

Title:	GRAphene Executive Summary	
Document No.:	DEV-GRA-G-011	
Issue:	01	Date: 28.05.2021
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Distribution:	Omnidea-RTG	LIMITED DISTRIBUTION
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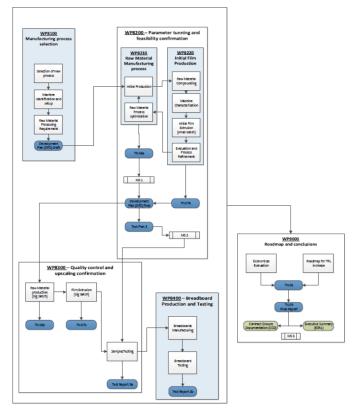
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Due to its well-established unique properties Graphene and its derivate have demonstrated to be a material of choice for many applications. The incorporation of Graphene into polymeric matrices has showed potential to improve material properties like strength, modulus, thermal stability and also gas permeability.

The aim of the activity, developed by Omnidea-RTG in conjunction with ESA, Pleione SA and Fraunhofer IVV, was to produce a thin film polymer-based product enhanced with Graphene nanoparticles to decrease He gas permeability while maintaining thermal bonding properties and without major penalties in UV resistance, for use in high-altitude inflatable structures. The proposed technological application is the usage of this thin film as envelope inner layer for high altitude airborne platforms which, from a lower altitude (vs. a LEO satellite) can perform Earth Observation or, alternatively, satellite data correction/validation.

The original ESA activity (contract 4000115792) focused on achieving a good baseline, in terms of Graphene per weight solution to create the TPU-GRA material, while this continuation activity focused on process control, industrialization potential demo and economical merits analysis.



Following task 8100 to confirm the feasibility of the production of the graphene thin film using the new industrial machine (and respective results summarized in the previous version of this document (i.e. [RD 4]), WP 8300 was destined to present the developments in material production and extrusion achieved for the "large batch" of produced TPU-GRA which was afterwards tested in WP8400 as summarized in [RD 3].

In reality task 8100 was finished by the 2nd extrusion attempt, having been calibrated but not achieved in the first extrusion attempt. Conclusion of WP8200 was more complicated since the extrusion attempt aimed at confirming parameter stabilization (extrusion attempt #3) was not successful in obtaining a good extrusion material, even if it was successful at confirming leakage properties thus, the decision had to be taken to extract the samples and breadboard material from extrusion batch #2. WP 8200 was then finalized by Nov. 2020 when the 4th extrusion successfully confirmed the extrusion #2, from Nov. 2019; thus, in all, 4 extrusion iterations were needed to finalize WP 8200, more than the originally 2 envisaged.

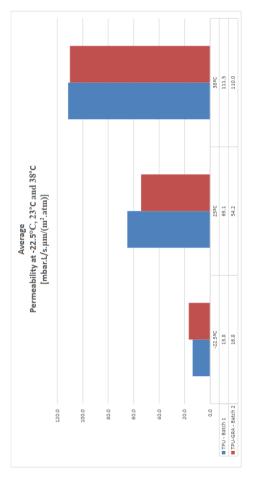
1 st Extrusion June 2019		3rd Extr. April 2020		
	2 nd Extr. Nov 2019		4th Extr. Nov. 2020	

Success in obtaining the target thickness (100um) as well as a uniform thickness distribution across the width of the extruded film also proved challenging. This caused performance issues during manufacturing and testing, as it negatively influenced the TPU-GRA permeability.



The sheets of Graphene enhanced material (TPU-GRA) provided by Fraunhofer-IVV had low defects and good homogeneity and consistency of the base material dispersion but big differences in thickness. The TPU-GRA material of this activity achieved very good mechanical properties and kept the good "elastic" TPU properties with an average reduction in the tensile strength of only 30% with a slightly higher elongation at break.

The permeability of the polymeric samples is better at lower temperatures, with both the TPU and the TPU-GRA samples confirming this trend. The Graphene enhanced samples presented better permeability than the TPU baseline for ambient temperature and just ever so slightly at elevated temperatures; nonetheless they have a worse performance at low temperatures. In the end the activity was able to produce to produce TPU-GRA material endowed with lower permeability than the comparable TPU material, with improvements of up to 17% at ambient temperature. With the progress during the activity, it was possible to finally achieve pressurizable breadboards which could even be burst tested.



For envisaged future developments a setup based on high shear dispersion with Industrial type evaporators is the envisaged option to again increased production capability one order of magnitude, using of a conveyor belt furnace/dryer and condensation system for safe/economical solvent collection/evaporation. This method is easy to combine with a pilot line (to directly extrude the thin film from the produced pellets) or to keep extruding in an external.

The economical evaluation described the production method used in the original activity, followed by the production method used in the current activity and finished by explaining the production method envisaged for a potential follow-on step; in doing so, the roadmap became an active part of the economical evaluation. This is because the critical assumption for the economical evaluation is that it would be unfair to compare the production costs of TPU-GRA with those of "base TPU" since the latter is produced in thousands of tons per year. From there, a case was created where production of up to 20 tons per year could be envisaged without breaking critical model assumptions. Afterwards the return on investment is measured from the difference between the extra TPU-GRA envelope cost (as TPU-GRA will always be more expensive than TPU) vs. the savings made on Helium costs, due to the lower monthly diffusion of TPU-GRA.

These calculations are presented bundled with a sensitivity analysis where one can see the impact of changing critical assumptions such as TPU-GRA production rate, Helium average monthly leakage rate, envelope size and Helium price. The conclusion is that, assuming the TPU-GRA delivers a 20% reduction in monthly average losses, for any annual production rate between 20 and 100 tons and current Helium prices, TPU-GRA have a positive net present value and a return on investment within a maximum of 2 years, as long as the envelope has an internal volume bigger than 600m3. As the current trend in HAPS envelopes is to go beyond this the economical evaluation shows that the original interest in developing TPU-GRA as a future alternative to "simple TPU" was justified.

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Annual Production	600	5280	21120	84490	168960	ka	Annual Production	21120	21120	21120	21120	21120 kg
ength	32.00	32.00	32.00	32.00	32.00		Lenith	8.00	12.00	16.00	24.00	32.00 m
Radius	4.00	4.00	4.00	4.00	4.00		Radius	1.00	1.50	2 00	3.00	4.00 m
/Dratio	4.00	4.00	4.00	4.00	4.00		L/D ratio	4.0	4.0	4.0	4.0	4.00 m
Area of envelope	603	603	603	603	603		Area of envelope		85	151	339	603 m2
Envelope volume	1877	1877	1877	1877	1877		Ervelope volume	29	60	235	339	1877 m3
Enverope volume	1677	10//	1077	18/7	18/7	ms	Enverope volume	29	30	235	792	16/7 m3
TPU-GRA - Price per m2	11.2	4.5	3.5	2.5		€/m2	TPU-GRA - Price per m2	3.5	3.5	3.5	3.5	3.5 €/m2
TPU-GRA - Inner Envelope cost	6,755€	2,710 €	2,085€	1,520€	1,022€		TPU-GRA - Inner Envelope cost	130€	293€	521€	1,173€	2,085€
TPU - Price per m2	1.7	1.7	1.7	1.7	1.7	€/m2	TPU - Price per m2	1.7	1.7	1.7	1.7	1.7 €/m2
TPU - Inner Envelope cost	1,013€	1,013 €	1,013€	1,013€	1,013€		TPU - Inner Envelope cost	63€	142€	253€	570€	1,013€
Price difference (TPU-GRA VS TPU)	5,741€	1,697 €	1,072 €	507 €	86		Price difference (TPU-GRA VS TPU)	67 €	151€	268 €	603 C	1,072 €
Helium prices	50€	50€	50€	50€	50€		Helium prices	50€	50€	50€	50€	50€ kg
Helium density STD	0.176	0.176	0.176	0.176		kg/m3	Helium density STD	0.176	0.176	0.176	0.176	0.176 kg/m3
Overpressure	10%	10%	10%	10%	10%		Overpressure	10%	10%	10%	10%	10%
Helium contained in inner envelope	363	363	363	363	363	kg	Helium contained in inner envelope	6	19	45	153	363 kg
Helium envelope losses per month - TPU-GRA	3.2%	3.2%	3.2%	3.2%	3.2%		Helium envelope losses per month - TPU-GRA	3.2%	3.2%	3.2%	3.2%	3.2% %
Helium envelope losses per month - TPU	4.0%	4.0%	4.0%	4.0%	4.0%		Helium envelope losses per month - TPU	4.0%	4.0%	4.0%	4.0%	4.0% %
Savinas per month	2.9	2.9	2.9	2.9	2.9	ka	Savines per month	0.0	0.2	0.4	12	29.84
Savings per year	34.9	34.9	34.9	34.9	34.9		Savings per year	0.5	1.8	4.4	14.7	34.9 kg
Savings value per year	1,744€	1,744 €	1,744€	1,744€	1,744 €		Savings value per year	27 €	92€	218€	736€	1,744 €
Comparison (Material Cost Vs Helium Loss gains)	-3.997 €	47.6	672 €	1.237 €	1,735 €		Comparison (Material Cost Vs Helium Loss gains	-40.6	-59.6	-50 €	133 €	672.6
comparison (waterial cost vs neirom coss gains)	-3,997 €	476	6/26	1,25/6	1,7354		Comparison (waterial Cost vs Herlum Cost gains	-400	-596	-50 €	1226	6/24
Comparisor	as Helium	price chan	195				Comparison as mont	bly Heliun	n envelop	losses var	v	
(@ constant Annual Production, 8	invelope vo	dume and	Helium en	velope los	ses)		(@ constant Annual Producti	on, Erweld	pe volume	and Heliu	, m prices)	
Annual Production	21120	21120	21120	21120	21120	kg	Annual Production	21120	21120	21120	21120	21120 kg
Annual Production Length	21120 32.00	21120	21120 32.00	21120	21120 32.00		Annual Production	21120	21120	21120	21120 32.00	21120 kg 32.00 m
						m						
Length Radius	32.00	32.00	32.00	32.00	32.00	m m	Length Radius	32.00	32.00	32.00	32.00	32.00 m 4.00 m
Length Radius L/D ratio	32.00 4.00 4.0	32.00 4.00 4.0	32.00 4.00 4.0	32.00 4.00 4.0	32.00 4.00 4.0	m m m	Length Radius L/D ratio	32.00 4.00 4.0	32.00 4.00 4.0	32.00 4.00 4.0	32.00 4.00 4.0	32.00 m 4.00 m 4.0 m
Length Radius L/D ratio Area of envelope	32.00 4.00 4.0 603	32.00 4.00 4.0 603	32.00 4.00 4.0 603	32.00 4.00 4.0 603	32.00 4.00 4.0 603	m m m m2	Length Radius L/D ratio Area of envelope	32.00 4.00 4.0 603	32.00 4.00 4.0 603	32.00 4.00 4.0 603	32.00 4.00 4.0 603	32.00 m 4.00 m 4.0 m 603 m2
Length Radius L/D ratio Area of envelope	32.00 4.00 4.0	32.00 4.00 4.0	32.00 4.00 4.0	32.00 4.00 4.0	32.00 4.00 4.0	m m m m2	Length Radius L/D ratio	32.00 4.00 4.0	32.00 4.00 4.0	32.00 4.00 4.0	32.00 4.00 4.0	32.00 m 4.00 m 4.0 m
Length Radius (V) ratio Area of envelope Envelope volume TPU-GRA - Price per m2	32.00 4.00 4.0 603 1877 3.5	32.00 4.00 4.0 603 1877 3.5	32.00 4.00 4.0 603 1877 3.5	32.00 4.00 4.0 603 1877 3.5	32.00 4.00 4.0 603 1877 3.5	m m m2 m3 €/m2	Length Rodius U/D ratio Area of envelope Envelope volume TPU-GRA - Price per m2	32.00 4.00 4.0 603 1877 3.5	32.00 4.00 4.0 603 1877 3.5	32.00 4.00 4.0 603 1877 3.5	32.00 4.00 4.0 603 1877 3.5	32.00 m 4.00 m 603 m2 1877 m3 3.5 ¢/m2
Length Radius (V) ratio Area of envelope Envelope volume TPU-GRA - Price per m2	32.00 4.00 4.0 603 1877	32.00 4.00 4.0 603 1877	32.00 4.00 4.0 603 1877	32.00 4.00 4.0 603 1877	32.00 4.00 4.0 603 1877	m m m2 m3 €/m2	Length Radius I/D ratio Area of envelope Envelope volume	32.00 4.00 4.0 603 1877	32.00 4.00 4.0 603 1877	32.00 4.00 4.0 603 1877	32.00 4.00 4.0 603 1877	32.00 m 4.00 m 4.0 m 603 m2 1877 m3
Length Redius U/D ratio Area of envelope Envelope volume TPU-GRA - Price par m2 TPU-GRA - Inner Envelope cost	32.00 4.00 4.0 603 1877 3.5	32.00 4.00 4.0 603 1877 3.5 2,085 €	32.00 4.00 4.0 603 1877 3.5 2,085 €	32.00 4.00 4.0 603 1877 3.5 2,085 €	32.00 4.00 603 1877 3.5 2,085€	m m m2 m3 €/m2	Length Rodius L/D ratio L/D ratio Envelope volume TPU-GRA - Price per m2 TPU-GRA - Inner Envelope cost	32.00 4.00 4.0 603 1877 3.5 2,085 €	32.00 4.00 4.0 603 1877 3.5 2,085 €	32.00 4.00 4.0 603 1877 3.5 2,085 6	32.00 4.00 4.0 603 1877 3.5 2,085 €	32.00 m 4.00 m 4.0 m 603 m2 1877 m3 3.5 €/m2 2,085 €
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Langth	32.00 4.00 4.0 603 1877 3.5 2,085 € 1,013 € 1,013 € 1,072 € 30 €	32.00 4.00 4.0 603 1877 3.5 2,085 € 1.7 1,013 € 1,072 € 40 €	32.00 4.00 4.0 603 1877 3.5 2,085€ 1,7 1,013€ 1,072€ 50€	32.00 4.00 4.0 603 1877 3.5 2,085€ 1.7 1,013€ 1,072€ 60€	32.00 4.00 4.0 603 1877 3.5 2,085€ 1.7 1,013€ 1,072€ 70€	m m2 m3 €/m2 €/m2	Langth Balliss About Annual Annual Annual Annual Annual Annual Condense Annual Thu Gilde Shi Share Thurlings cost Thu - Annual Annual Thu - An	32.00 4.00 4.0 603 1877 3.5 2,085€ 1.7 1,013€ 1,072€ 50€	32.00 4.00 4.0 603 1877 3.5 2,085€ 1.7 1,013€ 1,072€ 50€	32.00 4.00 4.0 603 1877 3.5 2,085 € 1.7 1,013 € 1,072 € 50 €	32.00 4.00 4.0 603 1877 3.5 2,085€ 1,7 1,013€ 1,072€ 50€	32.00 m 4.00 m 603 m2 1877 m3 3.5 {/m2 2,085 € 1.7 {/m2 1,013 € 1,072 € 50 € kg
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Jangth Makis VD ratio Marking Control of the Marking Control of the Marking Control of the Thu Gillon - Inner Envirops cost Thu - Arice pren2 Thu - Arice pr	32.00 4.00 4.0 603 1877 3.5 2,085 € 1,013 € 1,013 € 1,072 € 30 €	32.00 4.00 4.0 603 1877 3.5 2,085 € 1.7 1,013 € 1,072 € 40 €	32.00 4.00 4.0 603 1877 3.5 2,085€ 1,7 1,013€ 1,072€ 50€	32.00 4.00 4.0 603 1877 3.5 2,085€ 1.7 1,013€ 1,072€ 60€	32.00 4.00 4.0 603 1877 3.5 2,085€ 1.7 1,013€ 1,072€ 70€	m m2 m3 €/m2 €/m2	Langth Balliss About Annual Annual Annual Annual Annual Annual Condense Annual Thu Gilde Shi Share Thurlings cost Thu - Annual Annual Thu - An	32.00 4.00 4.0 603 1877 3.5 2,085€ 1.7 1,013€ 1,072€ 50€	32.00 4.00 4.0 603 1877 3.5 2,085€ 1.7 1,013€ 1,072€ 50€	32.00 4.00 4.0 603 1877 3.5 2,085 € 1.7 1,013 € 1,072 € 50 €	32.00 4.00 4.0 603 1877 3.5 2,085€ 1,7 1,013€ 1,072€ 50€	32.00 m 4.00 m 603 m2 1877 m3 3.5 {/m2 2,085 € 1.7 {/m2 1,013 € 1,072 € 50 € kg
Jangth Angel Makin Jan San San San San San San San San San S	32.00 4.00 4.0 603 1877 3.5 2,085 € 1,013 € 1,072 € 30 € 0.176	32.00 4.00 4.0 603 1877 3.5 2,085 € 1.7 1,013 € 1,072 € 40 € 0.176	32.00 4.00 4.0 603 1877 3.5 2,085 € 1,072 € 1,072 € 50€ 0.176	32.00 4.00 4.0 603 1877 3.5 2,085 € 1.7 1,013 € 1,072 € 60 € 0.176	32.00 4.00 4.0 603 1877 3.5 2,085€ 1.7 1,013€ 1,072€ 70€ 0.176	kg/m3	Largh Ballon Data San Annoles Data San Annoles Through San Anno par Ma Through San Anno par Ma Neuropar Anno par Ma Neuropar Anno par Ma Neuropar Anno par Ma Neuropar Anno par Ma	32.00 4.00 4.0 603 1877 3.5 2,085€ 1.7 1,013€ 1,072€ 50€ 0.176	32.00 4.00 4.0 603 1877 3.5 2,085 € 1,072 € 1,072 € 50 € 0.176	32.00 4.00 4.0 603 1877 3.5 2,085 € 1,073 € 1,072 € 50 € 0,176	32.00 4.00 4.0 603 1877 3.5 2,085 € 1,072 € 50 € 0.176	32.00 m 4.00 m 4.00 m 603 m2 1877 m3 3.5 G/m2 2,085 G 1.7 G/m2 1,013 G 1,072 G 50 G kg 0.176 kg/m3
Langth	32.00 4.00 4.0 603 1877 3.5 2,085 € 1,013 € 1,013 € 1,013 € 1,072 € 30 € 0.176 2,085	32.00 4.00 4.0 603 1877 3.5 2,085 € 1.7 1,013 € 1,072 € 40 € 0.176 10%	32.00 4.00 4.0 603 1877 3.5 2,085 € 1,072 € 1,072 € 0.176 0.176	32.00 4.00 4.0 603 1877 3.5 2,085 € 1,7 1,013 € 1,072 € 60 € 0.176 10%	32.00 4.00 4.0 603 1877 3.5 2,085 € 1.7 1,013 € 1,072 € 70 € 0.176 10%	m m m m m m m m m m m m m m m m m m m	Largh Badari Badari Aratoga valanta Francilaa valanta THU BADA. Inko gar m2 THU GADA. Inko gar m2 THU GADA. Inko gar m2 THU GADA. Inko gar m2 THU. Hang frankinga cost THU. Hang frankinga cost Philaman prices Philaman prices THU GADA STATUS	32.00 4.00 4.0 603 1877 3.5 2,085 € 1.7 1,013 € 1,072 € 50 € 0.176 10%	32.00 4.00 4.0 603 1877 3.5 2,085 € 1,072 € 1,072 € 50 € 0.176 10%	32.00 4.00 4.0 603 1877 3.5 2,085 € 1,013 € 1,013 € 1,013 € 50 € 0,176 10%	32.00 4.00 4.0 603 1877 3.5 2,085 € 1,072 € 50 € 0.176 1,072 €	32.00 m 4.00 m 4.00 m 603 m2 1877 m3 3.5 ¢/m2 2,085 ¢ 1.7 ¢/m2 1,013 ¢ 1,072 ¢ 50 ¢ kg 0.16 kg/m3 10%
Jangth Markin Markin Artin of envolope Thold An - Inter Frendport cost Thold Anternet (Thold Ad X 3 Thol) The difference (Thold Ad X 3 Thol) Designations Marking Administry Str.)	32.00 4.00 4.0 603 1877 3.5 2,085 € 1,013 € 1,013 € 1,072 € 30 € 0.176 10% 368	32.00 4.00 4.0 603 1877 3.5 2,085 € 1,013 € 1,013 € 40 € 0.176 1096 963	32.00 4.00 4.0 603 1877 3.5 2,085 € 1,013 € 1,013 € 1,013 € 0.176 0.176 0.176 363	32.00 4.00 603 1877 3.5 2,085 € 1,013 € 1,013 € 60 € 0.176 10% 363	32.00 4.00 4.0 603 1877 3.5 2,085 € 1.7 1,013 € 1,072 € 70 € 0.176 10% 363	m m m m m m m m m m m m m m m m m m m	uengh Leadur Loadur Loadur Loadur Loadur Loadur Loadur Loadur ThuGAA. Near Enrol ThuGAA.	32.00 4.00 4.0 603 1877 3.5 2,085 € 1.7 1,013 € 1,013 € 50 € 0.106 10% 363	32.00 4.00 4.00 603 1877 3.5 2,085 € 1,013 € 1,013 € 50 € 0.176 1265 363	32.00 4.00 603 1877 3.5 2,085 € 1.7 1,013 € 1,072 € 50 € 0.176 0.176 10%	32.00 4.00 4.00 603 1877 3.5 2,085 € 1,013 € 1,013 € 50 € 0.176 1,013 8 363	32.00 m 4.00 m 4.0 m 603 m2 1877 m3 3.5 (/m2 2,085 c 1.7 (/m2 1,013 c 1,072 c 50 c kg 0.176 kg/m3 10%
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Janghi Marian Marian Anna di envolgosi Mondose valuma Th'Gila. In Inter forvolgos esca Th'J. Inter Chrologos esca Utili. Inter Chrologos esca Hallman Mariang San Hallman Mariang San San Hallman Mariang	32.00 4.00 603 1877 3.55 2,085 € 1.77 1,013 € 1,072 € 30 € 0.176 10% 363 3.2% 4.0%	32.00 4.00 6.03 1877 3.5 2,085 € 1.7 1,013 € 1,072 € 40 € 0.176 1078 3.2% 4.0% 4.0%	32.00 4.00 603 1877 3.5 2,085 € 1.7 1,013 € 1,072 € 0.176 0.176 0.176 3.52 0.176 1.0178 3.2% 4.0%	32.00 4.00 603 1877 3.5 2,085 € 1.7 1,013 € 1,072 € 60 € 0.176 1078 3.2% 4.0% 4.0%	32.00 4.00 4.0 603 1877 3.5 2,085 € 1.7 1,013 € 1,072 € 0.176 10% 363 3.2% 4.0%	m m m m m m m m m m m m m m m m m m m	uegh Martin Martin Arsaid annibae Evolvise antoine Evolvise antoine ThU dan. None gen m3 ThU dan. None gen m3 ThU dan. None formag ThU has prinzip Anse afferenzi (Thu dan. None formag Mailun deniv (Thu dan. Thu dan. Thu Mailun deniv (Thu	32.00 4.00 4.00 6.03 1877 3.5 2,085 € 1.7 1,013 € 1,072 € 50 € 0.176 1063 2.0% 2.5% 1.8	32.00 4.00 603 1877 3.5 2,085 € 1.7 1,013 € 1,072 € 50 € 0.176 10% 363 2,6% 3.3% 2.4%	32.00 4.00 4.00 603 1877 3.5 2,085 € 1.7 1,013 € 1,072 € 50 € 0.176 1075 3.2% 4.0% 4.0%	32.00 4.00 603 1877 3.55 2.085 € 1.7 1.013 € 1.072 € 0.176 0.176 0.176 3.8% 4.8% 4.8%	32.00 m 4.00 m 4.00 m 4.00 m 4.00 m 3.00 m 3
Jangh Maria	32.00 4.00 603 1877 3.5 2,085 € 1.7 1,013 € 1,072 € 30 € 0.176 20% 363 3.2% 4.0% 2.9 3.4.9	32.00 4.00 4.00 603 1877 3.5 2,085 € 1.7 1,013 € 1.072 € 40 € 0.176 10% 3.2% 4.0% 2.9 34.9	32.00 4.00 4.0 603 1877 3.5 2,085 € 1.7 1,013 € 1,072 € 50 € 0.176 10% 3.63 3.63 3.63 4.0%	32.00 4.00 4.00 603 1877 3.5 2,085 € 1.7 1,013 € 1,072 € 60 € 0.176 10% 3.2% 4.0% 2.9 34.9	32.00 4.00 603 1877 3.5 2,085 € 1.7 1,013 € 70 € 0.176 10% 3.6% 3.2% 4.0% 4.0%	m m m m m m m m m m m m m m m m m m m	uegin Mada: Mada: Acea devolúcio Enotogia cultura Tri Gla A. Nora gen al Tri Gla A. Nora forma al Tri Gla A. Nora gen al Tri Gla A. Nora gen al Tri Gla A. Nora gen al Mala forma forma al Tri Gla A. Nora Mala forma forma al Tri Gla A. Nora Mala forma forma al Tri Gla A. Nora Mala forma forma and an oral forma Mala forma forma and an oral forma Mala forma forma and an oral forma Mala forma forma and an oral forma al Mala forma forma and an oral forma and all Mala forma forma and an oral forma and all San of tra forma and all forma and all forma and all forma Mala forma forma and and and all forma and all forma and all forma Mala forma forma and and all forma and all forma and all forma and Mala forma forma and and and all forma and all forma and all forma and bala forma and all forma and	32.00 4.00 4.00 6.03 1877 1,013 € 1,013 € 1,013 € 50 € 0.176 10% 2.5% 2.5% 1.8 2.1.8	32.00 4.00 4.0 603 1877 2,085 € 1.7 1,013 € 1,072 € 50 € 0.176 10% 3.6% 3.3% 3.3% 2.6% 3.3%	32.00 4.00 4.00 603 1877 1,013 € 1,013 € 50 € 0.176 10% 363 3.2% 4.0% 2.9 34.9	32.00 4.00 4.0 603 1877 2,085 € 2,085 € 1.7 1,013 € 1,072 € 50 € 0.176 10% 3.68 3.68 4.8% 4.8%	32.00 m 4.0 m 4.0 m 4.0 m 3.5 C/m2 3.5 C/m2 2.085 C 1.0 C/m2 1.013 C 1.072 C 1.013 C 1.072 C 0.075 kg/m3 1000 2.558 S 5.558 S 5.558 S
Janghi Marian Marian Anna di envolgosi Mondose valuma Th'Gila. In Inter forvolgos esca Th'J. Inter Chrologos esca Utili. Inter Chrologos esca Hallman Mariang San Hallman Mariang San San Hallman Mariang	32.00 4.00 603 1877 3.55 2,085 € 1.77 1,013 € 1,072 € 30 € 0.176 10% 363 3.2% 4.0%	32.00 4.00 6.03 1877 3.5 2,085 € 1.7 1,013 € 1,072 € 40 € 0.176 1078 3.2% 4.0% 4.0%	32.00 4.00 603 1877 3.5 2,085 € 1.7 1,013 € 1,072 € 0.176 0.176 0.176 3.52 0.176 1.0178 3.2% 4.0%	32.00 4.00 603 1877 3.5 2,085 € 1.7 1,013 € 1,072 € 60 € 0.176 1078 3.2% 4.0% 4.0%	32.00 4.00 4.0 603 1877 3.5 2,085 € 1.7 1,013 € 1,072 € 0.176 10% 363 3.2% 4.0%	m m m m m m m m m m m m m m m m m m m	uegh Martin Martin Arsaid annibae Evolvise antoine Evolvise antoine ThU dan. None gen m3 ThU dan. None gen m3 ThU dan. None formag ThU has prinzip Anse afferenzi (Thu dan. None formag Mailun deniv (Thu dan. Thu dan. Thu Mailun deniv (Thu	32.00 4.00 4.00 6.03 1877 3.5 2,085 € 1.7 1,013 € 1,072 € 50 € 0.176 1063 2.0% 2.5% 1.8	32.00 4.00 603 1877 3.5 2,085 € 1.7 1,013 € 1,072 € 50 € 0.176 10% 363 2,6% 3.3% 2.4%	32.00 4.00 4.00 603 1877 3.5 2,085 € 1.7 1,013 € 1,072 € 50 € 0.176 1075 50 € 0.176 1085 3.2% 4.0% 2.9	32.00 4.00 603 1877 3.5 2.085 € 1.7 1.013 € 1.072 € 0.176 0.176 0.176 3.8% 4.8% 4.8%	32.00 m 4.00 m 4.00 m 4.0 m 4.0 m 5.07 m 3.5 (/m2 2,085 C 1.7 (/m2 1,013 C 1,072 C 5.0 C kg 4.06 kg/m 3.5 kg/m 3.5 kg/m 4.0 kg/m

The following could be a summary of achievements accomplished during the current De-risk phase of the project:

- Confirm the best GRAphene formulation once the new film manufacturing process is stable, to guarantee the quality improvement. ⇒ accomplished √
- Improve the production of the raw material, from insitu processing to pellets-type production, providing repeatability and transition to industry standard machines. ⇒ accomplished √
- Improve the manufacturing scalability by changing the process from Doctor Blade into a process closer to those used in the plastic film industry. ⇒ only partially accomplished
- Confirm economic viability of the proposed technology and provide roadmap towards future developments. ⇒ accomplished by analysis √