E/S/R

Science for Communities

forensic

CRIME
SCIENCE &
INTELLIGENCE

2016-17

16-17 FINANCIAL YEAR

3 Total number of exhibits processed
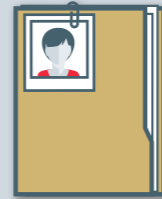**44 675**

Total number of samples in the Crime Sample Databank
39 526

DNA samples loaded to National Database
15 390

Total number of DNA profiles held in Database
184 516

Total cases
10 363

Total analyses
108 421

Homicide cases attended	**54**
Sexual assault cases	**506**
Offense against person cases	**268**
Burglary cases	**2197**
LTA blood alcohol assays	**7081**
Suspicious deaths	**39**
Man hours at a scene	**3743**
Man hours of court attendance	**692**
Laser scanned scenes	**25**
Crime Harm Index for cases handled by ESR	**1.038 MILLION**

Crime to Person links
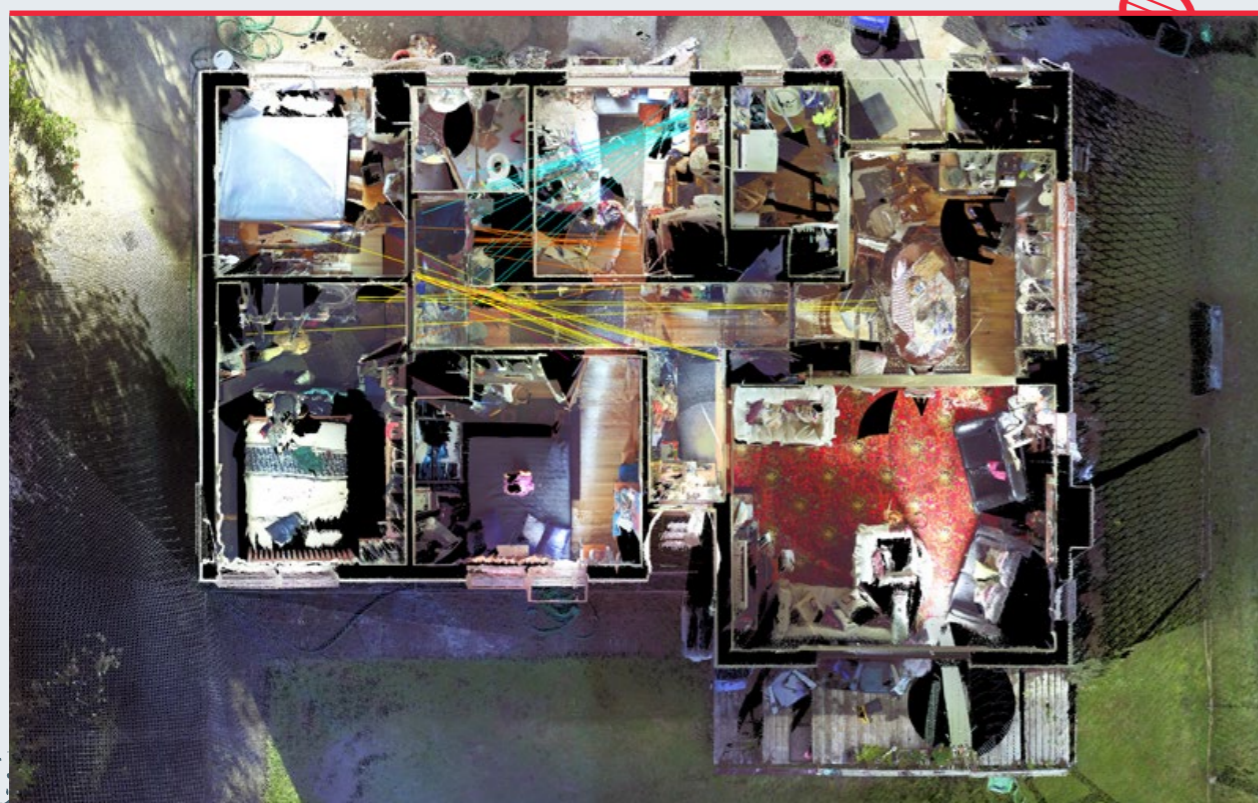*(1/7/16 – 30/6/17)*
3741

Crime to person link rate
75%

Crime to crime link rate
31%

Bringing the Crime Scene to life with 3D photography

*N*ew Zealand is a leader in the 3D field and ESR has been using the technology in a variety of ways. In 2015 ESR was part of a joint research bid for a project investigating how 3D evidence visualisation could change how evidence is presented and understood in court.

Since then ESR has continued to advance in the 3D capture and presentation of crime scenes and exhibits. Recent developments have allowed the Auckland Forensic Service Centre to explore a new 3D output package that allows Police and the courts to have unrestricted movement when exploring a crime scene in 3D. The package incorporates spherical photographs, scene photographs, analytical results and 3D representations of examined exhibits.

Further developments have allowed the Service Centre to begin exploring the use of virtual reality (VR) as a means of reinvestigating crime scenes, training both Police and ESR scene-going scientists, and proficiency testing. The first case to trial the 3D presentation and VR capability was Operation Pencarrow, a Police siege where over 40 shots were fired.

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iPads

Forensic Scientists are now using iPad Pros for scene examinations and laboratory note taking. They have made a tremendous amount of difference in terms of time frames as the scientists are able to produce sketches and floor plans as well as annotating photographs. The information is stored in an electronic case file in ESR's LIMS system, making it easily retrievable.

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New Zealand Customs ESR Screening Laboratory (CESL)

Every day thousands of people, packages and large amounts of cargo arrive at the New Zealand border and enter the country. The Custom's ESR Screening Laboratory (CESL) in Auckland is responsible for screening and identifying suspected drug samples seized by Customs at border security, and through the international mail centre.

the pace of drug manufacturing.

In order to increase identification of these substances, ESR embarked on a project in collaboration with the University of Auckland in 2015 to develop analytical methods that would identify unknown suspicious compounds.
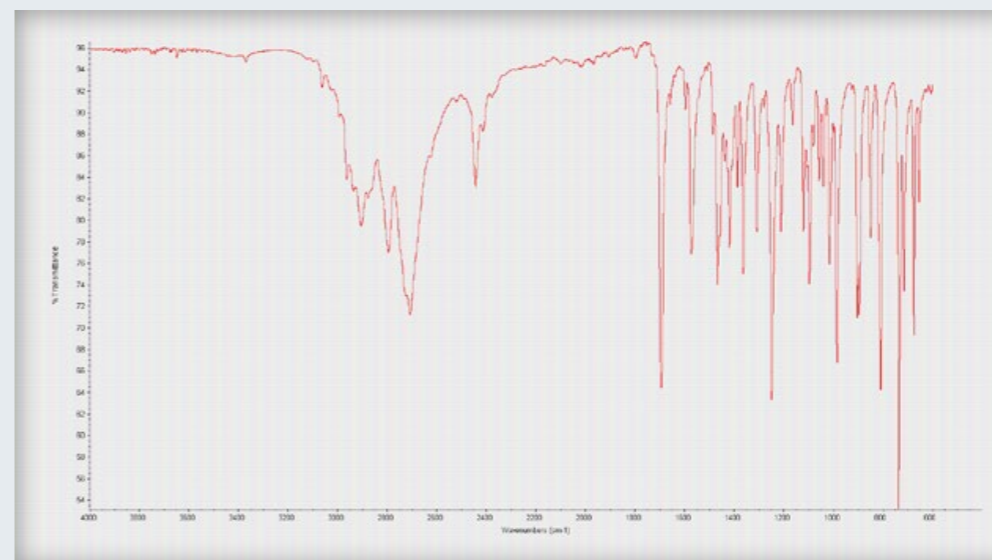
Overall, forty new designer drugs have been identified and the results recorded into a Designer Drug Database.
The image to the left is of the 'chemical fingerprint' of the designer drug 3-CMC, generated during this project.
The Designer Drug Database is now in use at the screening laboratory and accounts for nearly 15% of all identifications made at CESL.

With internet access widening the scope of drug sources, a new threat has emerged over recent years with the introduction of designer drugs becoming readily available online.

First generation designer drugs broke into the market under the guise of 'bath salts' with subsequent names ranging from 'herbal incense' to 'research chemicals' and a wide variety of alternative, seemingly harmless labelling, to try to circumvent monitoring and control.

The newly developed drugs mimic the effects of a controlled substance, while attempting to avoid legislative control and identification, using standard drug testing techniques. Many of the new drugs end up being controlled under the Misuse of Drugs Act 1975, or the Psychoactive Substances Act 2013. These drugs generally have a short life-span and as a consequence there is limited research available on the harm to end-users. Therefore, they pose significant risk to communities if they come into the country.

Suspicious seizures are sent for testing at CESL to be analysed and matched against databases of known compounds. However, many designer drugs avoid detection as they are sufficiently modified from known substances that current analytical methods can't identify them. With new compounds being manufactured constantly, analysis techniques struggle to keep up with

The process utilises a technique called Nuclear Magnetic Resonance (NMR) spectroscopy which is the same technology used for medical MRI radiology. This technique breaks the compound down like a jigsaw puzzle and pieces it back together again, providing its structure.

The project allowed for real-time updates to be made to capture information and trends on border seizures, compared to the months that it could take without this technique. The information is also essential to inform other agencies of potential risks that may be entering New Zealand communities, as well as assisting in Customs investigations.

With the increase in access, and constant evolution of designer drugs, real-time information is crucial. In order to keep ahead of a changing market, ESR will continue this work when further funding opportunities arise.

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Drugs in wastewater

Knowing where and when drugs are most commonly used is a valuable insight for Police and other agencies to inform and target the activity.


Combining two of ESR's expert capabilities in drug forensics and biowastes, ESR was commissioned by Police last year to test sites in Auckland and Christchurch to allow authorities to map drug-use patterns and provide better data than that achieved through self-reporting or drug arrests.

ESR analysed the wastewater in both cities to determine the amount, type and distribution of illicit drug use. Using a robust sampling protocol and a modified and validated extraction method, ESR tested for methamphetamine, heroin, cocaine, alpha PVP (bath salts) and ecstasy (MDMA).

Seven months of sampling (seven consecutive days per month) have produced some interesting results over each period.

Methamphetamine use is relatively constant day-to-day, suggesting habitual use. MDMA shows very distinct usage spikes at the weekends, indicating recreational use. These patterns are reasonably consistent each month.
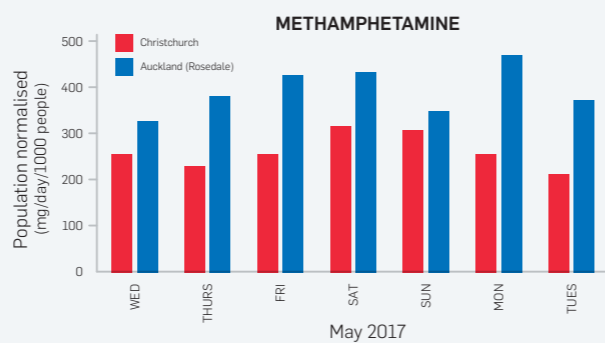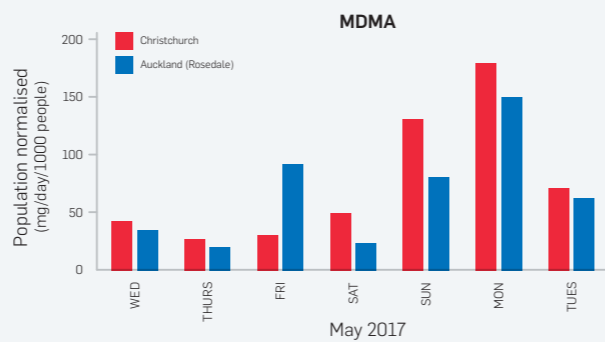
No obvious patterns are emerging yet between months, but it is still early days. It would be expected to take years of monitoring before long term trends emerge.

The findings have enabled Police and other agencies, such as Customs, to better understand drug-use patterns in the population and will be used as a baseline for future results.

One good news story has already emerged following very high usage of MDMA in Christchurch. Police and Customs increased resources, targeting MDMA at the airport. Within a few days a shipment was seized.

Waste water analysis is an emerging science and provides a valuable snapshot of the drug flow through cities. It is the first time such a test has been performed in New Zealand by a government agency.

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Next generation DNA

Two genomics and informatics projects will further develop Massive Parallel Sequencing (MPS) analysis capabilities and forensic-specific outputs this year. The Forensic Genomics project is developing intelligence outputs which will enable our forensic biology experts to determine an individual's ancestry, physical characteristics and age from an unknown sample.

MPS is also being used to develop our RNA expertise to enable us to determine the type of body fluid present in a sample. This takes our expertise beyond defining 'who' is present in a sample, to determine 'what' is present, and help answer how it might have got there. Supporting both projects is our Mt Albert Science Centre Sequencing Facility which is providing the MPS analysis outputs from the recently delivered Illumina MiSeq. machine.

Statistics and Bayesian interpretation has been ESR's specialist expertise for a number of years. A new Bayesian Networks research project will build on this to develop a statistical framework for the relative weight to be attached to scientific findings, in relation to the activity that took place. This process will support the courts to assess and consider multiple pieces of evidence together and to better answer the frequently asked questions informed by our court experience.

ESR has a number of e-learning training modules available to up-skill our staff as well as other forensic organisations. The project will take our extensive training material and convert it into e-learning resources, making them more accessible and interactive. As part of the project we are developing virtual reality content to support learning outcomes in key modules, allowing trainees to experience and participate in forensic training environments rather than just reading about them.

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Forensic training

The Forensic Team provides training on a variety of disciplines for forensic scientists. Police scene-of-crime officers, Police investigators and other law enforcement agencies in New Zealand regularly attend the training. There is a demand also from international clients so training can be delivered in New Zealand, the local country or combinations of both.

The courses cover forensic crime scene investigation (both in the field and in the laboratory), laboratory methods and technologies, forensic laboratory management, forensic quality management and giving evidence as an expert witness.

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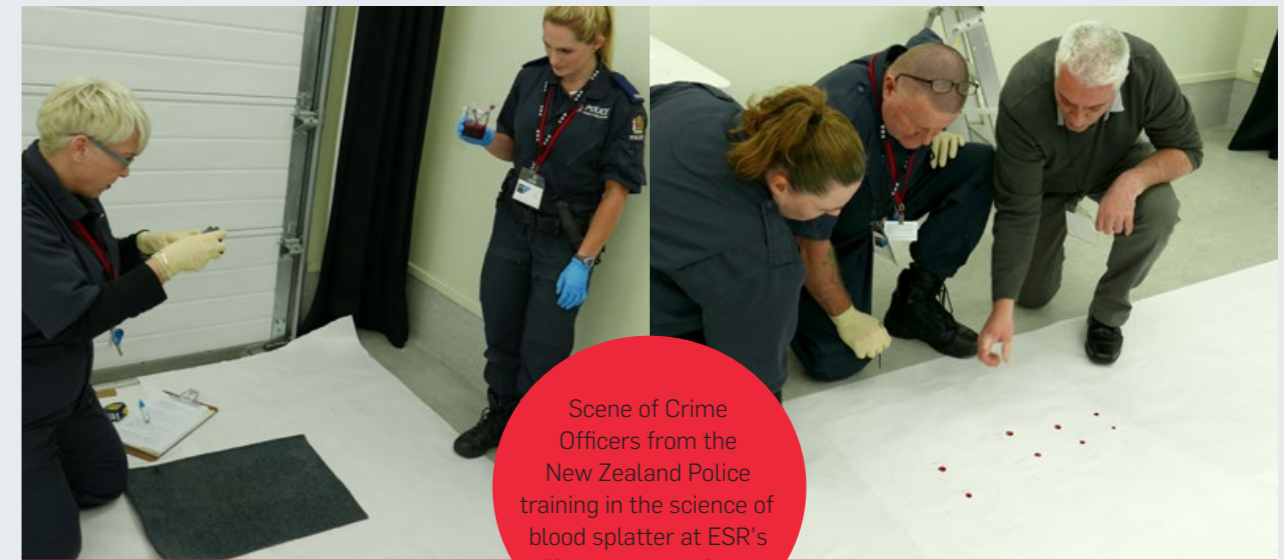
Scene of Crime Officers from the New Zealand Police training in the science of blood splatter at ESR's Kenepuru premises.

Forensic R&D

Lines / Routes:

- 3D, Digital and Data
- Physical Evidence
- Biology
- Drugs
- Clan Lab
- RNA
- Genomics
- Service Centre
- Blood Pattern Analysis
- Toxicology

Central hubs: Evidence Based Policing · E/S/R Forensic R&D

Stations (ideas/projects):
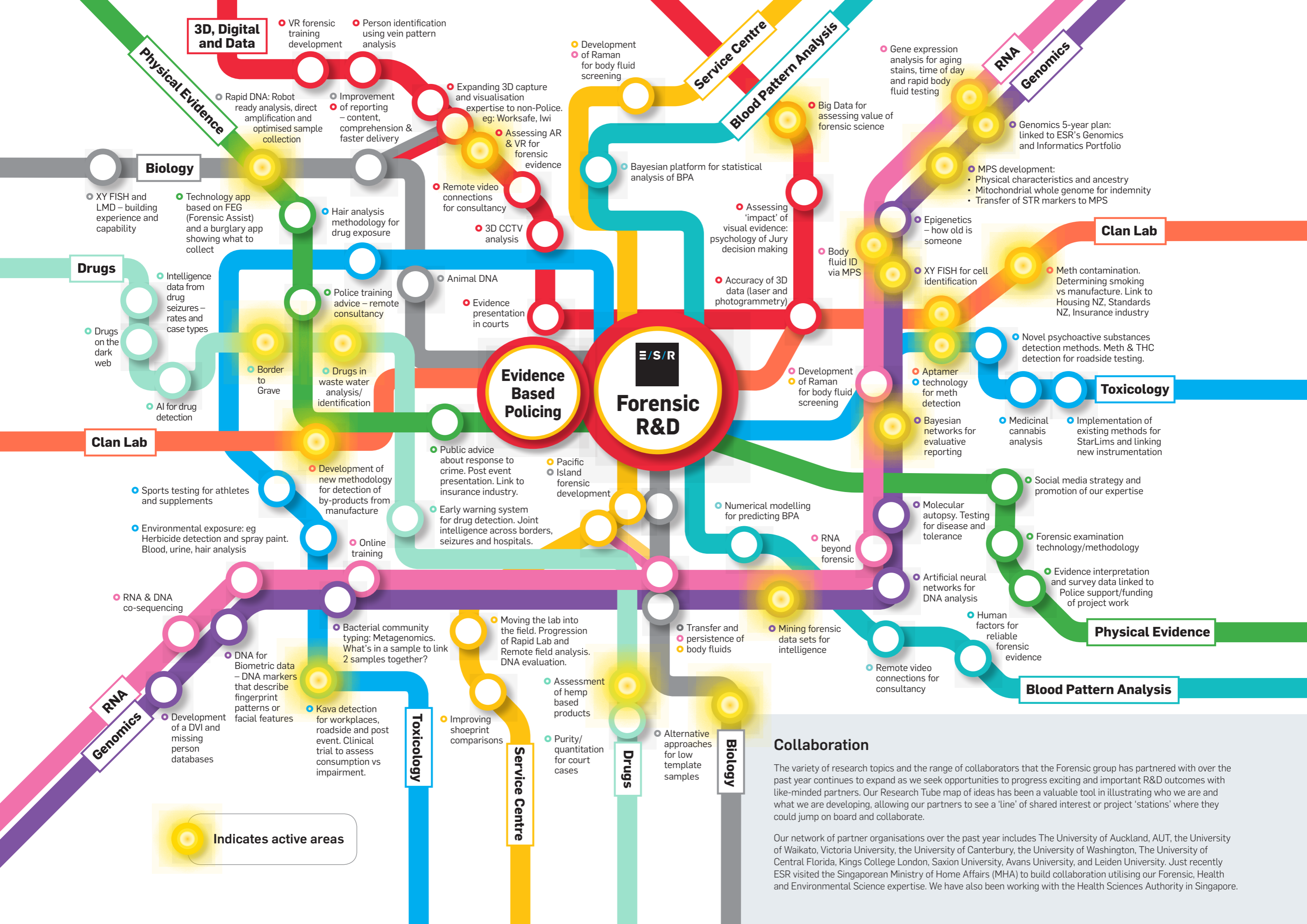
- VR forensic training development
- Person identification using vein pattern analysis
- Rapid DNA: Robot ready analysis, direct amplification and optimised sample collection
- Improvement of reporting – content, comprehension & faster delivery
- Expanding 3D capture and visualisation expertise to non-Police. eg: Worksafe, Iwi
- Assessing AR & VR for forensic evidence
- Development of Raman for body fluid screening
- Gene expression analysis for aging stains, time of day and rapid body fluid testing
- Big Data for assessing value of forensic science
- Genomics 5-year plan: linked to ESR's Genomics and Informatics Portfolio
- Technology app based on FEG (Forensic Assist) and a burglary app showing what to collect
- Hair analysis methodology for drug exposure
- Remote video connections for consultancy
- 3D CCTV analysis
- Bayesian platform for statistical analysis of BPA
- Assessing 'impact' of visual evidence: psychology of Jury decision making
- Body fluid ID via MPS
- MPS development:
  - Physical characteristics and ancestry
  - Mitochondrial whole genome for indemnity
  - Transfer of STR markers to MPS
- XY FISH and LMD – building experience and capability
- Intelligence data from drug seizures – rates and case types
- Drugs on the dark web
- Border to Grave
- Police training advice – remote consultancy
- Animal DNA
- Evidence presentation in courts
- Accuracy of 3D data (laser and photogrammetry)
- Epigenetics – how old is someone
- XY FISH for cell identification
- Meth contamination. Determining smoking vs manufacture. Link to Housing NZ, Standards NZ, Insurance industry
- AI for drug detection
- Drugs in waste water analysis/ identification
- Development of new methodology for detection of by-products from manufacture
- Public advice about response to crime. Post event presentation. Link to insurance industry
- Pacific Island forensic development
- Development of Raman for body fluid screening
- Aptamer technology for meth detection
- Novel psychoactive substances detection methods. Meth & THC detection for roadside testing.
- Sports testing for athletes and supplements
- Bayesian networks for evaluative reporting
- Medicinal cannabis analysis
- Implementation of existing methods for StarLims and linking new instrumentation
- Environmental exposure: eg Herbicide detection and spray paint. Blood, urine, hair analysis
- Early warning system for drug detection. Joint intelligence across borders, seizures and hospitals.
- Numerical modelling for predicting BPA
- Molecular autopsy. Testing for disease and tolerance
- Social media strategy and promotion of our expertise
- Online training
- RNA beyond forensic
- Forensic examination technology/methodology
- RNA & DNA co-sequencing
- Artificial neural networks for DNA analysis
- Evidence interpretation and survey data linked to Police support/funding of project work
- Bacterial community typing: Metagenomics. What's in a sample to link 2 samples together?
- Moving the lab into the field. Progression of Rapid Lab and Remote field analysis. DNA evaluation.
- Transfer and persistence of body fluids
- Mining forensic data sets for intelligence
- Human factors for reliable forensic evidence
- DNA for Biometric data – DNA markers that describe fingerprint patterns or facial features
- Development of a DVI and missing person databases
- Kava detection for workplaces, roadside and post event. Clinical trial to assess consumption vs impairment.
- Improving shoeprint comparisons
- Assessment of hemp based products
- Purity/ quantitation for court cases
- Alternative approaches for low template samples
- Remote video connections for consultancy

Legend: ⦿ Indicates active areas

Collaboration

The variety of research topics and the range of collaborators that the Forensic group has partnered with over the past year continues to expand as we seek opportunities to progress exciting and important R&D outcomes with like-minded partners. Our Research Tube map of ideas has been a valuable tool in illustrating who we are and what we are developing, allowing our partners to see a 'line' of shared interest or project 'stations' where they could jump on board and collaborate.

Our network of partner organisations over the past year includes The University of Auckland, AUT, the University of Waikato, Victoria University, the University of Canterbury, the University of Washington, The University of Central Florida, Kings College London, Saxion University, Avans University, and Leiden University. Just recently ESR visited the Singaporean Ministry of Home Affairs (MHA) to build collaboration utilising our Forensic, Health and Environmental Science expertise. We have also been working with the Health Sciences Authority in Singapore.

STRmix™ solving crime

In June 2017 a Florida murder case reaffirmed the reliability of probabilistic genotyping generally, and the use of STRmix™ software in particular.

In the State of Florida v. Dwayne Cummings the defendant was charged with two counts of first degree murder, as well as one count each of armed kidnapping and possession of a firearm by a convicted felon.

It was ruled that both probabilistic genotyping and STRmix™ – a sophisticated forensic software used by trained, experienced DNA experts to resolve mixed DNA profiles previously thought unresolvable – have been subjected to significant peer review and publication.

In its decision, the court noted,

❝ *The evidence before the court more than adequately convinces it that [probabilistic genotyping and STRmix™] have been accepted by peer review, as well as obtained general acceptance in the relevant community... Perhaps that is why nearly half of all forensic laboratories in the United States have purchased licences to use the STRmix™ software...*❞

Relying on mixture samples taken from a vehicle involved in the Cummings case, the State's expert used STRmix™ to determine that there was "extremely strong support" to conclude that Cummings and three unknown persons had contributed to the mixed DNA profile.

The Florida case comes on the heels of the FBI's recent validation of STRmix™ for use on mixtures of up to five persons, as well as across a wide range of templates and mixture ratios.

STRmix™ is also being used by numerous local, state, and federal agencies, including the U.S. Army Criminal Investigation Laboratory (USACIL) and the California Department of Justice.

Internationally, STRmix™ has been used in casework since 2012, and has been used to interpret DNA evidence in thousands of cases across labs in Australia, New Zealand, England, Scotland, Ireland, and Canada.

STRMIX. RESOLVE MORE DNA MIXTURES.

Fluid Dynamics of Bloodstain Pattern Formation

In June ESR delivered a Fluid Dynamics of Bloodstain Pattern Formation training course in Edmonton, Canada, for the fourteenth time.

The 40 hour advanced Bloodstain Pattern Analysis training course was co–instructed by ESR Forensic Senior Scientist, Rosalyn Rough, and University of Canterbury Associate Professor, Dr Mark Jermy.

Facilitated by the Edmonton Police Service and the Royal Canadian Mounted Police the course was attended by 11 Bloodstain Pattern Analysts from seven agencies throughout Canada.

Feedback was very positive, with attendees enjoying the hands-on practical approach taken throughout the week. Described as 'putting the science back into Forensic Science' the course is unique, focusing on the basic principles of fluid dynamics as they apply to bloodstain pattern formation. It is considered by many bloodstain pattern analysts to be an essential component of their advanced training.

ESR's Senior Forensic Scientist Rosalyn Rough is seated in the front row along with the attendees of the course.

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Misuse of Drugs

ESR has been actively working with the Ministry of Health, New Zealand Police, New Zealand Customs, National Drug Intelligence Bureau (NDIB) and the Expert Advisory Committee on Drugs (EACD) to help interpret the position of new psychoactive and syn-can (synthetic cannabinoids) drugs, well-known chemicals (CBD – has important implications for the medical marijuana situation) and less-well-known chemicals such as the t-boc structures.

The interpretation of the Misuse of Drugs Act and how these various chemicals/drugs sit within it is a difficult one and considerable work has been done by the ESR Drug Chemistry and Clandestine Laboratory teams to inform the debate and offer independent advice to the various agencies.

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ANZFEC

ESR is a member of the Australia New Zealand Forensic Executive Committee which provides advice and recommendations to the Australia and New Zealand Policing Advisory Agency (ANZPAA) and the National Institute of Forensic Science on current and emerging forensic science issues for Australasia.

The committee, which comprises of representatives from Forensic Science and Police agencies in Australasia has oversight of the delivery of the strategic plan approved by ANZPAA. The committee also supports the development and implementation of projects and services that improve forensic science outcomes for the justice sector. ESR is represented on five out of the nine Scientific Advisory Groups which are managed and co-ordinated by the National Institute of Forensic Science.

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ESR Forensic staff, Gilly Chandler *(Christchurch Forensic Service Centre)* and Michael Taylor *(Forensic Research Group)* were invited by Southern Troop Explosive Ordnance Disposal (EOD), New Zealand Army to trial using a high speed digital camera to film the detonation of breaching charges during a range training week. The results were quite spectacular!

Case insights from data

ESR is investigating how to use our forensic data to better inform how we prevent, respond or support the recovery from crime.

The six month pilot project was a collaboration between the social scientists in ESR's Environmental Science Group and casework experts in our Forensic Group. The approach provided a unique combination of systems thinking expertise and data analytics expertise to identify opportunities to use data to support system–wide improvements, not just in the delivery of forensic science but also across the broad social investment approach to justice.

The work conducted during the pilot focused on sexual violence crime and provided opportunities to understand and engage with the system, document and collate data sources, and identify forensic intelligence outputs that could support prevention, response and recovery from crime.

The extension of the project will continue to develop intelligence outputs for a range of case types that will benefit participants across the justice system.

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CellTyper 2

This year ESR completed a three year research project to develop an advanced body fluid identification test that can determine the type of cells present in a sample.

The test, code named CellTyper 2, uses ESR's expertise in mRNA analysis, and our patented gene expression detection technology, to identify traces of six body fluid targets that may be present in a forensic sample. The research was conducted by PhD student Patricia Albani and supervised by ESR's Dr Rachel Fleming and Jayshree Patel.

The accurate and sensitive test will enable ESR to confirm when blood, semen, seminal fluid, saliva, vaginal material, or menstrual blood is present. Providing information on the types of body fluid present now enables ESR's forensic experts to say not only 'who' is present in a sample, but also 'what' type of body fluid is present - which helps courts understand the type of activity that may have taken place.

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Border to Grave

New psychoactive substances (also known as 'synthetic cannabis', 'party pills' and 'legal highs') are proliferating internationally at an unprecedented rate, posing a significant risk to public health, with authorities having little ability to track and monitor changing trends.

Our new 'Border to Grave' project will build a surveillance framework for the identification of new psychoactive substances across ESR's drug testing activities. The project will provide a novel perspective on the link between the identification of new drugs at the border, through to their real time use and abuse in the community, including motor vehicle accidents, criminal case work and drug-affected patients admitted to emergency departments. The project will sit alongside our Environmental Science work looking at drugs in waste water. The project will enable identification of emerging psychoactive drug patterns and trends in New Zealand, and be a formative part of a drug early warning system.

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t-BOC-methamphetamine

*E*arlier this year a joint Police and Customs sting caught 160 litres of methamphetamine as it entered New Zealand, labelled as dishwashing liquid.

Preliminary testing of the liquid at CESL was unable to identify the liquid, but indicated that it might contain a concealed or controlled substance of some kind. The liquid was subsequently submitted to ESR for a full analysis which identified a novel substance, namely t-BOC-methamphetamine.

The identification led to an investigation into the substance t-BOC-methamphetamine, and how drug legislation would apply to such a substance.

Chemically altering a controlled drug is a common practice to evade detection techniques and legislative control. The discovery of t-BOC-methamphetamine

supports a new trend in drug concealment techniques, whereby a controlled drug is chemically altered, and then later reverted back to the original controlled drug. This can be done by adding a 'protective group', such as N-tert-butoxycarbonyl (t-BOC) to a controlled drug like methamphetamine.

There is the potential for other 'protective groups' to be utilised for similar concealment purposes. A project called 'Chemical Camouflage' has been proposed to New Zealand Customs Service to investigate this new phenomenon.

The research into t-BOC-methamphetamine has led to a research paper being accepted for publication in the Journal of the Clandestine Laboratory Investigating Chemists Association.

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Turn-around times

ESR has recently changed the way in which metrics around casework activities, such as volumes and turn-around times, are provided to Police. Previously a static report was generated each quarter. The new format is a dynamic, interactive tableau report generated monthly. This new reporting functionality allows Police to interrogate casework metrics to a far more detailed level and provides greater insight into forensic workflows at ESR.

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Databank process improvement

A new method for processing samples intended for the DNA Profile Databank was introduced in March 2017. There has been a number of efficiencies gained from this project, including a reduction in the turn-around times for samples. This means that links on the Databank may be obtained and reported more quickly.

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Crime Harm Index (CHI)
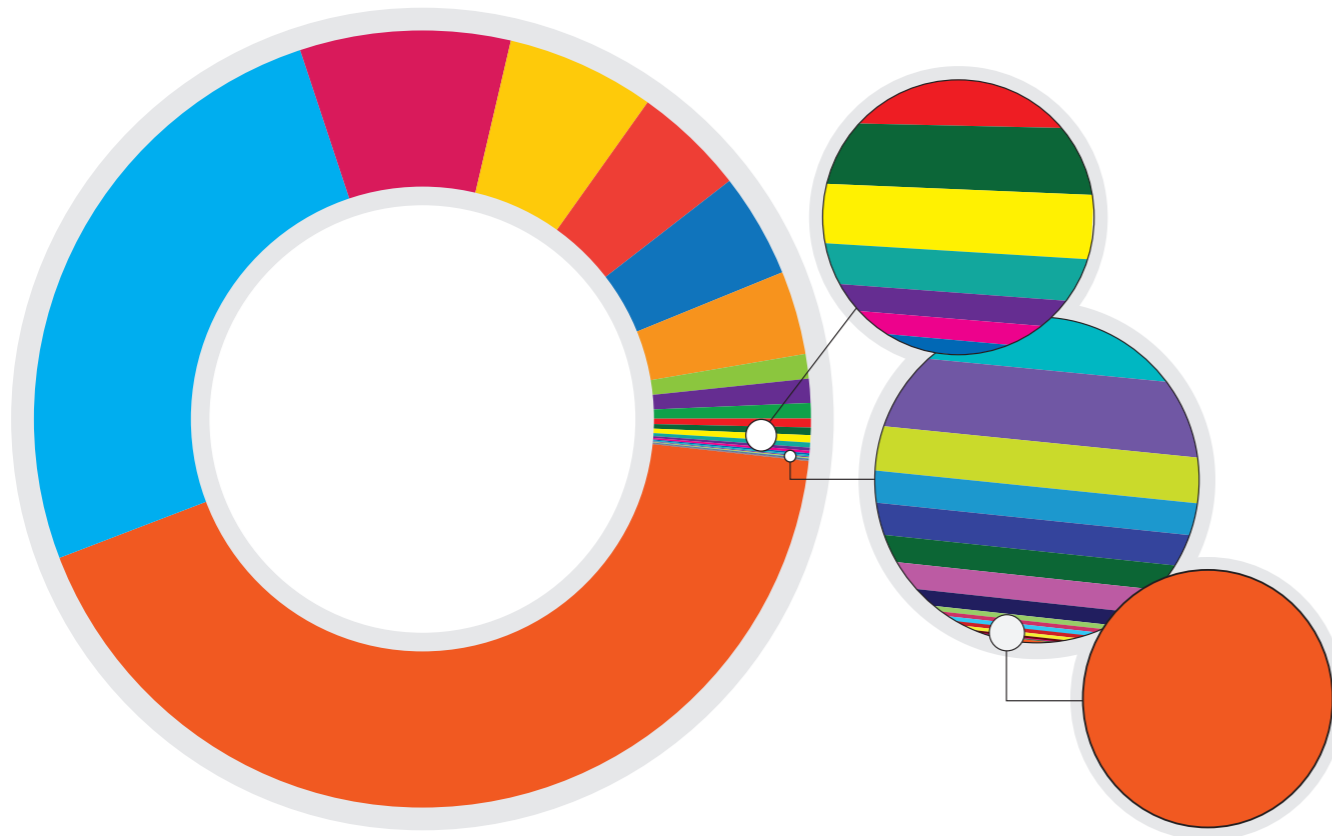
■ Sexual attacks	429777.30	42%	■ Immoral behaviour	6445.63	1%	■ Property abuse	540.21	0%	■ Fraud	30.00	0%		
■ Homicide	260363.20	26%	■ Destruction of property	3741.90	0%	■ Serious assaults	339.07	0%	■ Minor assaults	28.20	0%		
■ Drugs (new drugs)	88596.17	9%	■ Kidnapping and abduction	3182.88	0%	■ Abnormal sex	241.50	0%	■ Burglary	25.00	0%		
■ Robbery	62611.40	6%	■ Sexual attacks	3100.20	0%	■ Gambling act	235.73	0%	■ Fraud	15.00	0%		
■ Burglary	47179.65	5%	■ Sexual affronts	2066.68	0%	■ Drugs & antisocial	195.00	0%	■ Disorder	6.15	0%		
■ Grievous assaults	43941.79	4%	■ Theft	1311.38	0%	■ Group assemblies	185.75	0%	■ Family offences	6.15	0%		
■ Miscellaneous offences	35228.94	3%	■ Drugs (cannabis only)	1056.19	0%	■ Receiving	112.50	0%					
■ Sexual	10333.40	1%	■ Dishonesty	722.00	0%	■ Administrative	36.01	0%					
■ Drugs (not cannabis)	10144.04	1%	■ Intimidation and threats	545.55	0%	■ Family offences cont	30.00	0%					

ESR 2016-17 case type analysis in terms of Crime Harm Index (CHI) measure and impact

The CHI is a score that seeks to differentiate crime types based on a measure of the harm caused by each crime type. In the absence of a true measure of harm it relies on the use of sentencing data as a proxy for the harm caused.

The CHI is derived from the application of a metric which weights each crime based on the harm it causes, relative to other crimes. The CHI therefore allows weighted crimes to be aggregated to provide an overall measure of harm to society, as opposed to traditional measures of crime volume where all crimes are counted equally.

CHIs can be applied in various ways, such as:

→ Performance measurement and analysis: tracking total harm from crime over time and identifying changes and inter-district differences in the 'harm profile' (e.g. what proportion of harm is made up by different offence types).

→ Resource targeting: Harm-spotting to identify hotspots weighted by harm or identifying the victims or offenders who account for the most harm, to assist in targeting crime prevention activities to the highest concentrations of harm.

→ Evaluation: testing effectiveness of policing and crime reduction interventions by comparing not just volumes but harm indices before and after (e.g. has the harm reduced and by how much, are offenders reoffending less harmfully).

→ Triaging: Factoring harm into offender risk assessment and triaging decisions (e.g. out of court proceedings and interventions).

The New Zealand CHI has been developed to facilitate all of the above and for wider use by other justice sector agencies. The methodology developed by New Zealand Police translates and measures Harm in terms of Equivalents Prison Days (EPD) as measure of impact.

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Evidence based policing

ESR, New Zealand Police and the University of Waikato have joined forces to establish a world-class research centre to help better inform Police in their work to prevent crime and protect the public.

Evidence based policing ensures Police strategy, operations and tactics are based on the best possible evidence (information, crime science and problem-solving methods) to guide and inform staff, providing better outcomes for the Police, public and the Government.

The group will work together on Police research projects at the centre in Central Wellington.

Commissioner of Police Mike Bush commented that the work will be a valuable resource for Police and help them improve trust and confidence with the public. "Evidence will help us understand what works, what counts and what matters."

Initial research projects are likely to focus on key priorities for Police including victims, Māori offending and road policing.

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Investment in new robotics

To ensure efficient processes are maintained, and to future proof them, an investment has been made into upgrading two of the robotic platforms in the DNA Databank area. These robots enable the automation of parts of the DNA process allowing scientists to use their time more efficiently.

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OUR TRANSFORMATION PROGRAMME

THE SAFEST COUNTRY POLICING 2021

SAFER WHĀNAU

IWI AND COMMUNITY PARTNERSHIPS

POLICE COMMITMENT TO SOCIAL INVESTMENT

SERVICE DELIVERY AND MODERNISING OUR BUSINESS

POLICE HIGH PERFORMANCE FRAMEWORK

Forensic Evidence Guide (FEG)

ESR's Forensic Evidence Guide (FEG) is an online guide to assist Police to work with ESR to manage crime scenes and gather and process evidence.

The guide is confidential to New Zealand Police and provides information about:

→ Working with ESR: an introduction to forensic science

→ Managing the crime scene

→ Searching for evidence

→ Evidence types in detail

→ Collecting and packaging evidence

→ Analysing and reporting of evidence (an insight into how ESR scientists analyse and report on different evidence types).

The guide has a responsive design so it can be used both in the field, on mobile phone and on a desktop.

The web clip for the ESR Forensic Assist app is available for download in the New Zealand Police App store on mobile devices.

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FORENSIC (POLICE) PROGRAMME MANAGER
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Ξ/S/R

Science for Communities

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