

Deliverable D6.2: Final report on access to LiCal

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Comments	<p><i>The current document presents the overview of the trans-national access provided through the LiCal infrastructure. The purpose of the document is to report on the current status of each LiCal installation and show the overall statistics on the type of users accessing LiCal.</i></p> <p><i>The document acts as an update to the Intermediate Report on Access to LiCal provided on month 24 of the ACTRIS-2 implementation.</i></p>

Introduction:

LiCal has been set up following a long process for standardization and harmonization of calibration procedures within the ACTRIS community. Mature techniques were picked up by LiCal and are now offered to the users as services, while research and technological development continues in collaboration with EARLINET and ACTRIS.

The Lidar Calibration Centre (LiCal) started to provide a wide set of services to various users from the beginning of ACTRIS2 aiming to follow the needs of » the scientific community within and outside ACTRIS, » the requirements of various service providers and » the needs of the industry (lidar integrators and lidar components developers). During the ACTRIS2 project, the infrastructures provided by LiCal were updated and tuned to meet the lidar user needs by offering dedicated installations for specific applications involving both the equipment and the operators.

Infrastructures like the LiCal: LiCoTest, POLIS fixed, MUSA mobile and fixed are designed to offer services like inter-comparison with operational instrumentation and characterization of different lidar modules but are also involved in training activities. Coordinated check-up procedures to examine both the instruments and data (LiReQA and LiCheckUnit) allow a better exploitation of the data due to integrated procedures to determine key lidar parameters. The LiCalTrain unit is able to provide the theoretical knowledge to understand and operate scientific and operational lidar instruments.

The activities at LiCal covered a preparatory phase used to collect information on specific user needs and requirements that were followed by specific calls for specific LiCal installations (see D6.1). Based on the feedback of the applicants, the infrastructures were able to tune their services by offering more reliable products for the future. The preparatory phase was followed by the operational phase. During this phase, all LiCal facilities were accessed by various applicants (research, service providers and industry) within and outside the EU.

Access to LiCal TNA during ACTRIS-2

The second period of the project was focused on a continuous call opened for all LiCal installations. Facilities like LiCoTest and LiReQA implemented new services based on the latest scientific developments and needs (assessment of the G, H, k parameters for the depolarization calibration Freudenthaler 2016, testing the beam-expander focus). During the second reporting period, the LiCal infrastructure used more access days than was initially assigned. All resources used for the extra days were based on voluntary bases or on external resources.

During the first half of the project LiCal covered **431.5** access days followed by **507** access days during the second part of the project, with a total of **938.5** access days out of 810 (more than **115.8%**).

Individual LiCal facilities description

LiCalTrain was involved in two workshops that covered both basic and advanced training topics. The first workshop was carried out in the first RP and the second was carried out at the beginning of the second RP. During the second and third reporting periods, the LiCalTrain facility continued to offer support to users by the continuous call opened on the official LiCal website. Since most topics were already covered within the two workshops and since all access days dedicated to training were already used, the potential users applying to this facility were directed towards other LiCal facilities that were able to cover a training component within its TNA activities (like LiCheckUnit, LiReQA, MUSA and POLIS). Due to the high interest on training, the LiCalTrain was able to cover more than **145%** from the initially assigned access days.

- LiCalTrain provided **34 TNAs** for **44 users** covering a total of **291.5 access days** from a total of 200 covered by Actris2.

LiCoTest: During the second part of the project, the LiCoTest facility underwent a series of upgrades. The first call for the characterization and testing of lidar optical components (carried out in the first RP) was used to understand

the needs and requirements of the users. Based on the user feedback the LiCoTest laboratory was equipped with a series of new instruments for the characterization of optical components and filters. The new infrastructure is now able to fully characterize optical components for the three main wavelengths used within lidar application (UV, VIS and near IR). The lab is now able to determine the Mueller-Stokes parameters for most lidar optical components. The upgraded spectrometric equipment is able to perform accurate measurements for polarization dependent optics and in the same time provide information on the incidence angle used for these measurements.

- during the reported period LiCoTest provided **8 TNAs** for **5 users** covering a total of **68 access days** out of a total of 68 left available. Most of the TNA requests were submitted by the industry (**4 out of 8 TNAs** covering a total of **37 access days**).

LiReQA provides the analysis and feedback during the internal quality check-up tests required by EARLINET-ACRIS for validation of the long-term observational data. During the reported period of ACRIS-2 (second part), LiReQA provided continuous access offering support and feedback based on the collected test files submitted by each station. The regular QA are required from all EARLINET-ACRIS stations for the homogeneous characterization of all instruments that usually provide observational data to the ACRIS database. The LiReQA providers continued to organize periodic online meetings to discuss the QA tests (including a training component). The meetings were designed to analyze particular cases and try to find possible solutions together with the LiReQA applicants. This type of virtual access is aiming to optimize the QA testing process performed by each user. The feedback provided by LiReQA will help lidar groups to optimize the instruments and, if necessary, advise the user to apply for other facilities within LiCal.

- during the second part of the ACRIS-2 project, LiReQA provided **40 TNAs** for **45 users** covering a total of **133 access days**. The LiReQA covered a total of 62 TNAs for 68 users covering a total of 177 access days from a total of 160.

LiCheckUnit is designed to offer expert evaluation to inspect and debug lidar instruments. Since one important parameter for aerosol typing and mass concentration retrieval is the linear particle depolarization ratio, the calibration module used in the lidar system must provide stable and reliable results. The TNA requests during the second part of the project showed an increased interest from the private sector covering topics related to depolarization and lidar design. From a total of 9 TNA requests from the second and third RP, 4 TNA requests were submitted by the private sector.

- LiCheckUnit provided **9 TNAs** for **12 users** covering a total of **67 access days** for the second part of the project. The unit covered **11 TNAs** for **14 users**, covering a total of **78 access days** from a total of 112. The remaining access days were transferred to the other LiCal facilities that used all allocated access (LiReQA and POLIS)

MUSA fixed and mobile, POLIS: During the second part of the project, the reference lidar instruments were able to provide side-by-side inter-comparisons for instrument validation for a various number of lidar instruments. The TNA also included training activities provided at the inter comparison sites.

The *MUSA mobile* installation provided two extended campaigns in Greece and Italy covering a total of 65 access days. The *MUSA fixed* installation covered one extended campaign with a strong training component for the Lalinet community. The *POLIS* installation covered extended inter comparison campaigns in France, Poland and Spain.

- *MUSA fixed:* provided **1 TNAs** for **5 users** covering a total of **35 access days** in the reported period and a total of **3 TNAs** for **7 users** covering a total of **63 access days** from a total of 42.
- *MUSA mobile:* provided **2 TNAs** for **7 users** covering a total of **65 access days** in the reported period and a total of **3 TNAs** for **9 users** covering a total of **89 access days** from a total of 84.
- *POLIS:* provided **5 TNAs** for **13 users** covering a total of **116 access days** in the reported period and a total of **6 TNAs** for **15 users** covering a total of **140 access days** from a total of 112.

Other indicators for the entire period of the project:

The total access provided by LiCal exceeds 115%.

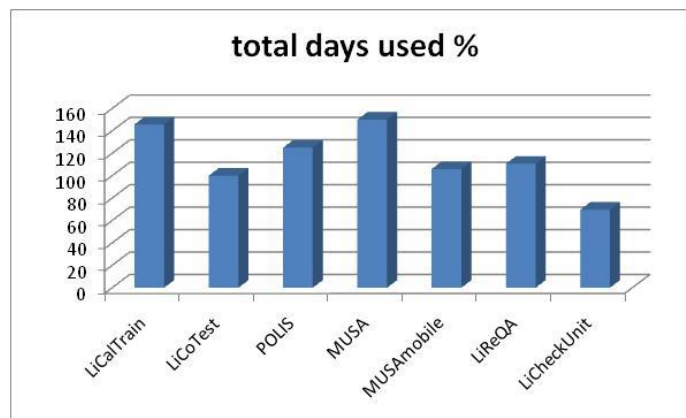
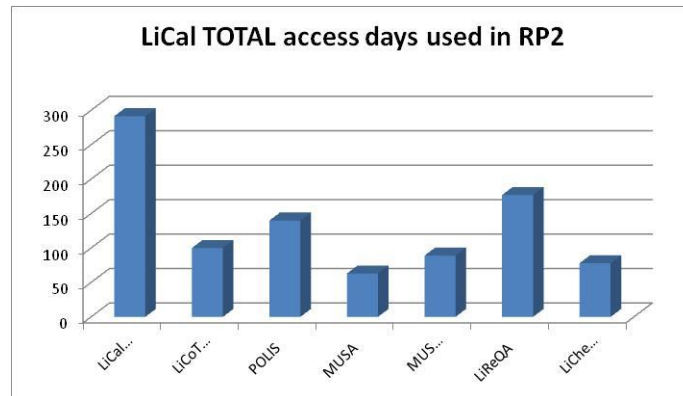
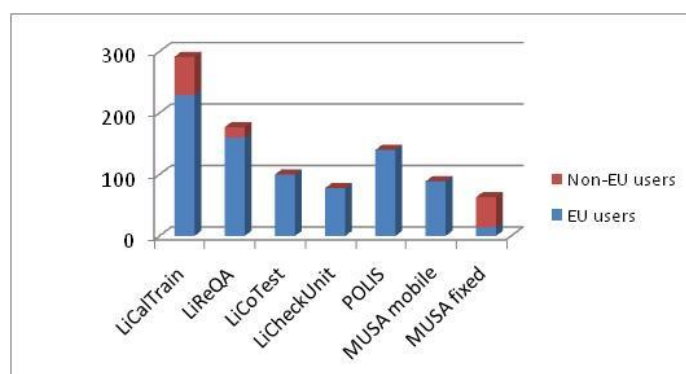


Fig 2 a-b: TNA access days used during the entire period of the project

The quantity of access provided by LiCal to **non-EU users** is **13.69%** out of the total access days used (corresponding to 128.5 access days to non-EU members).



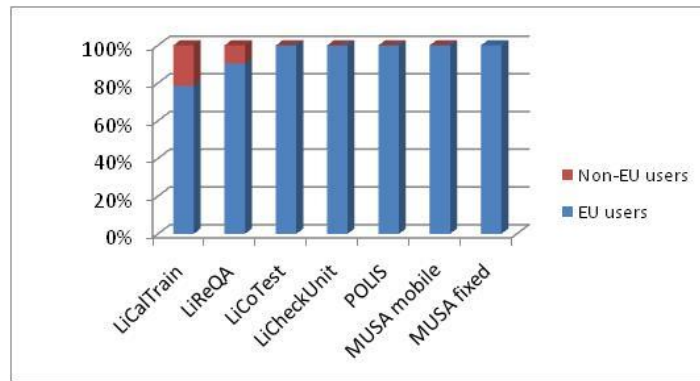


Fig 2 a-b: LiCal indicators for quantity of access to EU/non EU members at each LiCal facility during the entire period of the project.

- LiCal provided access to 46 women users from a total of 187 users (covering **24.6%** of the total LiCal access).

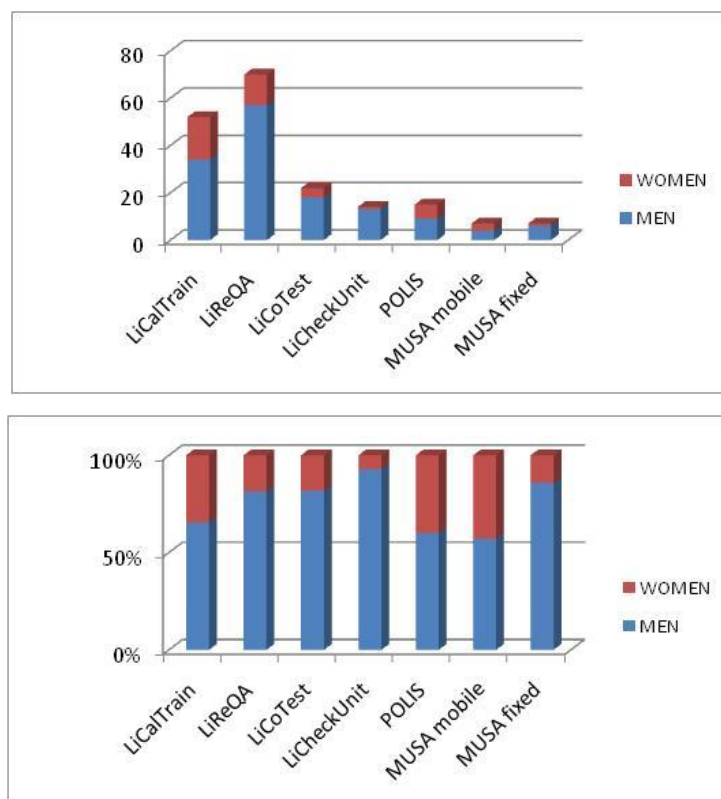


Fig 3 a-b: LiCal indicators related to gender equality at each LiCal facility during the entire period of the project.

- During the first reporting period LiCal provided **9.86%** of the total access TNA days to the **private sector** and **5.91%** to **public services**.

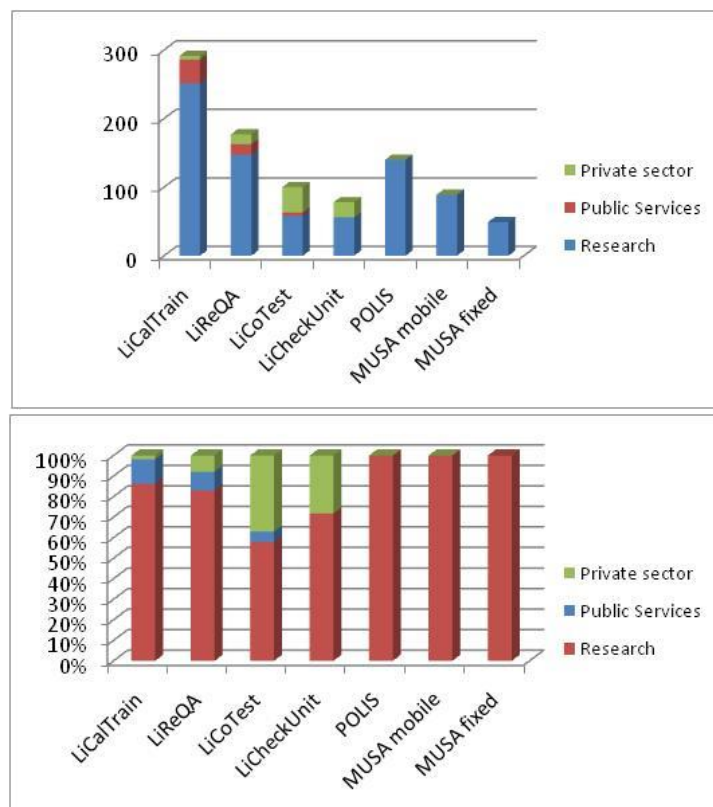


Fig 4 a-b: LiCal indicators for the quantity of access provided to private sector and public services at each the LiCal facility during the entire period of the project.

The total amount of access days used during the three reporting periods

Short name of Infrastructure	Installation no	Installation Short Name	Unit of access	Min Qty of access to be provided in Annex I (A)	Access provided in RP1	Access provided in RP2	Access provided in RP3	Total access provided (B)	Difference (B-A)
LiCal	1	LiCalTrain	1 RWD	200	177.5	114	0	291.5	91.5
LiCal	2	LiCoTest	1 RWD	100	25	7	68	100	0
LiCal	3	POLIS	1 RWD	112	0	24	116	140	28
LiCal	4	MUSA	1 RWD	42	28	0	35	63	21
LiCal	5	MUSAmobile	1 RWD	84	0	24	65	89	5
LiCal	6	LiReQA	1 RWD	160	34	30	113	177	17
LiCal	7	LiCheckUnit	1 RWD	112	11	5	62	78	-34

Impact

The LiCal infrastructure was the result of the extended experience developed within the European lidar research community through several joint research projects like ACTRIS-2 and predecessor projects (ACTRIS, EARLINET-ASSOS and EARLINET). The lidar research community continues to sustain a joined effort and to build a quantitative comprehensive unbiased database of the aerosol distribution on the continental scale.

All standard and measurement protocols were promoted continuously by all LiCal TNA activities within the ACTRIS-2 community but also to external users like the external scientific community, the user community and the private sector.

By addressing directly to the private sector, LiCal is continuously facilitating a direct connection between the scientific community and SMEs that provide environmental services, instrumentation, optical components and opto-electronic modules. The SMEs awareness of LiCal activities will lead towards new opportunities for knowledge

transfer, procedures and new commercial standards for emerging technologies in future remote sensing products available on the market.

INOE, LMU and CNR were jointly operating the Lidar Calibration Centre in ACTRIS-2 project, to develop an efficient program for assuring the quality of the lidar measurements. In total, LMU, CNR and INOE have provided 938.5 units of trans-national access covering direct comparisons with reference systems, characterization of optical components, analysis of test measurements, assessment of instrumental biases, and training. More than 15 lidar systems were annually checked by LiCal, and more than 15 new lidar operators from Europe and Latin America have been trained to implement EARLINET's QA program.

The Lidar Calibration Centre will continue to operate as part of the ACTRIS Centre for Aerosol Remote Sensing (CARS), one of the eight Central Facilities of the ACTRIS research infrastructure. Many of the tasks in CARS are shared between the three Units (INOE, LMU and CNR), in order to continue the work carried out in LiCal.

CARS CNR will be involved specifically in all tasks requiring collaboration with the Data Centre, CARS INOE will be specifically involved in all tasks related to development of the QA/QC tools to be implemented at the ACTRIS observation platforms, while CARS LMU will be specifically involved in all tasks requiring top-level expertise in optical design and measurement quality assurance.

Promotion of the LiCal services :

Promotion of LiCal services was realized via ACTRIS website, EARLINET website, the ITaRS portal and the official LiCal website. The LiCal infrastructure was also promoted during invited talks, conferences, workshops and project meetings. Each beneficiary used its own relevant mailing list to promote the infrastructure (CNR, INOE, LMU).

Facilities

The Lidar Calibration Training Laboratory (LiCalTrain) operates a multiwavelength depolarization Raman lidar, a scanning depolarization UV lidar, a tropospheric ozone lidar and complementary instrumentation (Scanning Microwave radiometer, C-ToF Aerosol Mass Spectrometer, Aerosol Chemical Speciation Monitor, Aethalometer, Aerodynamic Particle Sizer, Integrating nephelometer), as well as dedicated software tools to test, characterize, calibrate and validate lidar measurements. It is ideal to train the operators how to apply regular check-ups and maintain the calibration.

The Lidar Components Testing Laboratory (LiCoTest) has a long expertise in characterizing laser beams and optical components using power and energy meters, Tektronics oscilloscopes, Beam Profiler with M2 option, BeamScope, gonimeter and interferometer. This lab also covers spectroscopic ellipsometry measurements and spectral characterization of interference filters, beam splitters and dichroic mirrors, characterization of the aging process with the Perkin Elmer UV-VIS NIR Spectrometer. Electronic blocks are tested with Agilent and Tektronics pulse-form generators and analysers. This installation delivers full characterization of the optical and electronic components which are part of the transmitter and receiver, essential when assessing the instrumental (systematic) errors.

The Lidar Remote Quality Assurance (LiReQA) operates dedicated software tools (raytracing for analyzing the transmitter and receiver optics, lidar polarization analysis software, lidar radiation power budget analysis software, analysis of test measurements specialized for individual lidar setups) to perform fault diagnosis of any lidar system.

The Lidar Check-up Unit (LiCheckUnit) is a portable unit (laser power meter, polarization analysis instruments for inspection of transmitter and receiver optics, adapted instruments for checking the alignment of the lidar system, e.g. CCD camera & special optics adapted to the lidar system, lidar pulse simulator for inspection of the detection electronics) which can be used at the user site to inspect and debug the instrument.

The mobile reference lidar POLIS measures at two elastic wavelengths – 355 nm and 532 nm and their N2-Raman shifted wavelengths – 387 nm and 607 nm, and linear depolarization ratio at 532 nm and 355 nm. It can be easily moved to the user's site to perform side-by-side intercomparison. It is the only reference lidar with depolarization at 355 nm.

The reference lidar MUSA (in fixed or mobile configuration) is a multi-wavelength depolarization Raman with 3 elastic – 1064, 532, 355 nm, 2 Raman – 607, 387 nm, and linear depolarization ratio at 532 nm. It is the only reference instrument operating simultaneously 3 elastic (including the infrared) and 2 Raman channels. The system can be moved at the user site (if the user's lidar is fixed) or can be operated at the host for longer intercomparisons.

The lidar calibration centre: a multi installation facility in the framework of ACTRIS

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Abstract

The lidar calibration centre (LiCal) provides a wide range of applications for detailed lidar and ceilometer characterization. Depending on the installation, the facility provides characterization of single lidar components, optical blocks and direct comparisons with reference lidar instruments. LiCal offers the opportunity to apply for lidar debugging, optimization and intensive training workshops for new lidar users. This paper gives an overview on the concept and current activities.

Results

LiCoTest
 Measurement of parallel and perpendicular transmittance of lidar steering mirrors in the emission
 Tests were performed on several points to assess the spatial homogeneity of optical properties

LiReQA
 Telecover test to check the alignment of the emitting and receiving optical units
 Depolarization calibration tests - (Freudenthaler, 2016)

MUSA mobile
 Lidar inter-comparisons
 Range corrected signal
 Signal intercomparison for instrument validation

Characterization of the 355nm waveplate + PBS + about XTFRM at 355 nm (extinction ratio)

Measurements done for: waveplate, PBS- polarizer beam splitter, P1 - reflection polarizer, P2 - transmission polarizer.
 Setup:
 1) laser + glass + waveplate + P1 + detector,
 2) laser + glass + waveplate + P2 + detector,
 3) laser + glass + waveplate + PBS + P1 and P2 + detector

Measuring the transmission of neutral density filters (low power) at 355, 387, 532, 607, and 1064 nm
 The transmission (%) was determined in the domain of 500 to 1100 nm using a Perkin Elmer Lambda 1050 WH.

a: Rayleigh Fit test to see telescope - emission alignment issues mainly in the far field
 b: analysis of the relative deviation for Rayleigh fit test

Ray-tracing to debug lidar instrument design faults

Apply for access to LiCal

28thILRC, 25th-30th June 2017, Bucharest, Romania
 contact: belegante@inoe.ro

Figure WP6.5: LiCal advertising at the 28 ILRC conference 25-30 June 2017

LiCal advertising was performed by several channels:

- Websites
 - LiCal website (<http://lical.inoe.ro>)
 - ACTRIS website (www.actris.eu/Outreach/News/CallsforTNA/LiCalcall2016.aspx)
 - ITaRS portal (<http://itars.uni-koeln.de/static/index.php.1.html>)
 - https://twitter.com/ecars_project/status/821269434237153280
 - ECARS website (<http://ecars.inoe.ro>)

- Outreach activities
 - Invited talks (*Planned training activities* at Lical, Doina Nicolae, 2nd ACTRIS-2 General Assembly Meeting ESA/ESFRIN Frascati, Italy, March 3, 2016; *The Lidar calibration centre, a recently established ACTRIS calibration facility*, Belegante Livio, 2nd ACTRIS-2 General Assembly Meeting ESA/ESFRIN Frascati, Italy, March 3, 2016)
 - Conferences (EGU 2016, April, Vienna, Austria)
 - Workshops (ECARS workshop, May 2016, Magurele, Romania)
 - Project meetings (MULTIPLY - <http://environment.inoe.ro/article/172/multiply-about>, ECARS - <http://ecars.inoe.ro/>)
 - ILRC 2015 (“Lidar Calibration Centre” Gelsomina Pappalardo, Volker Freudenthaler, Doina Nicolae, Lucia Mona, Livio Belegante, Giuseppe D’Amico, ILRC 27, July 5 - July 10, 2015 New York, USA)
 - ILRC28 2017 – submitted paper and poster

- Mailing lists (each beneficiary was responsible to distribute promotional information about LiCal via email)