641	1,016.9	705.3	592.4

... ensuring an **effective resource deployment** in its Sites and Plants

Arthur D. Little's framework for the design of a Value-Based Approach for the Evaluation of Investment Options in Oil & Gas Plants

Conclusions

- The proposed Value-Based Approach supporting large investments stemming from Process Safety initiatives involves several benefits, in particular:

Provide a sound basis to assess exposure to risks of oil&gas facilities and plants for complex organisations (multisite and multinational)

Provide a structured and practical methodology to assess the benefits of Process Safety interventions and to evaluate return on investments

Help with the selection of investments and their prioritization

Define objective criteria to compare costs and benefits at Plant, Site and Company wide level

Facilitate the development of a structured investment Plan over time

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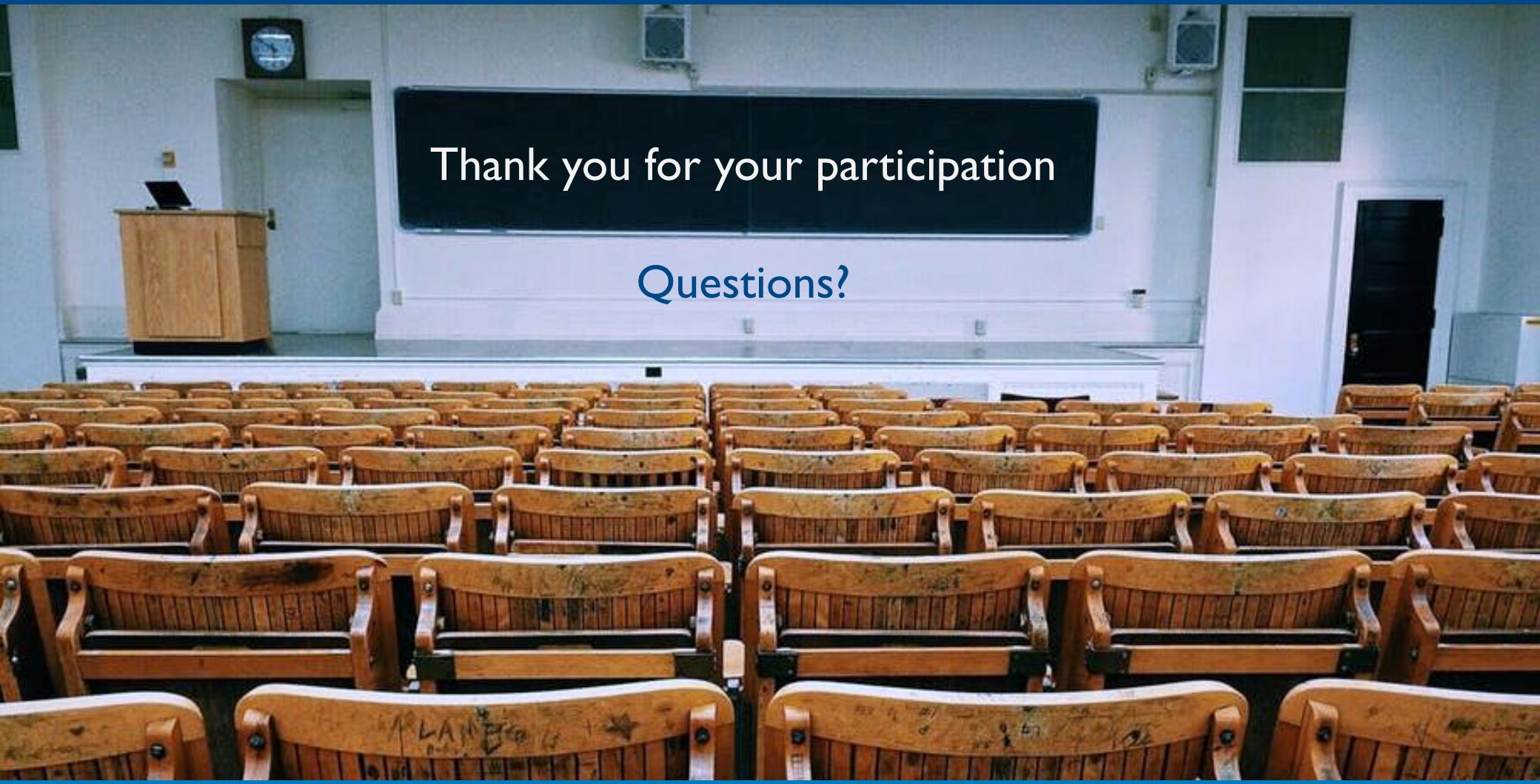

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We navigate our clients through changing business ecosystems to uncover new growth opportunities. We enable our clients to build innovation capabilities and transform their organizations.

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