Artemis operational statistics

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The Artemis team delivered a total of nine user experiments from April 2015 to March 2016, as well as three weeks of development projects in partnership with facility users. In total, we delivered 99 days (20 weeks) of user access and twelve weeks of dedicated experiment setup. Table 1 shows the schedule for the year.

Week beginning	Experiment
30/03/2015	Set-up for Minns
06/04/2015	
13/04/2015	Minns 13220015
20/04/2015	
27/04/2015	Development
04/05/2015	
11/05/2015	Minns 13220015
18/05/2015	
25/05/2015	Laser service and maintenance
01/06/2015	
08/06/2015	Set-up for Moser, Schwenke, Thornton, Bertoni and Gierz
15/06/2015	
22/06/2015	
29/06/2015	Staff training
06/07/2015	Open Week
13/07/2015	Laser service and maintenance
20/07/2015	Set-up for Moser
27/07/2015	
03/08/2015	Moser 15120032
10/08/2015	
17/08/2015	Set-up for Schwenke
24/08/2015	Schwenke 15120043
31/08/2015	
07/09/2015	Thornton 13220017
14/09/2015	Set-up for Bertoni and Gierz
21/09/2015	Bertoni 15120037
28/09/2015	
05/10/2015	Gierz 15120027
12/10/2015	
19/10/2015	Changeover and bakeout
26/10/2015	
02/11/2015	Laser service and maintenance
09/11/2015	Set-up for Carley
16/11/2015	Carley 15120039
23/11/2015	
30/11/2015	Set-up for Brocklesby
07/12/2015	Brocklesby 16120012
14/12/2015	
21/12/2015	Christmas shutdown
28/12/2015	
04/01/2016	Engineering
11/01/2016	Development
18/01/2016	
25/01/2016	Laser Down
01/02/2016	Development
08/02/2016	Laser Down
15/02/2016	Set-up for Thornton
22/02/2016	Thornton 16120007
29/02/2016	
07/03/2016	Changeover
14/03/2016	Laser service and maintenance
21/03/2016	Engineering
28/03/2016	

Table 1. Artemis schedule for 2014-15.

Experiments and set-up

Six of the nine experiments in this reporting year were studies of time-resolved photoemission from condensed matter. Five of these used the angle-resolved photoemission chamber, and one used the ultrafast demagnetization chamber with time-of-flight detector. Of the remaining experiments, one was on time resolved photoemission in the gas phase, and the others on XUV coherent imaging. The Artemis team dedicates approximately one week of set-up to each experiment, before users arrive. Similar experiments are grouped together, to minimize set-up time.

Facility performance and reliability

Figure 1 shows the availability and reliability calculations for the 2015-16 year. We run the laser continuously from Mondays through to Fridays during experiments, and regularly carry on data-taking over weekends. In this calculation, the availability for unsupported data-taking overnight and at weekends is weighted equally with supported hours.

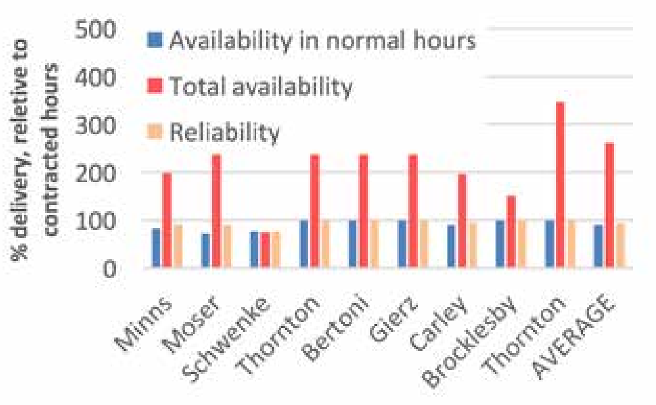

Figure 1. Availability and reliability for user experiments in 2015-16

The average availability is 262%, an improvement upon last year. We were able to deliver five experiments without losing any time at all to laser alignment, achieving 100% reliability and availability. The overall reliability has increased to 94% from 70% the year before.

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Gemini operational statistics 15/16

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During the reporting year, April 15 – April 16, a total of 5 complete experiments were delivered in the Astra-Gemini Target Area and 2 experiments in TA2. In total 29 high power laser experimental weeks were delivered the Gemini Target Area and 23 weeks to TA2. The delivered schedule is presented in Figure 2.

The availability of the Gemini laser system (delivery to the Gemini Target Area) was 80% during normal working hours, rising to 136% with time made up from running out of normal working hours. The reliability of the Gemini laser was 87%. An individual breakdown of the availability and reliability for the experiments conducted is presented in Figure 1.

The high levels of total availability were made possible by the continued unique operational model employed on Gemini, which involves running the laser late into the evening. In addition, frequent weekend operational days were made available.

Two main system access slots were made available during the year. The first slot saw the replacement of the Astra amplifier 1 and 2 pump lasers for new Quanta Ray systems to address reliability, replacement of the LA2-LA3 transport relay pipe for a stainless steel version to improve optics lifetime and installation of an adaptive optic at the output of the Astra system. During this access period measurements were made of the full power Gemini focal spot in the target area.

The second system access period was used to install a new long pulse beamline for implementation as a shock driver for the April 2016 Eakins experiment. For further details of this installation see the article by Hawkes et al elsewhere in this report.

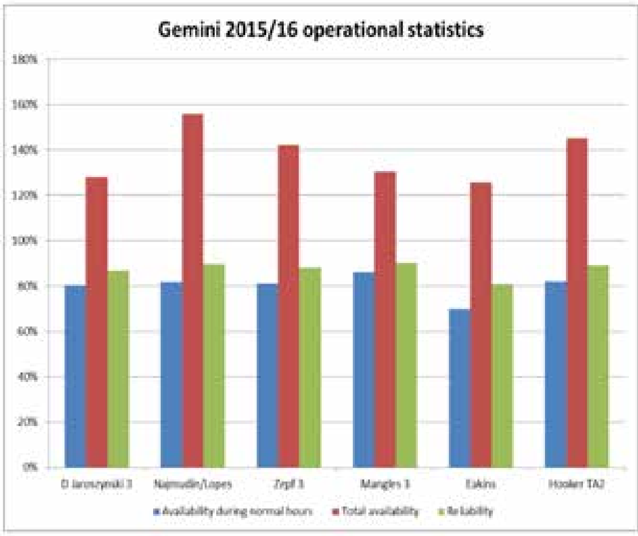

Figure 1. 2015/16 operational statistics

Week commencing	Gemini	TA2
30/03/2015		
06/04/2015		
13/04/2015	System access	
20/04/2015		
27/04/2015		
04/05/2015	Maintenance	
11/05/2015		
18/05/2015		
25/05/2015	Jaroszynski	
01/06/2015	15110013	Hooker
08/06/2015		15110002
15/06/2015		
22/06/2015		
29/06/2015	Open week prep	
06/07/2015	Open week	
13/07/2015		
20/07/2015	System access	
27/07/2015	Najmudin/Lopes	Hooker
03/08/2015	15110008/15110009	15110002
10/08/2015	System access	
17/08/2015		
24/08/2015		Hooker
31/08/2015	Najmudin/Lopes	15110002
07/09/2015	15110008/15110009	
14/09/2015		Extension
21/09/2015		
28/09/2015	Maintenance	
05/10/2015		
12/10/2015		System access
19/10/2015	Zepf	
26/10/2015	15110010	
02/11/2015		Hooker
09/11/2015		Extension
16/11/2015	Maintenance	
23/11/2015		Hooker
30/11/2015	Mangles	Extension
07/12/2015	15210013	
14/12/2015		
21/12/2015	Christmas 2015	
28/12/2015		
04/01/2016		
11/01/2016		
18/01/2016		Lead work
25/01/2016	System access	
01/02/2016		Engineering access
08/02/2016		
15/02/2016		Set up access
22/02/2016		
29/02/2016		
07/03/2016		
14/03/2016	Eakins	Commercial access
21/03/2016	15210011	
28/03/2016		

Figure 2. 2015/16 Gemini operational schedule

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Lasers for Science Facility

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OCTOPUS facility

In the reporting period (April 2015 to March 2016), 28 different User groups performed a total of 35 experiments. A total of 84 weeks' access was delivered to the UK User community including 4 weeks to European Users throughout the year. Biology and Bio-materials formed the majority of applications, see Figure 3.

A full breakdown of number of weeks applied for versus number of weeks scheduled is shown in Figure 1 indicating an oversubscription ratio of 1.57:1.

There were a total of 22 formal reviewed publications from this year's efforts.

ULTRA facility

In the reporting period (April 2015 to March 2016), 18 different User groups performed a total of 22 experiments. A total of 51 weeks' access was delivered to the UK User community including 4 weeks to European Users throughout the year. Chemistry formed the majority of applications, see Figure 4.

A full breakdown of number of weeks applied for versus number of weeks scheduled is shown in Figure 2 indicating an oversubscription ratio of 1.45:1.

There were a total of 28 formal reviewed publications from this year's efforts.

User satisfaction

The average User satisfaction marks obtained from the scheduled Octopus and Ultra Users are shown in figure 5, with an average satisfaction of 91.9% across the categories. There were a total of 91 hours downtime reported over the combined 135 weeks of access.

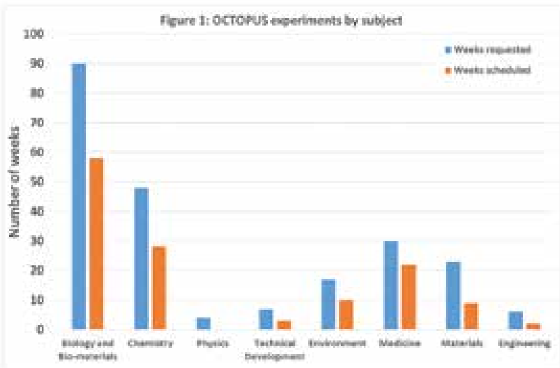

Figure 1: OCTOPUS experiments by subject

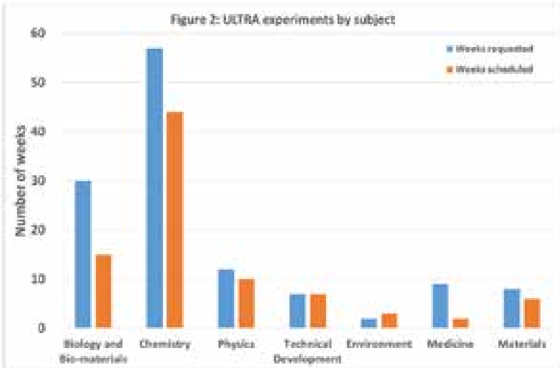

Figure 2: ULTRA experiments by subject

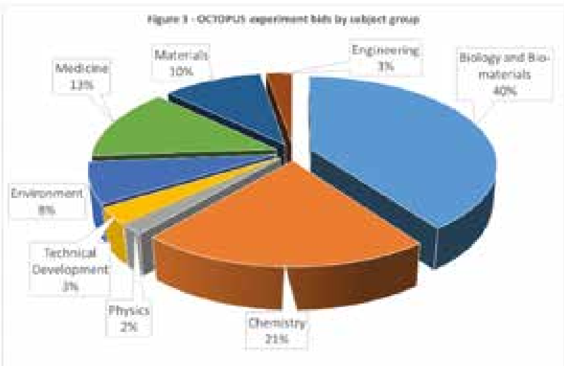

Figure 3 - OCTOPUS experiment bids by subject group

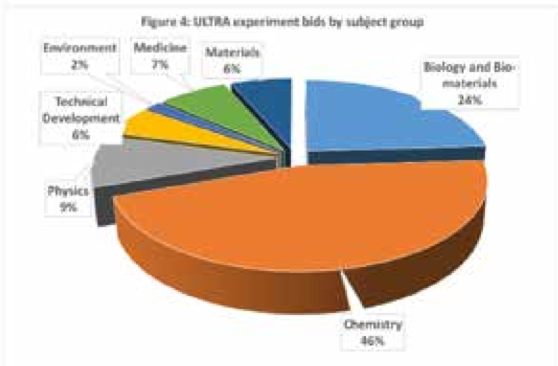

Figure 4: ULTRA experiment bids by subject group

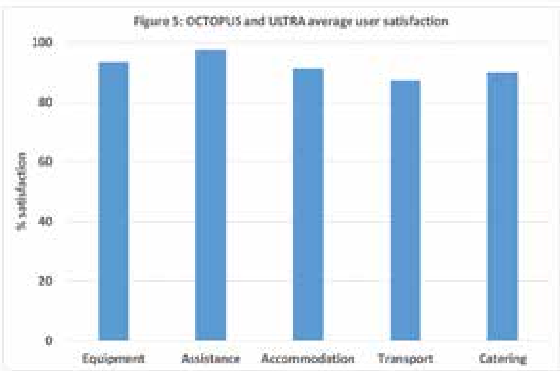

Figure 5: OCTOPUS and ULTRA average user satisfaction

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Vulcan Operational Statistics

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Introduction

Vulcan has completed an active experimental year, with 61 full experimental weeks allocated to target areas TAW and TAP between April 2015 and March 2016.

Table 1 shows the operational schedule for the year, and reports the shot rate statistics for each experiment.

PERIOD	TAW	TAP
	2015	
04 May – 14 Jun	**T Dzelzainis** XUV probing of warm dense matter (112, 17, 84.8%) (89.7%, 111.3%)	**M Borghesi** High dose-rate effects in cell radiobiology employing ultrashort ion bursts (56, 3, 94.6%) (87.5%, 110.1%)
27 July – 30 Aug	**P McKenna** Fast electron transport in transient states of warm dense matter (101, 8, 92.1%) (84.1%, 116.5%)	**J Green** Resistive guiding and focusing of hot electrons in conical magnetic mirror targets (82, 9, 89.0%) (79.8%, 111.1%)
31 Aug – 13 Sep		**Plasma mirrors** (19, 1, 94.7%) (82.5%, 100.8%)
21 Sep – 25 Oct	**D Riley** K-edge shift under different plasma environments (122, 4, 96.7%) (75.3%, 128.9%)	**M Borghesi** High dose-rate effects in cell radiobiology employing ultrashort ion bursts (142, 6, 95.8%) (77.5%, 105.1%)
09/23 Nov – 13 Dec	**M Borghesi** Evolution of electrostatic and magnetosonic collisionless shocks in tenuous plasmas (143, 10, 93.0%) (89.8%, 119.0%)	**M Roth** Probing new laser driven ion acceleration shcemes with thin cryogenic targets (20, 4, 80.0%) (78.8%, 109.0%)
	2016	
11 Jan – 07/14 Feb	**M McMahon** Shock melting of cerium probed using single photon energy dispersive x-ray diffraction (99, 14, 85.9%) (86.1%, 116.4%)	**D Neely** Deuterium hydrogen composite beams for fast ignition (69, 11, 84.1%) (82.9%, 105.1%)
29 Feb –03 Apr	**G Gregori** Dynamics of hydromagnetic radiative shocks (87, 12, 86.2%) (83.5%, 108.3%)	P McKenna Collimated, high density jets of multi-MeV electrons from near-critical density targets (91, 9, 90.1%) (80.5%, 113.0%)

Table 1: Experimental schedule for the period April 2015 – March 2016

(Total shots fired, failed shots, reliability)

(Availability normal, additional hours)

Numbers in parentheses indicate the total number of full energy laser shots delivered to target, followed by the number of these that failed and the percentage of successful shots. The second set of numbers are the availability of the laser to target areas during normal operating hours and including outside hours operations.

The total number of full disc amplifier shots that have been fired to target this year is 1143. Table 2 shows that this figure compares very favourably with recent years. 108 shots failed to meet user requirements. The overall shot success rate to target for the year is 91%, compared to 92%, 89%, 88% and 88% in the previous four years. Figure 1 shows the reliability of the Vulcan laser to all target areas over the past five years.

	No of shots	Failed shots	Reliability
11 - 12	641	54	92%
12 - 13	860	93	89%
13 - 14	1015	121	88%
14 - 15	1087	133	88%
15 - 16	1143	108	91%

Table 2. Shot totals and proportion of failed shots for the past five years

The shot reliability to TAW is up very slightly at 90%, compared with 88% in 2013-14. The shot reliability to TAP is around 85%, down from 91% the previous year.

Analysis of the failure modes reveals that, as in recent years, the two overriding causes of failed shots are alignment and front end related issues. It is difficult to distinguish these two causes and we are in the process of commissioning high repetition rate diagnostics (camera-based energy monitors, spectrometers and autocorrelators) in the front end and throughout the laser area to identify and resolve specific sources of instability.

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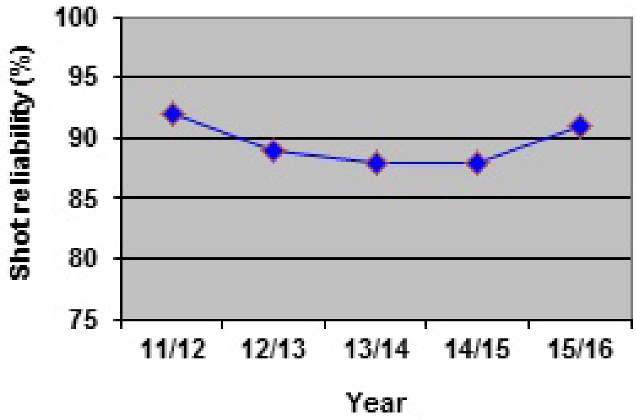

Figure 1. All areas shot reliability for each year 2011-12 to 2015-16

There is a requirement which was originally instigated for the EPSRC FAA that the laser system be available, during the five week periods of experimental data collection, from 09:00 to 17:00 hours, Monday to Thursday, and from 09:00 to 16:00 hours on Fridays (a total of 195 hours over the five week experimental period). The laser has not always met the startup target of 9:00 am but it has been common practice to operate the laser well beyond the standard contracted finish time on several days during the week. In addition, the introduction of early start times on some experiments continues to lead to improvements in availability.

On average, Vulcan has been available for each experiment to target areas for 83.2% of the time during contracted hours, compared with 85.3% for the previous year. Although this figure is slightly down, the overall availability is slightly up from 111.9% in 2014-15 to 112.4% to all target areas. The time that the laser is unavailable to users is primarily the time taken for beam alignment at the start of the day.

Target Fabrication Operational Statistics

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RAL Experiments

Target Fabrication's support in the reporting period April 2015 to April 2016 was predominantly for Vulcan target areas, with only one of the 12 supported experiments in Gemini. Despite this, the number of supported experiments only decreased by one, a marked increase in the support required by Vulcan experiments. The Target Fabrication group supported a total of 4 experimental weeks for Gemini and 53 weeks for Vulcan. The total number of weeks support for solid target experiments was 57 weeks, down from 64 in the last reporting period. The Target Fabrication group also provided targets for two academic access experiments at AWE which are reported separately at the end of this report. This report does not include support for other areas of the CLF including Artemis and the LSF.

1) Target Numbers

For the reporting year the total target numbers produced are shown in Table 1. The table is broken down into separate experiments and gives data on total target numbers produced and the subset consisting of high specification targets that have been produced. High specification targets are defined as targets that have taken significant highly skilled micro assembly or micromachining to be produced above and beyond typical target manufacture.

The total number of targets for use at RAL produced by the group in 2015-2016 was 2371 compared to 1937 in 2014–2015 and 2507 in 2013-2014. During 2015-2016 the number of high specification targets decreased from 87 to 77 accounting for 3% compared to 4% last reporting year.

Experiment	Targets Produced	High Specification Targets
0515 TAP	326	
50515 TAW	241	
0715TAP	113	40
0715TAW	235	
00915 TAW	220	11
1115 TAW	324	
0116 TAP	35	
0116 TAP	311	
0216 GTA	91	22
0216 TAW	243	
0316 TAP	139	
0416TAP	93	
TOTAL	**2371**	**77**

Table 1: Target production summary for 2015-2016. High specification targets include 3D micro-structures, low density targets and mass limited targets.

2) Target Categories

Targets can be separated into seven main categories as shown in Figure 1 and Table 2.

Ultra-thin foil targets are specified as having a thickness <500nm and require a coating capability and a skilled fabricator to process; thick foils make up the rest of single component foils. Multilayer foils are stacks or layers of foils that require thin film coating capability to deposit multiple layers onto an existing foil; they are often different composition layers with different thicknesses. Alignment targets are specified as wires or pinholes that are used for set-up purposes. 3D micro-structures are complex 3D geometries that require skilled assembly or micro-machining to produce them. Foam targets are low density polymer structure manufactured through chemistry based techniques.

Target Category	Targets Produced 2015-2016	Targets Produced 2014-2015	Targets Produced 2013-2014
Ultra-thin Foil	197	530	679
Thick Foils	1349	708	685
Multi-layered Foils	605	500	653
Alignment	110	85	97
3D Micro-structures	99	82	334
Foams	0	5	33
Mass-limited	11	0	22
TOTAL	**2371**	**1937**	**2507**

Table 2: Target category summary for the last 3 reporting years. 3D micro-structures are targets that require micromachining or skilled micro-assembly. Mass-limited targets are targets designed to have minimal support structures

Figure 1: Targets delivered by type

It should be noted that figure 1 is not a reflection of staff effort. Assembly time for a single thick foil target is relatively short; for a batch of mass-limited targets, trials, manufacture and characterisation activities can amount to weeks of effort.

Each experiment usually requires similar targets with varying thickness, composition or geometry. For example: a thin foil experiment typically requests a thickness scan of a particular material. For foil experiments each thickness or composition change requires a separate coating run and for 3D experiments each geometry change requires a new assembly set up. Each change needs to be characterised and logged adequately. Within the total of 2371 targets there were 324 unique target variations which averages 7 targets per variation. Last reporting year the average number of targets per variation was 6. The flexibility provided by the group is a key capability of the CLF and enables the user community to fully utilize the limited time that is available during each experiment on both the Vulcan and Gemini laser systems.

3) Experimental Response

It is seen as a significant strength of Target Fabrication to be rapidly responsive to experimental results and conditions by working collaboratively with user groups. The Target Fabrication group responds to experimental changes during a campaign and often implements a number of modifications or redesigns to the original requests. The number of modifications and variations on each experiment is variable and is dependent on the type of experiment and also on experimental conditions such as diagnostic and laser performance. For this reporting period a total of 652 targets were modified or redesigned from the target list agreed upon in the planning stage. This makes up 27.5% of the total targets delivered. In the last reporting year the percentage was 25% and the year prior to that the modified percentage was 22%. As was the case last reporting year: three of the thirteen experiments accounted for the majority of the modified targets; in 0715TAW 84.6% of the total targets were modified, 79% for 1115TAW and 62% for 0915TAW. These three experiments were particularly demanding for Target Fabrication which often produced modified targets in less than a day. Target modifications required significant effort especially in the case of complete geometry change or alterations to coating specifications.

4) Adapting to Demand

The Target Fabrication group endeavors to be adaptable to the changing demands of the user community as experiments develop. Each experiment that is carried out often has widely varying target demands and as a result the group is constantly developing its capabilities.

For this and last two reporting years, foils have dominated the target types comprising just over 90% of the targets delivered. The large number of thick foil type targets can be attributed to the increased support of Vulcan target areas. In the last reporting year Target Fabrication supported many more Gemini experiments with ultra-thin foil requirements.

Ultra-thin and multilayer targets are reliant on coating plant capability and numbers are largely in line with the two previous years.

5) Waste Reduction

Unexpected delays or changes during an experiment often result in a number of targets that have been fabricated but that are not shot by the end of experimental campaign. Targets are collected shot targets totaled 288 accounting for 12.1% of the total targets made. In 2013-2014 a 16% return of un-shot targets was recorded, in 2012-2013 it was 19%, for 2011-2012 and 2010-2011 the proportion was 43% and 10% respectively.

Any un-issued or returned targets are carefully sorted and high specification targets are stored under closely controlled conditions for potential use on future experiments. Where possible all spare target components and mounts are also stored for future use. The variety of mounts and components held in stock by the Target Fabrication group contribute to their ability to adapt target designs quickly in response to experimental changes.

There has been a noticeable reduction in waste since the complete implementation of the ISO9001 Quality Management System (QMS) which has allowed the Target Fabrication group to plan experimental delivery of targets in a more structured way. The improved planning processes enable long term delivery projects to be managed effectively. It should be noted that this has not led to less flexibility as the percentage of modified and re-designed targets is in line with the figures for before the implementation (2009-2010, 2010-2011).

Approximately one percent of targets were returned as non-conforming under the QMS in this reporting period.

Orion Academic Access

The Target Fabrication Group has supplied targets to the AWE Orion academic access campaign for groups from the University of York and Imperial College London. In total 215 targets have been delivered for a total of 6 weeks access to Orion. The targets have been complex and have called for the implementation of a range of existing and new technologies including micromachining and gas filling of targets. Further work will be carried out to develop the technologies to enable new target types to be offered to CLF users.

External Contracts

Scitech Precision Ltd, (a spinout company from CLF Target Fabrication) has supplied micro-targets, specialist coatings and consultancy to a number of external contracts. In the year 2014-2015 a total of 53 contracts were completed for coatings, characterisation and also full target design and assembly. This is an increase from 44 in the previous year. The contracts were delivered to external facilities in countries including France, Germany, Italy, India and the US. In this reporting year Scitech Precision has supplied phase plates to LULI, LCLS, GSI and other large facilities.

Summary

Target Fabrication has supported 12 experiments in the CLF and eleven other international facilities in the last year as well as providing an increasing amount of characterisation services and acting as a knowledge base for Target Fabrication activities throughout Europe. This year has seen a decrease in the total number of weeks supported at 57 but an increase in total target numbers to 2371 delivered. Over 90% of the targets delivered were foil type targets with an extremely high turnover of thick foils due to the higher than usual proportion of Vulcan experiments to Gemini.

The number of targets modified from initial target request in the experiments has continued to gradually climb from 22% in 2013-2014, 25% in 2014-2015 and 27.5% this reporting period. As with last reporting year the vast majority of modified targets were due to three experiments.

References

1. D.Haddock, C. Spindloe & M. Tolley , Target Fabrication Operational Statistics, CLF Annual Report 2014-2015
2. D.Haddock, C. Spindloe & M. Tolley , Target Fabrication Operational Statistics, CLF Annual Report 2013-2014
3. D.Haddock, C. Spindloe & M. Tolley , Target Fabrication Operational Statistics, CLF Annual Report 2012-2013, p74-75
4. D.Haddock, C. Spindloe & M. Tolley , Target Fabrication Operational Statistics, CLF Annual Report 2011-2012 , p71-72
5. H. F. Lowe, C. Spindloe & M. Tolley, Target Fabrication Operational Statistics, CLF Annual Report 2010-2011 , p76-77
6. H. F. Lowe, C. Spindloe & M. Tolley, Target Fabrication Operational Statistics, CLF Annual Report 2009-2010 , p55-56

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