ESA STUDY – PROGRESS REPORT

ESA Contract No:	SUBJECT:	INSTITUTE:
4000117034/16/NL/NDe	**SURGE**: Simulating the cooling effect of urban greenery based on solar radiation modelling and a new generation of ESA sensors	Pavol Jozef Šafárik University in Košice, Institute of Geography

ESA Contract No: 4000117034/16/NL/NDe	No. of Volumes: 1 This is Volume No: 1	INSTITUTE'S REFERENCE: SURGE_PR1

ABSTRACT (Executive Summary of the Project):

The aim of this feasibility study is to assess the applicability of the Sentinel-2A multispectral satellite imagery for approximating the dynamics of solar radiation transmittance of urban greenery leading to its cooling effects via modelling the spatial distribution of solar radiation in a complex urban environment represented by a 3-D city model. The main technical objective of the project is to define the relationship between a high-resolution 3-D geometry of urban greenery and vegetation metrics in selected periods throughout the year. The study will be used to evaluate the proposed approach in the development of a toolbox enabling urban planners and researchers to mitigate heat risk based on solar radiation modelling and Sentinel-2A multispectral data.

The work described in this report was done under ESA PECS Contract. Responsibility for the contents resides in the author or organisation that prepared it.

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Simulating the cooling effect of urban greenery based on solar radiation modelling and a new generation of ESA sensors (acronym SURGE)

Progress Report 1

1. Introduction

The objective of the progress report is to provide all actors with actual information concerning the status of the project "Simulating the cooling effect of urban greenery based on solar radiation modelling and a new generation of ESA sensors (acronym SURGE)" from 01/06/2016 to 30/11/2016.

The aim of this project: This project will serve as a preparatory study to assess the applicability of the multispectral satellite imagery for approximating the dynamics of solar radiation transmittance of urban greenery to assess the cooling effects of the greenery via modelling the spatial distribution of solar radiation in a complex urban environment represented by a 3-D city model.

The main technical objectives: The main technical objective of the project is to define the relationship between 3-D geometry of urban greenery and vegetation metrics in selected periods throughout the year. The imagery to be acquired by the new generation of ESA Sentinel 2-A satellite sensors will be used to derive the vegetation metrics and it will be downscaled to higher resolution datasets. The final outcome of this study will be in the proof-of-concept which identifies critical functions and characteristics of the proposed approach. This study can be used in the future to develop a toolbox enabling urban planners and researchers to mitigate heat risk based on solar radiation modelling and Sentinel-2A multispectral data for urban greenery parameterization.

2. Highlight Summary

During the first 6 months we have achieved the following results:

1. The central part of the Košice City was identified as a suitable study area.
2. Periodical terrestrial laser scanning of urban vegetation was performed on four smaller sites selected within the study area to acquire ground truth representation of vegetation for particular phenological phases in high resolution and high accuracy.
3. Airborne laser scanning data, photogrammetric orthoimagery, and vector based 3-D city model was generated for the study area.
4. Multispectral data products of the Sentinel 2A and Landsat 8 sensors were downloaded for the study area and their applicability for the projects was analysed.

The work is progressing normally according to the plan.

3. Work Summary Status (during the reporting period)

Work package	Activities	Responsible Person	Status
WP1: Study management	1.1. Meetings of the project team	Jaroslav Hofierka	On-going
WP2: Data, methods and architecture of the system	2.1. Review of the state-of-the-art on vegetation transmittance (D1)	Michal Gallay	Finished
	2.2. Selection of the study area	Jaroslav Hofierka	Finished
	2.3. Procurement of services (airborne survey Košice)	Michal Gallay	Finished
	2.4. 3-D city model	Michal Gallay	On-going
	2.5. Generation of 3D time series of urban greenery	Ján Kaňuk	On-going
	2.6. Gathering of Sentinel 2A imagery	Michal Gallay	On-going
	2.7. Urban greenery field mapping	Alena Petrvalská	On-going

1. Detailed Progress of Work

WP1 – Study management

Since the official start of the project in June (over the last 6 months), we had 2 meetings of the project team. The kick-off meeting was held on 2 June 2016 where we reviewed our research plan and specifically activities for the WP2 for the first 6 months period. We selected the study area (central part of the Košice City) and we briefly discussed conditions of the procurement of airborne laser scanning and data processing. The procedure of the public procurement of the service on airborne laser scanning and photogrammetry of the central part of the Košice City was started in June 2016. The Photomap s.r.o company settled in Košice was selected among three competitors for supplying this service and the data were delivered on 30 November 2016. The second meeting of the project team was held on 7 September 2016, when we reviewed works done and we suggested a detailed plan for finalisation of the activities in WP2 in the remaining period. We had several short presentations on the preliminary results, specifically regarding periodical terrestrial laser scanning of the study area as well as vegetation mapping and photographic documentation of urban greenery. Besides this, the project leader had regular meetings with the WP2 leader discussing the ongoing activities as well as various management and financial issues. The SURGE project website was launched for presenting the aims, team, methods, and results of the project for public (Fig. 1).

Fig. 1. Print screen of the SURGE project website for disseminating the results and work progress on the project.

WP2 – Data, methods and architecture of the system

Provide summary of the work performed. Upcoming TNs

This feasibility study focuses on the Košice City in Eastern Slovakia as an example of urban space typical for moderate climate of Central Europe. The project team is based in this city therefore it is meaningful to establish the study on an area within Košice. Based on thorough discussions of the team, we selected a study area with a feasible size and sufficient diversity of urban greenery which would be suitable for ground-based mapping, airborne survey and large enough for monitoring by Earth observation satellites such as Sentinel 2A and Landsat 8. The area comprises 4 km^2 of the central part of the Košice City and it is delineated in Figure 2. Within this area, we have selected four smaller sites representing certain types of urban greenery (park, alleyway, residential greenery). In these four sites, we have been periodically conducting terrestrial laser scanning (TLS) since April 2016 synchronously with Sentinel 2A overpasses (according to weather conditions +/- 1-2 days). We have also considered the frequency of TLS with respect to the progress in vegetation phenology. Summary of the TLS survey is reported in Table 1. Images of the TLS time series can be seen on the project website http://esa-surge.science.upjs.sk/index.php/study-sites.

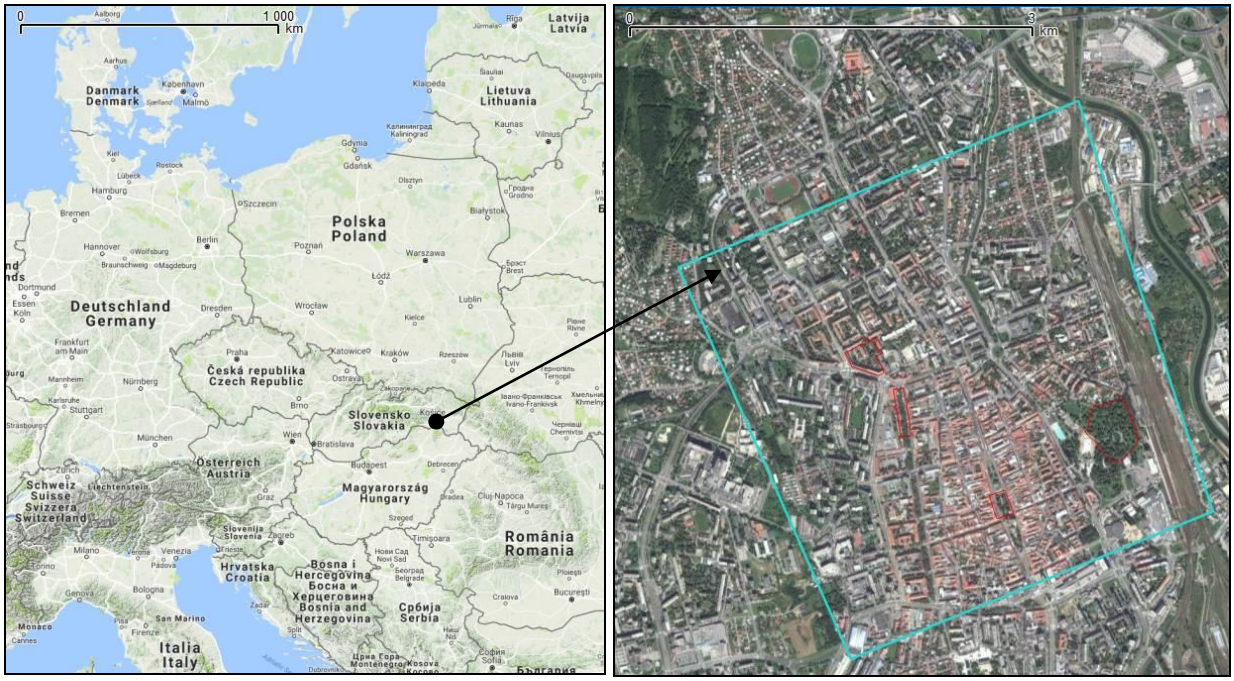


Figure 2. Location of the Košice City within Europe (left) and the study area within the city (right). The cyan line outlines the area subject to airborne lidar and photogrammetric data collection and the line delineates selected sites for repeated terrestrial laser scanning. The background maps are © Google.

Table 1. Dates of terrestrial laser scanning data collected on four sites in the study area of the Košice City with associated total accuracy of scans registration.

City park (Mestský park)	**Main street (Hlavná ulica)**	**Moyzesova ulica (street)**	**Hvozdíkov park**
			
April (0.032m)	April (0.029m)	April (0.062m)	April (0.045m)
June (0.023m)	June (0.018m)	June (0.023m)	June (0.038m)
July (0.029m)	July (0.014m)	July (0.023m)	July (0.016m)
August (0.023m)	August (0.016m)	August (0.025m)	August (0.019m)
September 14 (0.026m)	September 14 (0.015m)	September 14 (0.034m)	September 14 (0.018m)
September 23 (0.024m)	September 23 (0.016m)	September 23 (0.042m)	September 23 (0.018m)
October 14 (0.023m)	October 14 (0.010m)	October 14 (0.034m)	October 14 (0.017m)
October 27 (0.020m)	October 27 (0.010m)	October 27 (0.024m)	October 27 (0.018m)
November 8 (0.020m)	November 8 (0.008m)	November 8 (0.026m)	November 8 (0.017m)
November 23 (0.024m)	November 23 (0.012m)	November 23 (0.028m)	November 23 (0.020m)

Custom aerial survey was procured to acquire 3D airborne laser scanning (ALS) data and photogrammetric imagery to map urban greenery over the whole study area (Fig. 2, 3). Also 3-D vector models of buildings (Fig. 4) were supplied within this service. The data will be used to generate a 3-D city model of the study area in the next 6 month period. Furthermore, we have been continuously downloading Landsat 7 ETM+, Landsat 8 OLI/TIRS, Sentinel 2A

multispectral data from the data hubs (Table 2-3, Fig. 5). We conducted preliminary analysis and comparison of the satellite imagery with other data sources. The applicability of multispectral satellite imagery for assessing vegetation transmittance was reviewed and a report was generated as the Deliverable 1 titled "Report on the reviewed applicability of multispectral satellite imagery for derivation of vegetation transmittance". Detailed field survey of vegetation (trees and bushes) was performed to map the species, health condition, size and other parameters of the greenery within the four sites (Fig.6). In the next period, we will conduct such a survey within the whole study area.

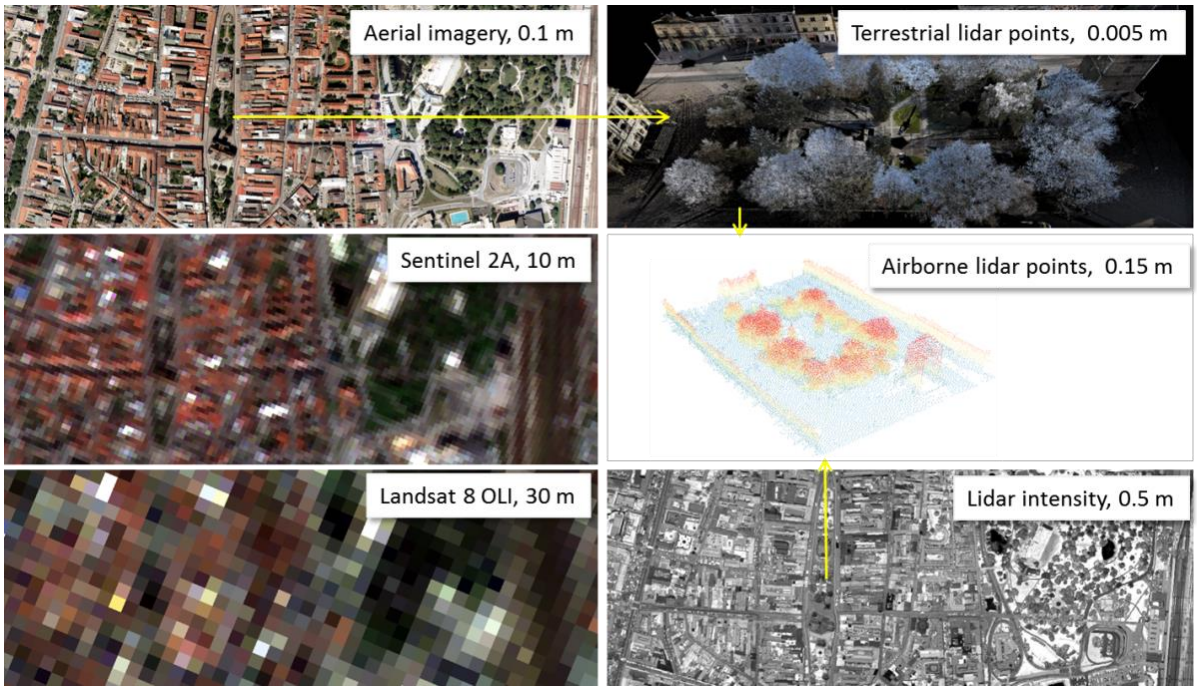


Figure 3. Overview of the acquired spatial data for the study area and associated spatial scales. The images show the central part of the Košice City, Slovakia.

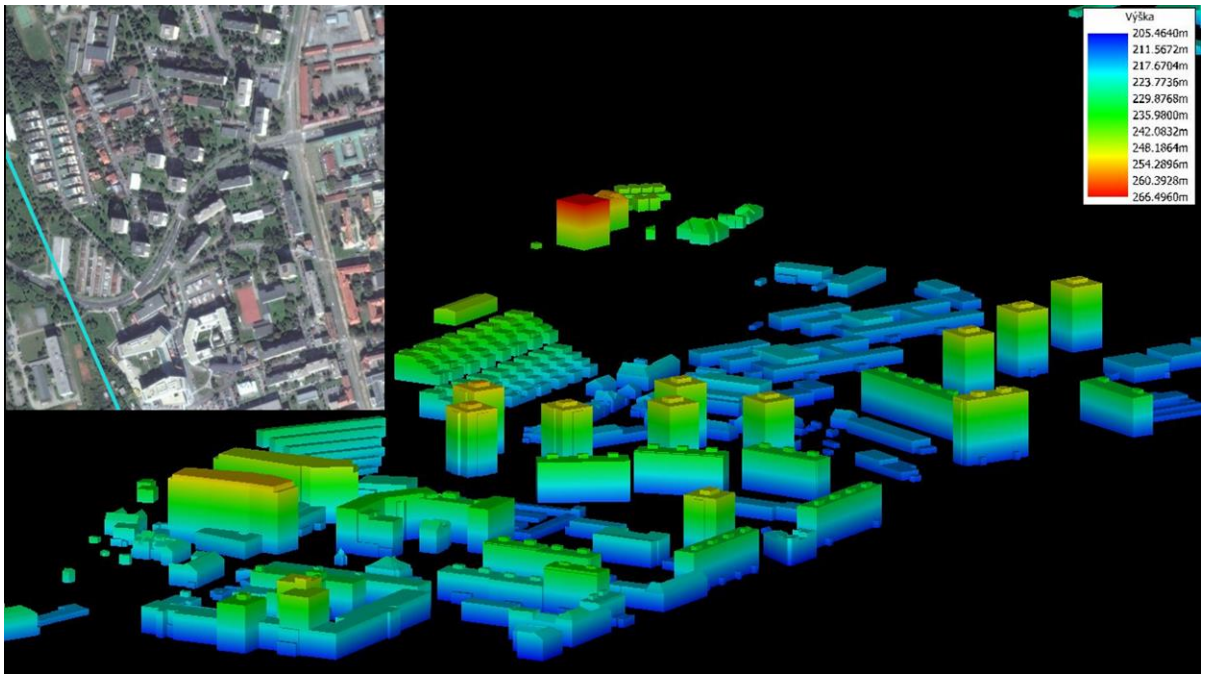


Figure 4. 3-D vector model of buildings derived from the ALS data and photogrammetric data coloured by elevation above mean sea level.

Table 2. Suitable Sentinel 2A level 1C products downloaded to date for the study area

March	April	May	June	July	August	September	October	November
28.3.2016	7.4.2016	7.5.2016	6.6.2016	6.7.2016	5.8.2016	4.9.2016	14.10.2016	23.11.2016
	17.4.2016	10.5.2016	9.6.2016	9.7.2016	8.8.2016	7.9.2016		23.11.2016
	20.4.2016	20.5.2016	16.6.2016	16.7.2016	15.8.2016	14.9.2016		26.11.2016
	27.4.2016	27.5.2016	19.6.2016	26.7.2016	18.8.2016	24.9.2016		
	30.4.2016		26.6.2016	29.7.2016	25.8.2016	27.9.2016		
			29.6.2016		28.8.2016			

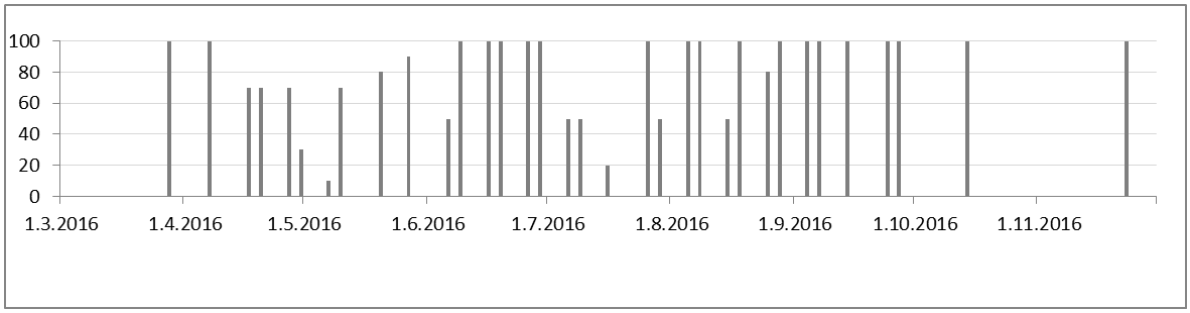


Figure 5. Estimated clear sky percentage of Sentinel 2A level 1C products downloaded for the Košice City study area in 2016.

Table 3. Landsat 8 level 1 products downloaded to date for the study area of the Košice City.

March	April	May	June	July	August
1.3.2016	2.4.2016	4.5.2016	5.6.2016	7.7.2016	1.8.2016
10.3.2016	11.4.2016	13.5.2016	16.6.2016	16.7.2016	8.8.2016
17.3.2016	18.4.2016	20.5.2016	21.6.2016	23.7.2016	
26.3.2016	27.4.2016		30.6.2016		

Table 4. Example of attributes recorded in mapping trees in the Košice City.

Id	**Date**	**Lat**	**Long**	**Species**	**Health**	**Pheno**	**Cat**	**Function 1**	**Function 2**	**Function 3**	**Crown diameter (m)**	**Urb cat 1**	**Urbcat2**
0208	20160714	48°43,572	21°15,057	Acer negundo	Z	O	3	B	C	D	6	A	B
0209	20160714	48°43,562	21°15,048	Tilia cordata	Z	KK	3	B	C	D	5	A	B
0210	20160714	48°43,559	21°15,046	Tilia cordata	Z	KK	3	B	C	D	8	A	B
0211	20160714	48°43,551	21°15,050	Tilia cordata	Z	KK	3	B	C	D	6	A	B
0212	20160714	48°43,545	21°15,052	Tilia cordata	Z	KK	3	B	C	D	10	A	B
0213	20160714	48°43,542	21°15,047	Acer saccharum	Z	O	3	B	C	D	9	A	B
0214	20160714	48°43,538	21°15,049	Fraxinus ornus	P25	O	3	B	C	D	7	A	B
0215	20160714	48°43,534	21°15,052	Tilia platyphylos	Z	KK	3	B	C	D	13	A	B
0216	20160714	48°43,528	21°15,053	Acer platanoides	Z	O	3	B	C	D	15	A	B

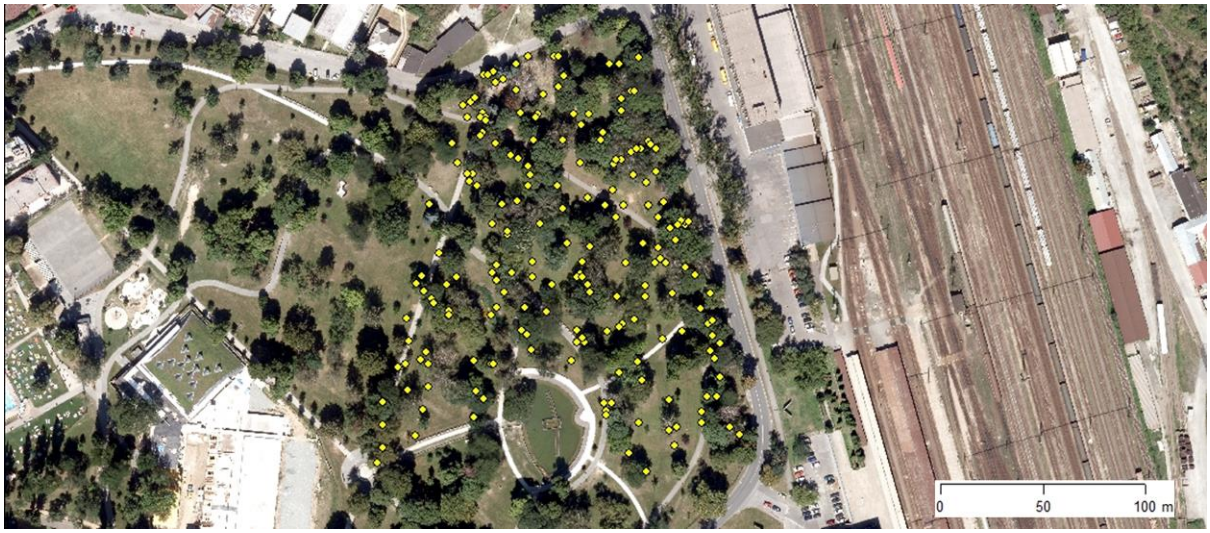


Figure 6. Point geodatabase as a result of field mapping of urban greenery mapped in the City park (Mestský park) with assigned attributes shown Table 4.

2. Problems, Issues and Risk Areas

We can confirm that no major problems occurred during the first 6 months period. We highly appreciate the on time transfer of the advance payment which was almost fully spend on the supply of the airborne lidar and photogrammetry 3D data for the study area. Therefore, we have no other resources to financially support the project although we are able to subsidise the necessary expenditures from internal university resources until the Milestone 1 is reached. For this reason, we would like to suggest earlier payment of a part of the finances for which we will be eligible after providing the Deliverable 2 "Generated 3D city model". The results achieved within the first 6 months provide evidence that a significant amount of work was done to reach the Milestone 1 and provide the D2.

3. Meetings

Meeting Name	Description/ Purpose	Location	Planned Date	Actual Date	Attendees
Kick-off meeting	Kick-off meeting of the team	Kosice	2nd June 2016	2nd June 2016	Pavol Jozef Safarik University
Regular team meeting	Presentation of progress and discussion of planning and problems	Kosice	7th September 2016	7th September 2016	Pavol Jozef Safarik University
Progress meeting	Progress meeting	Kosice	June 2017		Pavol Jozef Safarik University
Final meeting	Final meeting	Kosice	May 2018		Pavol Jozef Safarik University

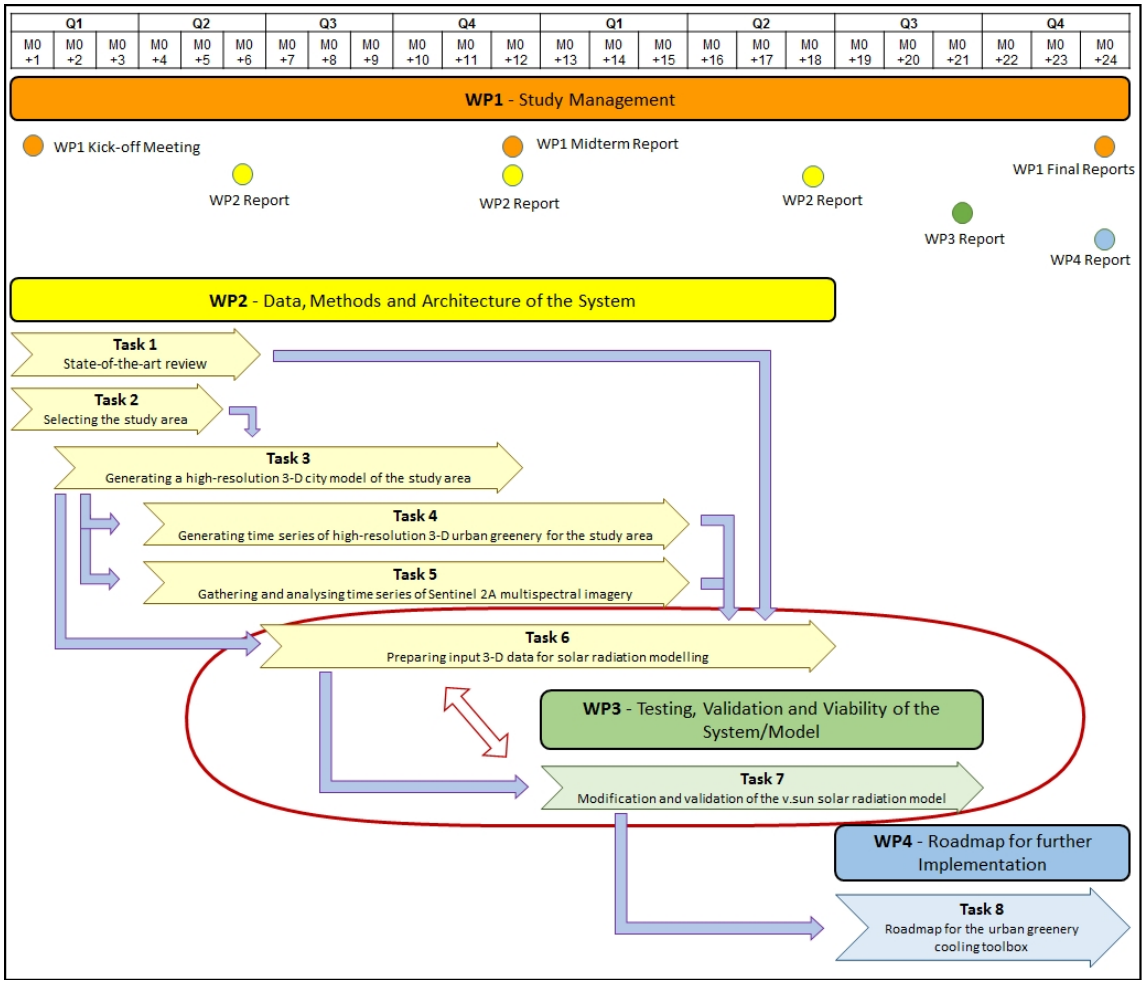
4. Deliverables Status

Deliverable Identifier	Title/ Description	Original Delivery Date	Planned Delivery Date	Associated Milestone	Status
D1	Report on the reviewed applicability of multiscpetral satellite imagery for derivation of vegetation transmittance	Nov-2016	Nov-2016	Milestone 1	Finalised
D2	Generated 3-D city model	May-2017	May-2017	Milestone 2	Planned
D3	Midterm report	May-2017	May-2017	Milestone 2	Planned
D4	Report on derivation of satellite based vegetation metrics and downscaling to high-resolution data	Nov-2017	Nov-2017	Milestone 3	Planned
D5	Report on definition of algorithmic structure of the toolbox	Feb-2018	Feb-2018		Planned
D6	Roadmap report on implementation of the toolbox	May-2018	May-2018	Final	Planned
TDP	Technical data package (containing all approved technical notes)	May-2018	May-2018	Final Review	Planned
FPR	Final Project Report	May-2018	May-2018	Final Review	Planned
ESR	Executive Summary	May-2018	May-2018	Final Review	Planned

5. Milestone Payment Plan: Status

ID	Description	Amount	Contractual date	Actual/ Expected Date	Status
MP1	Advance payment: Offset against MS1	17500	Upon signature of the Contract by both Parties	xxx	Paid
	Progress (MS1): Upon successful completion and delivery of D1 & D2 under WP2 and acceptance of all related deliverables	12500	June 2017	June 2017	Not yet Due
	Progress (MS2): Upon successful completion and delivery of D4 under WP2 and acceptance of all related deliverables	12450	December 2017	December 2017	Not yet Due
	Final Settlement (MS3): Upon the Agency's acceptance of all deliverables items due under the Contract and the Contractor's fulfilment of all other contractual obligations including submission of the Contract Closure Ducumentation	7491	June 2018	June 2018	Not yet Due

6. Planning



7. Action Item – Status List

NA

8. Any other Business

This feasibility study was contracted within the first call of the ESA/PECS projects for Slovakia. Therefore, the Ministry of Education, Science, Research and Sport of theSlovak republic is keen to organize public meetings to promote the interest and capabilities of Slovakia to contribute to the European space research. We were invited to present the aims of the SURGE feasibility study in Bratislava during two events. The first was held at premises of the Ministry on 1 December 2015 where Jaroslav Hofierka presented the key approach of the SURGE project. The second event on 5 May 2016 was held at the Slovak Technical University in Bratislava where Michal Gallay presented a poster on the SURGE project aims and research approach. The main goal of the event was the talk of the Director General of the ESA Johann-Dietrich Wörner to the Slovak research community about the ESA's vision and future perspective.

9. Reasons for slippage and/or

NA