WE CAN DO SO MUCH TOGETHER

tecnalia

Inspiring Business NANOSAFE 2016 Grenoble, 8th October 2016

Implementation of a safe-by-design approach in the construction of three open pilot plants for manufacturing nano-enabled products targeted to the European aeronautics and automotive industries

Jesús M. López de Ipiña¹, Sonia Florez¹, Richard Seddon¹, Angel Hernan², Xabier Cenigaonaindia², Mario Insunza², Antonios Vavouliotis³, Vasilios Kostopoulos⁴, Paulina Latko⁵, Paweł Durałek⁶

(1) TECNALIA, (2) Sisteplant SL, (3) Adamant Composites Ltd., (4) University of Patras, (5) Technology Partners Foundation, (6) TMBK Partners





DSS2016.EU

tecnalia) Inspiring Business

Index

Project PLATFORM (GA 646307) Project consortium PLATFORM framework for safe product and safe production Motivation and context The regulatory framework for the safe design and putting into service the PPPs SbD principles of the Machinery Directive Link between EHSRs (mandatory) and harmonized standards (voluntary) Harmonized standards Five steps for the design, construction and putting into service the PPPs according to MD requirements (EHSRs) Safe by Design (SbD) and Safety Integration Systematic and iterative approach for risk assessment and risk reduction (EN - ISO 12100) PLATFORM SbD Tool (v1) Strategies for airborne emissions verification (EN ISO 14123-1) To summarize



Open access pilot plant for sustainable industrial scale nanocomposites manufacturing based on buckypapers, doped veils and prepregs (PLATFORM)



The final objective of project PLATFORM is to put into service and operate, in the shortterm (2020), three NEW PLATFORM Pilot Plants (PPPs) for the INDUSTRIAL PRODUCTION and COMMERCIALIZATION of nano-enabled products (bucky papers, treated prepegs, and doped non-woven veils) (TRL6 2018, TRL9 2020 – Business Platform)



PLATFORM consortium



PLATFORM framework for safe product and safe production



Motivation and context

- The future commercialization needs as well as the intended use of PPPs by third parties force the design and construction of PPPs in conformity with legal requirements (CE marking), before putting them into service and made available to workers.
- The Machinery Directive 2006/42/EC (MD) is the European regulatory framework for the design and construction of new machinery - as future PPPs.
- PPPs are not required to comply with the provisions of Directive 2006/42/EC until they are put into service (expected in 2020). But in 2020, all requirements of the MD will be mandatory for PPPs.

The regulatory framework for the safe design and putting into service the PPPs: The Machinery Directive 2006/42/EC (MD)



Motivation and context

- In this regulatory context, project Platform is conducting the design of PPPs to comply with all the provisions of the MD to:
 - 1) facilitate the CE marking in 2020 (TRL9), as well as
 - **2) avoid potential economic costs** associated with future re-adaptations or modifications needed to ensure compliance with MD, when PPPs are put into service.
- The major project CHALLENGE is to integrate all nanosafety issues in the well established SbD process of machinery according to MD.



SbD principles of the Machinery Directive

Principles of Safety Integration (SbD) often referred to as the 3-step method (MD):

1. Eliminate or reduce risks as far as possible (inherently safe machinery design and construction),

2. Take the necessary **protective measures** in relation to **risks that cannot be eliminated**,

3. **Inform users of the residual risks** due to any shortcomings of the protective measures adopted, indicate whether any particular **training** is required and specify any need to provide **personal protective equipment**.

Prevention through Design (PtD), **Safe-by-Design (SbD)** or Safety Integration (SI) are similar concepts that refer to design out hazards or minimize risks early in the design process.



- The Directive sets out the mandatory ESSENTIAL HEALTH AND SAFETY REQUIREMENTS (EHSRs) for machinery while detailed technical specifications for fulfilling these requirements are given in European harmonised standards.
- Machinery manufactured in conformity with a harmonised standard shall be presumed to comply with the EHSRs covered by such a harmonised standard.
- Thus harmonised standards are essential tools for applying the Machinery Directive.
- Harmonised standars: A, B and C-types
- No harmonized standards for nanosafety

Link between EHSRs (mandatory) and harmonized standards (voluntary)

Nano Decision making

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM



EN ISO 14123-1

November 2015

ICS 13.110

Supersedes EN 626-1:1994+A1:2008

English Version

Safety of machinery - Reduction of risks to health resulting from hazardous substances emitted by machinery - Part 1: Principles and specifications for machinery manufacturers (ISO 14123-1:2015)

Harmonized standards



Five steps for the design, construction and putting into service the PPPs according to MD requirements (EHSRs)



							1 HIERO CONTRACTOR NO 1	HER ESTIMATOR JEOTH IN COLORING								A REALTHANKER AND REALEDON WAS ADDRESSED.								
e Machin	10 201 P		Oje	using mode			Reard	Hazardoux situation	Hazandous event			Risk	before)			Measures Autorians for Risk reduction				(Alw)			Standards	Verill
°n n			1 1	_						144	Peer a	1	Arrest	Classic		Description	1	ł	1	a set	Clean C			
	Dependen Co	Commissioning	*	Annale	75.1	Res material	Expression in 1887 CMT by impaction, consistent with solar, spons or manufactures or parameterized solar.	Operator leading (maring) the OLT devolution (devolution containing MICOV)	Emission Justing of selecting of a fact containing MATOR!		6			+1		A safety containment hank located under the risk area with arrange- requests, thus of protection applyment (places, charminal glences, protection electric); Automated half samelening spakes (pump)		2	4			LON	Pargenes Nations Noriging Docket, Inter Mil. Nr. 49. Guartes Tables park or an an En 199 Guartes de protectio anna ta policitas e foi nel Guartes de protectio anna de	
9	Dependen Co	Camilacianing	**	Menor 1	75.1	Ray material	Expressive in HEVCOT by impaction, constant with salar, eques or manuax membraness or persentation itsnigh salar.	Operator leading (searing) the OVT detailation (should derive sentering MVCNP)	Emission (asking or spisaling) of a failt containing MATOR?		6			41		A salisty containment task located under the cick area with arrange cospectry, then of protection applyment (given, chemical givenes, protection stationg). Assessment that two-barring system (pump)		2			4	LON	Bargona makia nongripolodich mas UM An JA Guaras nations pas in an an Pe tre Guaras is process in proteins a tre constant protein.	Π
9	Dependen La	in	*	Annate	71.1	Ray material	Expression in MECOLT by impaction, contact with skin, spins or maximum manufactures or penaltocker investigit skin.	Operator baseling (maring) the OAT description (description containing MIPOR)	Emission (assing or spinaling) of a fault somating birt OC.		6			41		A salary containment hank housed under the risk area with arreagh requests, then of protecting any investigations, interview generations, protection statistics). Automated that transforming system (party)		2	4			LON	European materials monophysical deficitions with the Alexandra materials and any services for the Gaussian Representation processing performance of the Company of the Comp	Π
	Dependen La	- Una	**	Menori 1	75.1	Res material	Expressive in HEVCAT by ingenition, containt with salar, eyes or manufacture membraness or permittaken through salar.	Openator Assilting (searing) the CNT detailation (shouldars containing MNCNT)	Emission (asking or spisaling) of a fast somating MATON.		4	3	3	41		3 salary containment task located under the child area with arrange requests; One of protection any protecting locates, protection electricity, Automated India nanolening system (surrey).	3	3	4	4	4	LON	UM AN AN COMPANY TO APPLY TO ANY THE UM AN ANY COMPANY TO APPLY T	Π
6	Dependen Co	Cananiasianing	*	Annate	71.8	Panalog likeleg visige	Expression in MECOLT by impaction, contact with skin, spins or maximum manufactures or penetroliker investigit skin.	Operator proving the serio and CNT description (description containing MIPCHP)	Emission Justice or spinology of a fault somating MATOR.		6			- 11		A subity containment have located under the risk area with arrough sequency, thus of protection any protect glocus, sharround glocus, protection statistics). Automated half nerslaming system (party)			4			LON	Depose hande horspip books, take UM At AN Gurne takes per or an an EX IVE Gurne is precise arrange peters	Π
4 10	Dependen Co	Cammissioning	**	Menal 1	71.8	Panalog lianing stage	Expressive in 1897 OcT by regardine, contact with salar, expressive macross membraness or permittaken Rocagit salar.	Operator proving the serio and OVT description (should be containing MNCH7)	Emission (anting or spinstory) of a fast contacting birt (24)		6			41		A salaty cantalonant task located under the risk area with arough capacity, loss of protection applicants (please, sharolind gleases, protection circling). Assessed had transforming spaces (party)	3	2	4		4	LON	Response Autoritie Haraging standards, Index shall also alle Suarrais Harbins parts of any sea Dis trit Guartee de protección anna sua politicas	Π
7 10	Dependen La	ine .	*	Antonaie	71.8	Passing litering utage	Expressive in HEVCAT by ingenition, containt with salar, eyes or manufacture membraness or permittaken through salar.	Operator proving the serie and OVT description (should be containing MICOVT)	Emission (asking or spisaling) of a fast somating MATON.	4	6		4	41		A salary canadower back located under the chil area with arough capacity, then of protection application (given, showing given, protection circles); Anamated half transforming system (party)	а	2	4	4	4	LON	Pergena righta forgerg stodert, rate META AN Guaran holding pet et alle an De tre Guaran de processo anteres a potente e la forgeración	Π
1 0	Dependen La	- Unit	**	Menal 1	71.8	Family lianing sings	Expressive in 1887 OcT by ingenition, contact with takes, eyes or maximum membraness or permittaken Proceeds takes.	Operator proving the serio and OVT description (should be containing MNCNP)	Emission (seeing or spin-bing) of a fault somaining MATOR?	- 1	6			41		A safety vertainment and insule other the table area with enough requiring the efforts the explorated gives, sharring gives, empirical protocil. Assemblies had a productive source (same)	а	2	4		4	LON	Antiperta fatera fatera sera e anti-	Ħ
0	Chiperson Ch	 Cisaring 		line .	71.4	Ceuring	Exposure in MPCAT by repairier, consert with size, eyes or	Causing and managements of the sorterator by or	Constraint a fusion arrang MVCNT is		4	4		44		Provalues for cleaning and maintenance, training	3	4	2	4	7	MEDIAN		T
-	Fileing Co.	Canniacianing		Annak	12.3	Marine statup	Exposure in MPCAT by operate, contact with take, eyes or	Filming steps is serving	File lead-up during operation	3	3					File folio deardoring in della ad ancie control passan	3	2	6	6	4	LOW		1
-	Fileing Co.	Cannacianing		Annak	12.3	Marine statup	Expension to MPCOVT by Expension, contact with sales, eyes or	Fibring steps is serving	The lifes of its and all and there is no more lifes to be held	h	4	4	h	44		Barnur is detert rail and rg	2	2	2	4	4	MEDIA	Parlamentation (Pc) animalian (PC Ini 1988) anti-	
-64	Nate Mater Co	Camilacianing	٨	Antonia	12,3	Marine statup	Expression in 1887-ChT by impaction, constant with takin, expressor manuace maniferences or parameteristics through takin.	Planing stage is serving	Weak wate containe junitating MEOC) is meriliariant and easter water instage accurs.		4	4	à	+1		Final and a container level samer with appropriate safety level (depination if resulted and normal stop after level maches) (safety extra space must be let in the consider the Disater design semal	3	3	2	4	6	MOLM	Performance and (Pe) and ratio (Pe this sector and)	
-	Filming Co.	Canniaciariog	84	Nexa11	12.3	Mohine startup	Expresses in Mir Orl' by reparter, contact will star, eyes or	Fibring steps is serving	Film leadury during operation	3	3	3				Filer hotor dimensioning on design and lension sorted (second	3	2	6		4	LON		1
-	Fileing Co.	Canniacianing	84	Network 1	12.3	Marine statup	Expension to Mit Chill by ingenities, contact with side, ages or	Fibering stage is serving	The lifes of it, and all and there is no more	h	4	4	3	44		Barner to Artist reliancy	3	2	2	6	4	MEDIAN	Parlamenta (Pc) animalian (PC Ini 1988) anti-	-
-	Nate Mater Second	Camilacianing	**	Menal 1	12,3	Marine statup	Expenses to MECOT by regardler, contact with skin, eyes or manual numbers ar percentation through skin.	Planing stage is serving	Wester water container (containing MEOC) is monthlast and assets water instage accurs.		4	4	à	+1		Final and a container level samer with appropriate safety level (depination if resulted and normal stop after level maches) (safety extra space must be let in the consider the Disater design semal	3	3	2	4	6	MOLM	Partment and (Pc) animatics (Ph bit 1989) and	*
-	Fileing Lin	- Una		Annak	12.3	Marine statup	Expressive to MECOLT by impaction, contact with sales, eyes or	Fibering steps is serving	File leadup deing spectro.							File histor dimensioning on design and tension seried barran	3	2	4	4		LOW		1
-00	Filming Liv	- Unit		Annak	12.3	Mohine eleting	Expression in Self-Chill by ingenition, contrast with sales, eyes or	Fibring steps is serving	The lifer of it and all shall be a name	3	4	4		- 11		Earney's detect relianding	3	2	2		6	MEDIAN	Performance Least (Pc) and ratios (EX10.2 Years), and a	1
-	Nate uster stepad	ine .	٨	Annale	τι,	Martine start-sp	Express to MPCNT by regulation, contact with skin, eyes or manual transformers or percendent integet skin.	Placing steps is serving	Varia varia containe (containing MiCOE) is sentilised and assist water lashage secures		4	*		*1		Trade autor container lovel camor with appropriate calory lovel (Replication F resolut) and somet sing stran lovel searchest (subay extra space much last in the considerer for literator during service extra space much lovel and strangest service.	а	3	2	4	4	MOLM	Parlamentari (P.) animata (P.163 (1993) atrij	
-	Filming Lin	- Una	84	Revol 1	12.3	Mohine eleting	Enjoyune in Mir Chill by regarder, contact will said, ages or	Fibring steps is serving	Film leadury during spanation.							File hour dramaning in daily and areas would be use	3	2	6			LOW		
-	Fileing Lin	- Una	141	Nexal1	12.3	Marine statup	Expension to MECOLT by impaction, contact with sales, eyes or	Fibering steps is serving	The lifer roll is anded and there is no more lifes to be left		4			41		Barrow to detect relianding	3	2	2	4	4	MEDIAN	Parlomanus Last (%) animation (IN IK3 TRANST 2015)	Т.
-93	Nate user Lin	ine .	**	Menor 1	τι,	Martine start-op	Express to MPCNT by regulation constant with skin, eyes or manual transformers or presentation through skin.	Planing steps is serving	Varia varia containe (containing MiCOE) is sentilised and assist water lashage secures					*1		To where evolve increasing level service with appropriate safety level (Replication F resulted) and service sing where level services are level to be considered for fitted and services are activated as a service are services.	а	2	2		4	MOLM	Partmenting (P) animalie (PA bit 1993) anti-	
8	Filming Co.	Constanting	*	Annak	72.4	Adding liker	Expresses in HEVOLT by impaction, contact with skin, spec or marries membranes or president inneghtalism	Operator passing a new like through the tallers	Containable residual fusit containing WECKT under Par services sharehar ar Par west The	3	4	3	4	a		Joining the new liker with the previous, one was that the previous, liker guides, the new stre.	3	2	4	4	4	LON		Τ
-	Filamp Co.	Cannissianing	**	Nerval 1	72.4	Adding like	Expressive to MECOLT by impaction, contact with skills, eyes or marines manifestates or paralitation through skills.	Operator adding like under the sursoon chamileer	WIChT under Har sacuran shamker ar for past film		4		4			Joining the new like with the previous one so that the previous liker guides the new sea.			4			LOW		
9	Fileing La	ar promotioni ar promotioni	4 A	Annale	12.1	Adding liker	Expresses to HEVOLT by inpution, contact with skin, eyes or manual membranes or provinsion inmugh skin.	Operator solding like under the suscess chamber	Containable residual fusit raniableg MICOIT under ite samaen shamker ar for each Dar	3	4		6	a		Joining the new like with the previous one sus that the previous like guides the new stre.	а	2	4	4		LON		Τ
-02	Fileing La	ar programmed to all	-	Reval 1	72.4	Adding like	Expressive to MECOLT by impaction, constant with salar, expressive manuses manufactures or presentation incough salar	Operator adding like under ihe cancers chamileer	WIChT under ihn variant chamilier at file aut file		4		4	0		Joining the new like with the previous are us that the previous liker guides the new stre.		2				LON		
8	Pasing 1 filtration Co weating	Constanting	*	Annak	72.4	Adding liker	Expresses to MECAT by inpution, contact with skin, spec or marines membranes or provinsion inmugh skin.	Buckgraper is passed from the like	Contact with wet Backgrouper contacting MNCN	3	6	*	4	44		ina alpoiada approxi gina, chanical ginner, potesta salang	3	2	6	4	4	LOIR	UNL PER AN Guarna maintea para at ante ana En 1918 Guarnas de protocolas antres ha poductea quinceas y na formaripaciantea	T
-	filmation Con matching	Cannissianing	81	Menal1	12.1	Adding liker	Expresses in WEOCT by ingestion, contact with skin, open or marines membranes or parameterism inmagit skin.	Burigaper is partial from the like	Contact with wet Rectipager contacting MINCN	4	6	4	4	44	and an	ina oʻpnlarita aqipmati ginas, shanisai ginnas, polasilar asalogi	3	2	4	4	4	LON	UK 25 25 26 Source hadres par or an est Ph 154 Gaunes in protector source to protection p in home protection UK 25 25 25 Contract factors and an est of	_
47	filmation Line	- Una	*	Antonale	72.4	Adding liker	manas hantearas o pereinder Proghain.	Burigaper is posial hars the like	WICh		6	4	4	- 14		entrol post cauco boot barren barren	3		6	- 6	4	LOW	En 174 Guartas de prosectio acora los podurtes quintina y se formariperantes	
-	filmation Line	- Una	-	Reval 1	72.4	Adding like	Espenare in MFCNT by inpution, contact with skin, eyes or manage membranes or personalest incorpt skin.	Buckgraper is passed from the like	Centeri alli set Buchpaper serialning MNCN		6		4	44		ina siyotatia apiprati gina, shanini ginan, yolotia Johog	- 2	2	4		4	LON	Pe eta lisartas de procesiar acres na polarta quintes y las historipetantes	
ą	Filming Co.	Cauring	EP-	End production	12.6	Cearing	response to the city opplical, carried all city, spectral manage transformers at secondaria fronds allo	Operator cleaning its pool and the carson chamber	canadi and manual fair 2018/2019		4	4	3	44		Provalues for cleaning and maintenance, training	3	4	~		7	MEDLM		1
-	Washing Co.	Commissioning	*	Annale	73.4	Adding liter	Expressive in SECOLT by regardine, contact with salar, expressive macrosc manifestatis or parameterism Record Falar	Operator possing the shallost water from the part	Contact with residual half incontainer contacting MICOD		4		- 8	-		A salaty cartalonant task insulat under its risk anar silt arough requestly, the elementar explorant (pleas, sharring genes, protecter station), Assectant bal nandoring quart (purp)	а	2	4	- 4	4	LON	Bargeria hanna hongrip socketik. Han Mil At At Garna hongrip socketik on Et 474 Garna is potentik sortektik pitertik UK 474 Garna is potentik sortektik UK 575 Garna istori	
-	Washing Co.	Cannissianing		Annale	Thi	Adding liter	Regionard & Mercula by republic, contact with sale, eyes or manages manifereness or parameterism through sales	Operator adding like under the cancers chamber	centering MiCOT	- 2	- 4	- 3		40	-	using the new two way we had been that the previous liker publics the new one.	۰.	2	- 6			LOH .		+
-	Washing Co.	Canniasianing	80	Kinusi J	Thi	Addingther	Reprised to the short of republic, contact with sale, eyes or marine membranes or security for thready size	Operator adding Dar under the cancers chamber	canadi anti manadi kali koomkahar canapina MPOP		4		- 1	40	3	salah be new we we ma province the so that the province liker middle the new stre.	3	2				3		_
-	Marting Do	ar processioni	1 ×	Annak	Th.4	Adding like	Expensive in MECOT by impositor, contact with skin, eyes or manuals manifesteries or penetration instagle skin.	Operator acting like under ihe cancers chamileer	Contact with residual fluid in container contacting MICOD		4			- 10		Johing the new like with the previous are so that the previous liker paints the new one.		- 2				LON		
		174 DELLA					1 personal composition		- Income	_	_			_					_					_

The process has been guided by the harmonized standard EN ISO 12100 (and EN-ISO 14123-1,2), taking the relevant phases of life cycle, expected uses and operation modes of PPPs into account

Systematic and iterative approach for risk assessment and risk reduction followed to eliminate hazards as far practicable and to adequately reduce risks by the implementation of protective measures (EN - ISO 12100)







- PLATFORM SbD Tool (v1) is a simple and friendly Microsoft Excel tool to guide the safe design and risk assessment of PPPs, in accordance with the EHSRs of the Directive 2006/42/EC.
- This tool can be applied to the overall risk assessment of PPPs or only for risks related to the use and handling of ENMs and NEPs.

PLATFORM SbD Tool (v1)



1.3. RISK	ASSESSMENT AND RISK REDUCTION									
MACHINE ZONE:	Drying tunnel									
LIFE STEP:	Use	Create a new worksheet for each Life Step and	lor Op	erating	Node	(Clik e	on the tab, Move or co	ру, С	reate	а сору)
OPERATING MODE:	Normal									

	2. HAZARD II	DENTIFICATION AND	0 3. RISK ESTIMATION (IS	O/TR 14121-2:2012)				4. RISK EVALUATION AND RISK REDUCTION (ISO/TR 14121-2:2012)											
Pof	Taek	Hazard	Hazardoue eituation	Hazardous event	Risk	(bet	fore)	Measures /solutions for Risk redu	ction		Risk (af		er)	Standarde		Ver	ificat	tion	
iter	Idək	Tiazai u			S	Ρ	R	Description	Туре	SF	S	Р	R	Standarus	Ν	М	FT	DV	С
A1-O-A1-01	Drying the buckypaper	Respiratory disease due to inhalation of and aerosol of toxic substances	Operator is driving the machine (Drying)	Emission of a substance that can be hazardous			0	Installing an exhaust system with HEPA filter					0	EN ISO 14123- 1:2015					
A1-O-A1-02								Slight negative pressure											
A1-O-A1-03																			

Excel spreadsheet to document the stages of hazard identification, risk estimation, risk evaluation and risk reduction of the risk assessment & risk reduction process, including the verification of the measures / solutions required for adequate risk reduction.



1.4. CONTROL SYSTEM (SIL and PL REQUIRED)

NACHINE ZONE:					
LIFE STEP:	Create a new worksheet for each Life Step and/or O	perating Mode (Clik on	the tab, Move	or copy, Crea	ite a copy)
OPERATING MODE:					

	2B. SAFETY FUNCTIO	NS									3. RISK REDUCTION			
		Risk classification									Measures /solutions for Risk red	uction		
	Description	;	Safety	Inte	grity Le	vel Performance Level								
Ket.			E	EN 6206		61-5		EN ISO 13849-1			Description	Verification		
		Se	Fr F	Pr A	v C	SIL	S	F	Α	PL				
A1-O-A1-01														
A1-O-A1-02														
A1-O-A1-03														
								_						
								_						
								_						
						L								

Excel spreadsheet to evaluate and document the **Safety Integrity Levels (SIL)** and **Performance Levels (PL)** required by the **control systems of PPPs related to safety** functions.



Verification

Strategy 1: Measuring PPPs airborne emissions and the performance of the control systems integrated in these machines, in general, according to EN 1093-1.

On-line measurement using CPC-OPC + Laser Induced Incandescence LII-EC (AT) will be explored .

Strategy 2: Measuring PPPs immissions. If strategy 1 is technically unfeasible, indirect technique, by measuring the occupational exposure of the workers and comparing such measurements with suitable criteria.

Occupational exposure to all types of CNT can be quantified using NIOSH Method 5040 (Personal sampling + offsite analysis, including TEM). NIOSH REL of $1 \mu g/m^3 8$ -hr TWA (NANOCYL 2,5 $\mu g/m^3$).

Strategies for airborne emissions verification (EN ISO 14123-1)



To summarize

- **1. PPPs design**: SbD following MD principles for safety integration and integrating all relevant nanosafety aspects to achieve final safe designs in conformity with relevant EHSRs (Technical File).
- **2. PPPs construction:** according to the SbD produced in step 1 and in a controlled dedicated room.
- 3. PPPs SbD verification by: 1) Visual inspection, 2) Measurement, 3) Functional testing, 4) Design validation or 5) Calculation.
- **4. PPPs putting into service and CE marking:** after fulfilling all the obligations relating to the conformity with the MD.

Strategy for PPPs design, construction and putting into service

Thank you very much for your attention!





(jesus.lopezdeipina@tecnalia.com)



Project PLATFORM have received funding from the European Union's Horizon 2020 research and innovation programme, under grant agreement No 646307. This presentation reflects only the author's views and the Commission is not responsible for any use that may be made of the information contained therein.

Visit our blog: http://blogs.tecnalia.com/inspiring-blog/



www.tecnalia.com