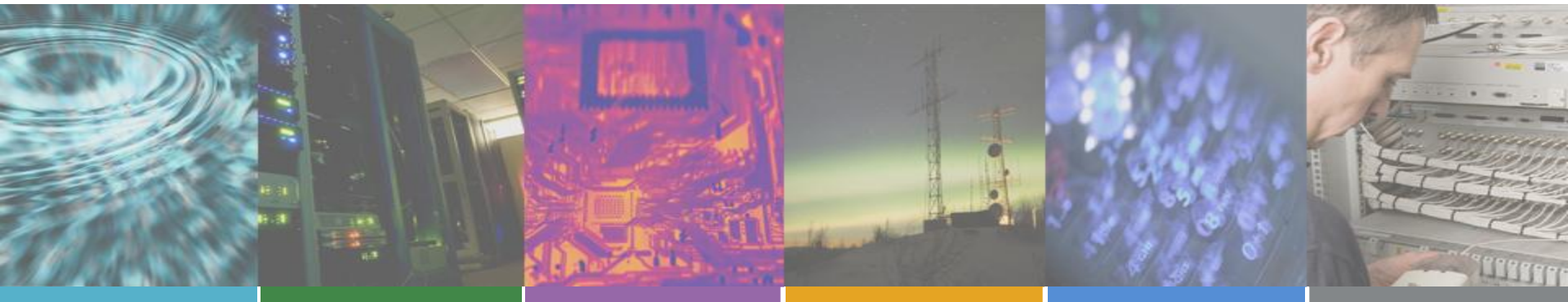


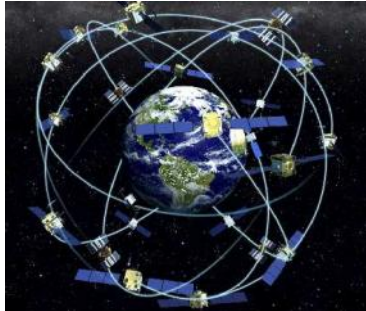
Vehicle borne GPS jamming incidents detected in the SENTINEL project



Prof. Charles Curry B.Eng, FIET
Managing Director
Chronos Technology Ltd

CGSIC
17th Sept 2012
Nashville

The SENTINEL Project



- GNSS **S**ervices **N**eeding **T**rust **I**n **N**avigation, **E**lectronics, **L**ocation & timing
- UK Government Funded R&D Project, 2 years, ~£1.5m
 - through **Technology Strategy Board**
 - **“Trusted Services”** Call



- Research service to establish extent to which GNSS and eLoran PNT signals can be trusted
 - at point of use, 24x7x365
 - In specific user-community applications
 - Built on the GAARDIAN project which researched “Detection”
 - adding “Location” of interference source

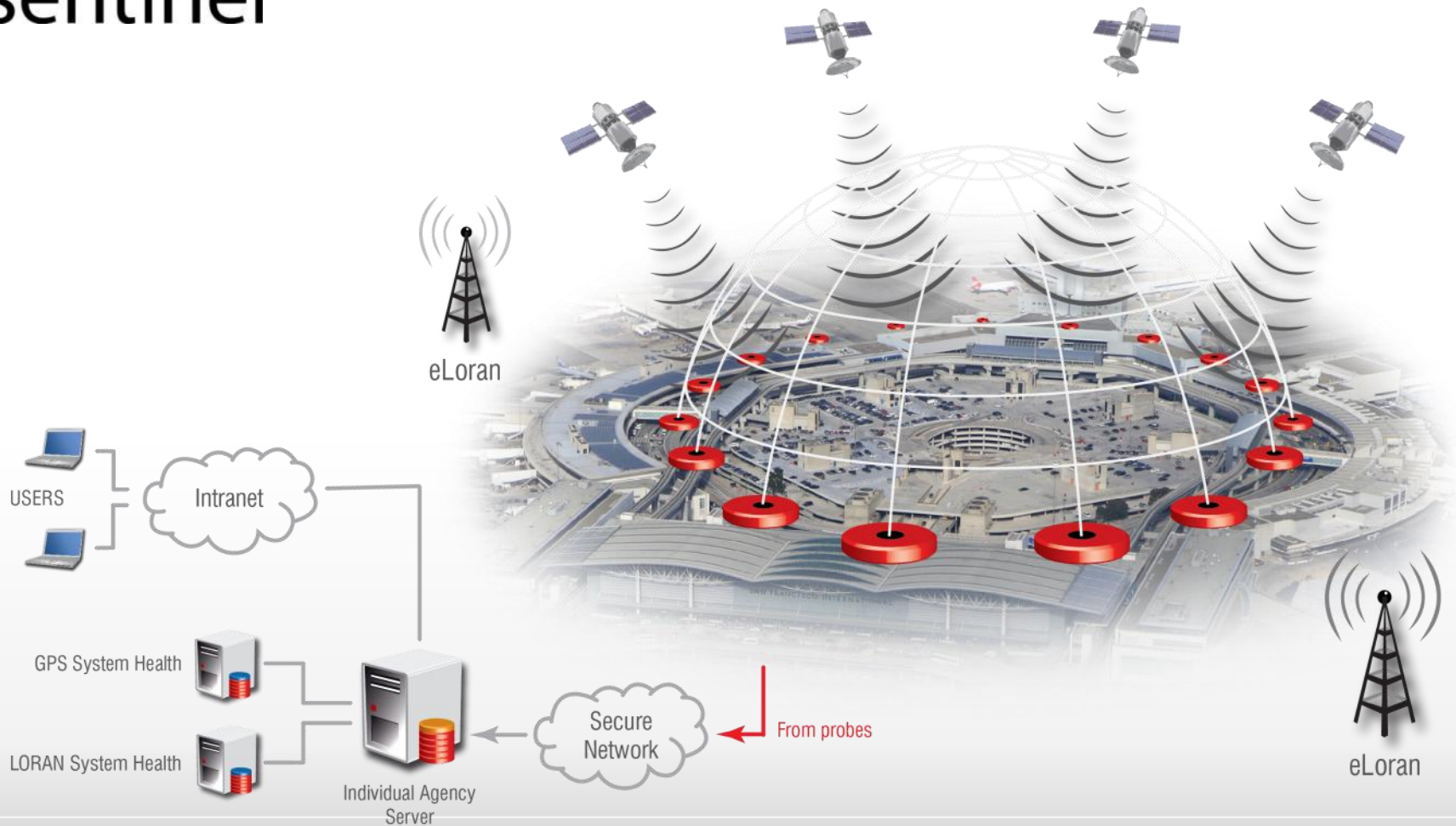


The SENTINEL Partners



- ACPO-ITS – Association of Chief Police Officers
 - User Community – Law Enforcement
 - Brings other Government agencies into the collaboration
- GLA – General Lighthouse Authorities
 - User Community - Maritime
 - eLoran
- University of Bath - Dept. of Electrical & Electronics
 - GPS & Space Weather
- Ordnance Survey
 - User Community – Land Geolocation
- NPL – National Physical Laboratory
 - Time, UTC Traceability
- Thatcham Vehicle Security
 - Certification of safety critical services
- Chronos Technology Ltd
 - GAARDIAN Research
 - SENTINEL Project Leader





Real time detection & location of GNSS interference for the protection of critical infrastructure facilities and services



The Deliverables



- Joins User Community with Technology Innovators
- Deploy Clusters of GAARDIAN probes into “SENTINEL” networks
- Planned Phased Approach
 - GAARDIAN probe redeployment
 - New probe development
 - Tactical Deployment & Testing to prove technology
 - Different scenario deployments
 - Multimodal deployments e.g. Port, Motorway, Airport

Tactical Deployments

- GAARDIAN proved “Detection” of short events
- Vehicle passing with cigarette lighter jammer!
- SENTINEL confirmed capability at Jamming trials June 2011 & 2012 – Summer !

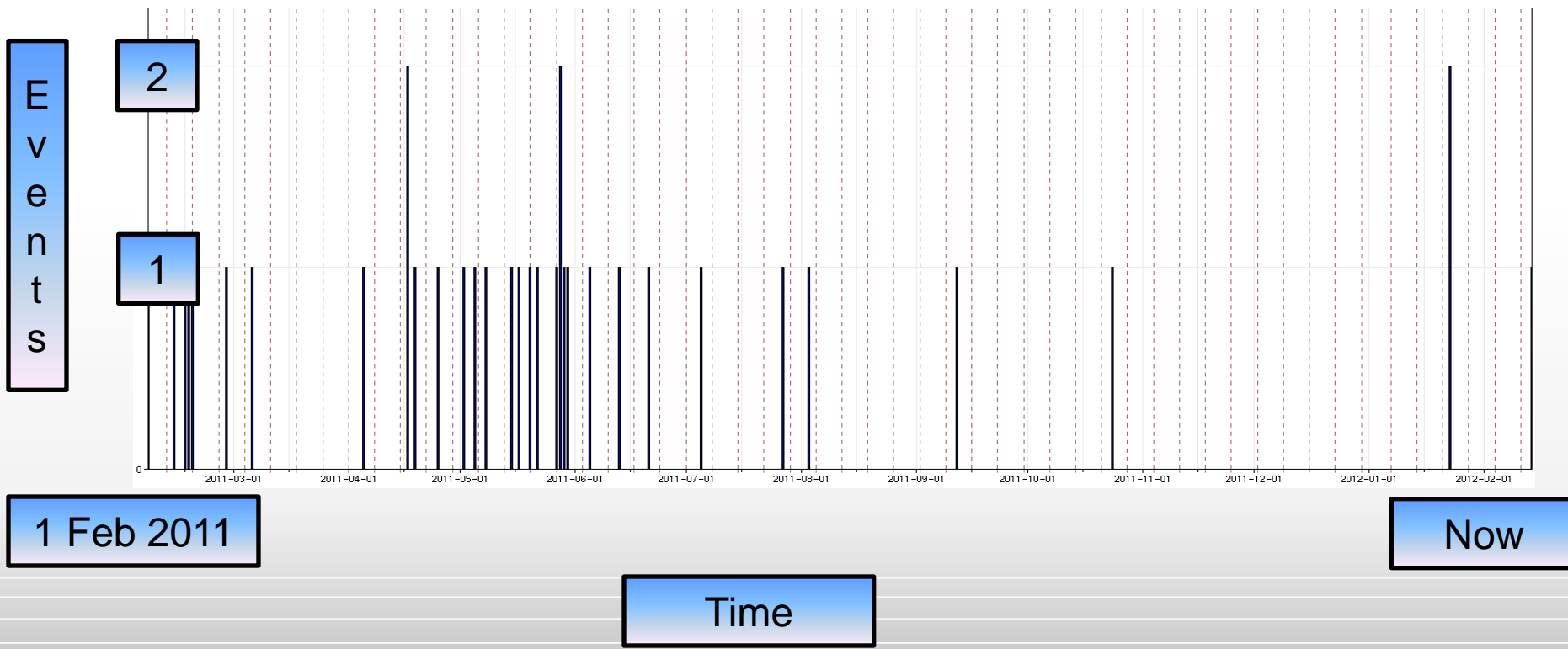


Data Analysis from Around the UK

- SENTINEL Phase 1 Results
- Redeployment of GAARDIAN probes
- OS Differential GPS Reference Station Sites
- Reason – Intermittent Loss of Service
- Selected various locations
- Will present results from 4 locations.....

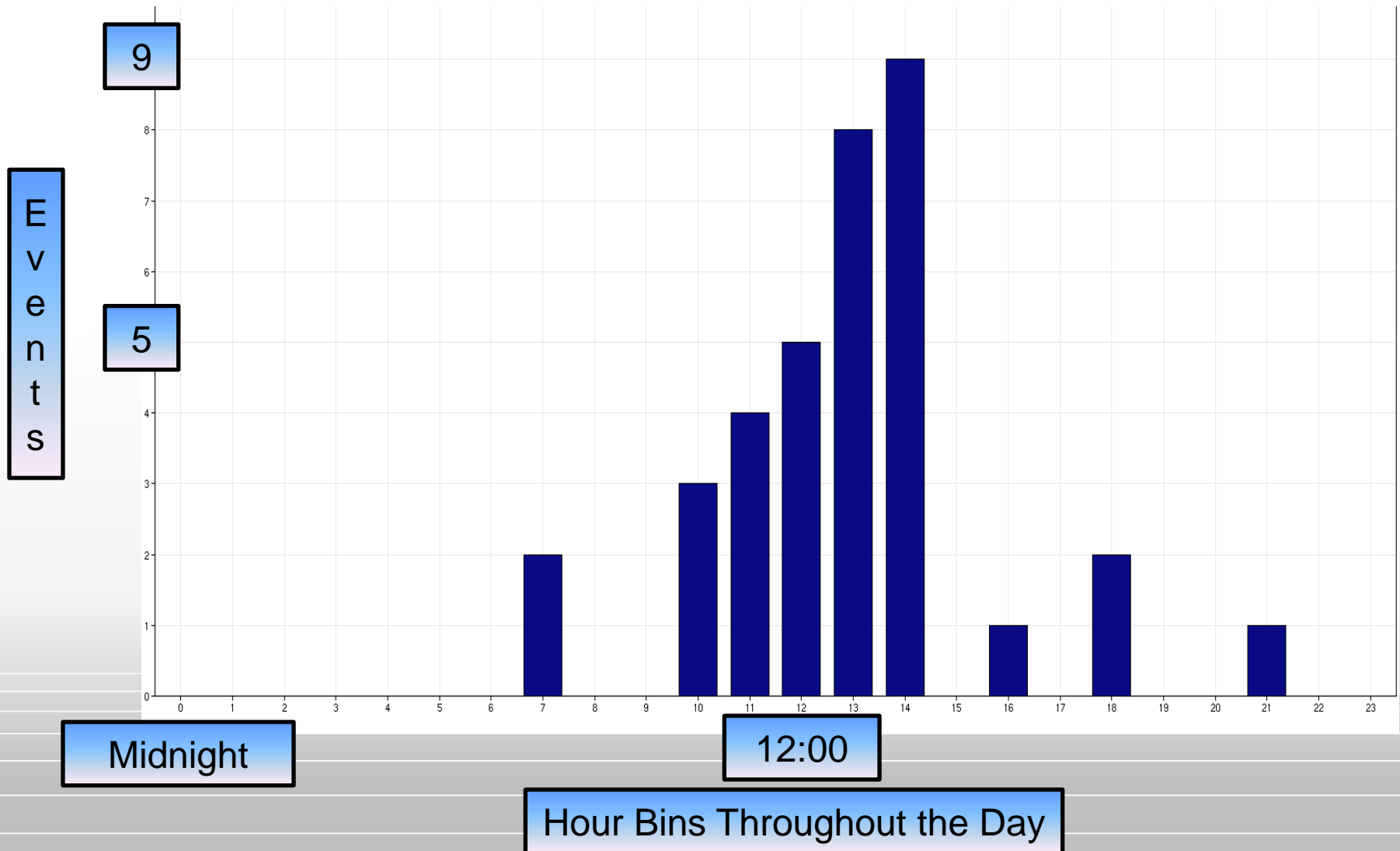
Location "A" – 12 Months of Data

Small Town - Urban A
0/1/2 events per day – 36 Total

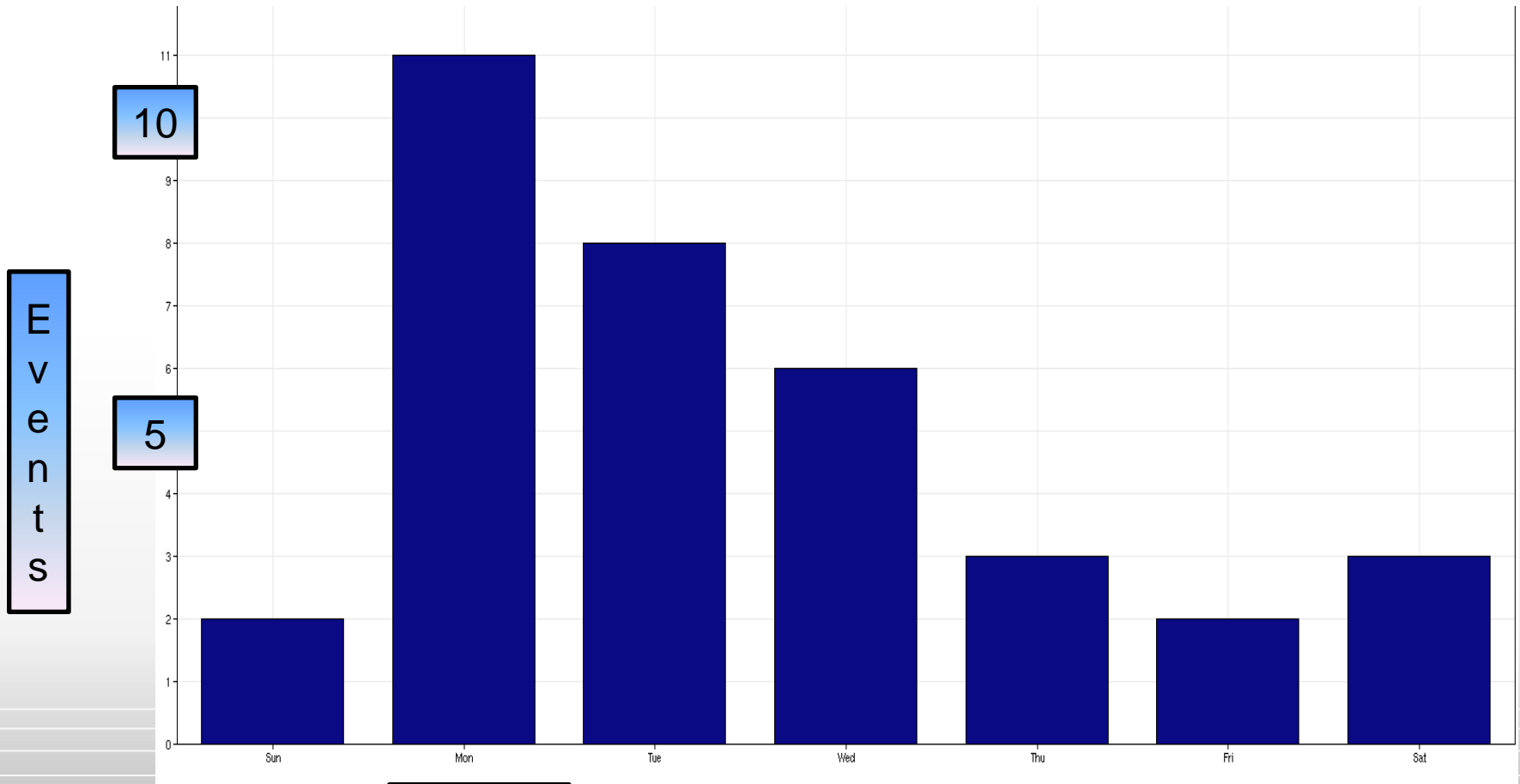


Can we detect a pattern?

Location "A" – Hour Bins



Location "A" – Day Bins



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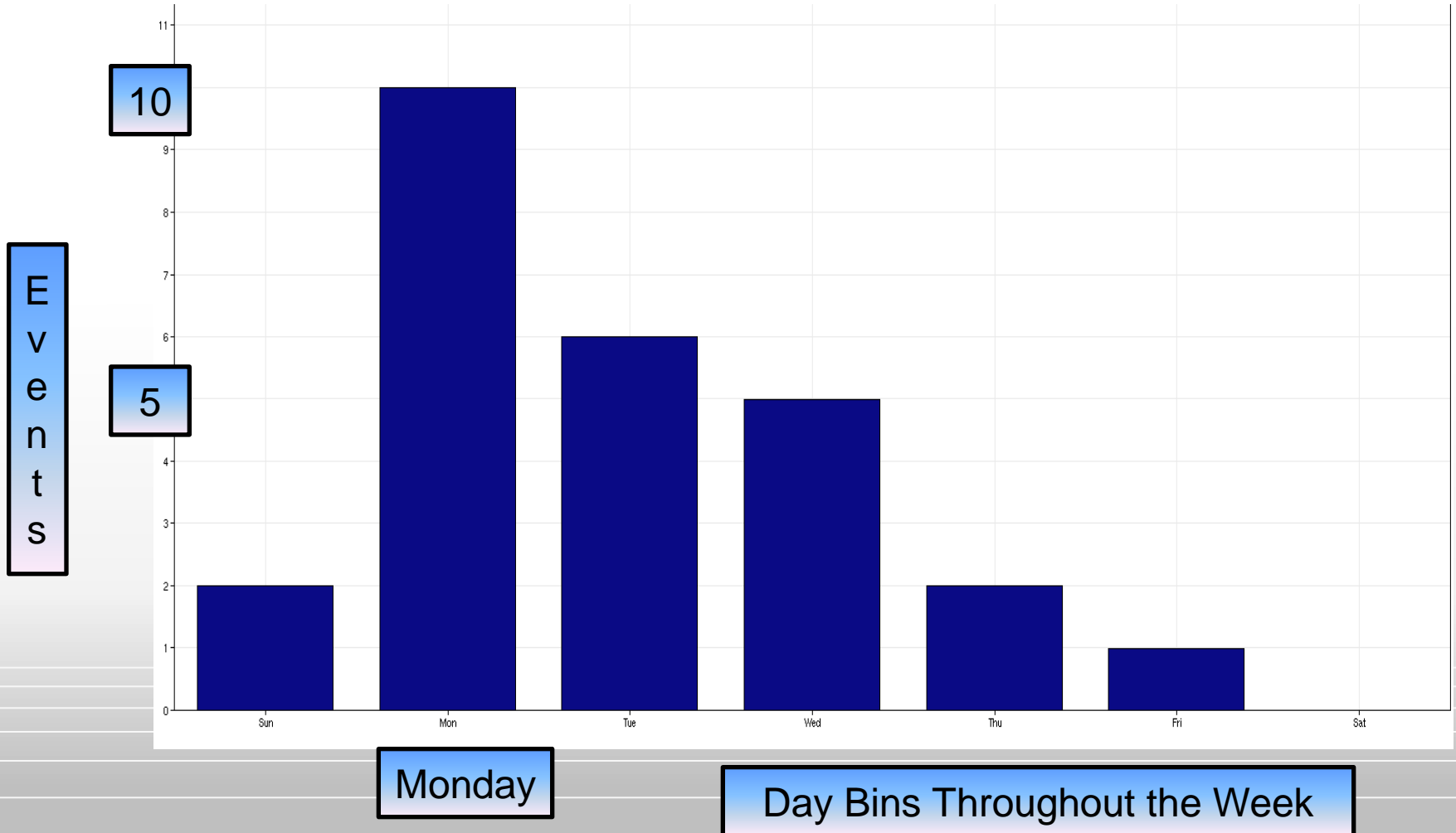
10

5

Monday

Day Bins Throughout the Week

Location "A" – 11am-2pm



Sit and Wait!

**Hand Held
GPS Jammer
Detector**



**Along comes
“White Van
man”**

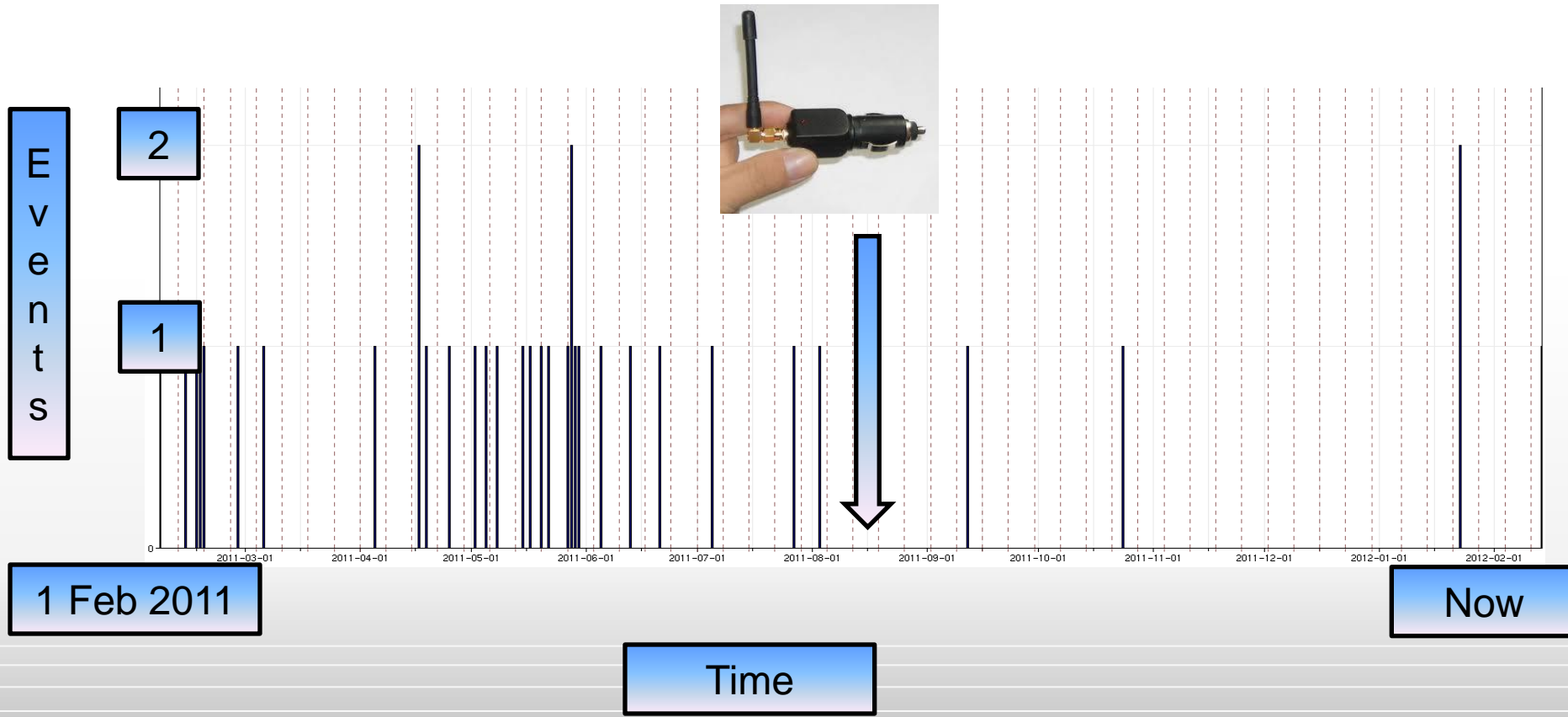
**Investigations
lead to device
confiscation**



Location "A" – 12 Months of Data



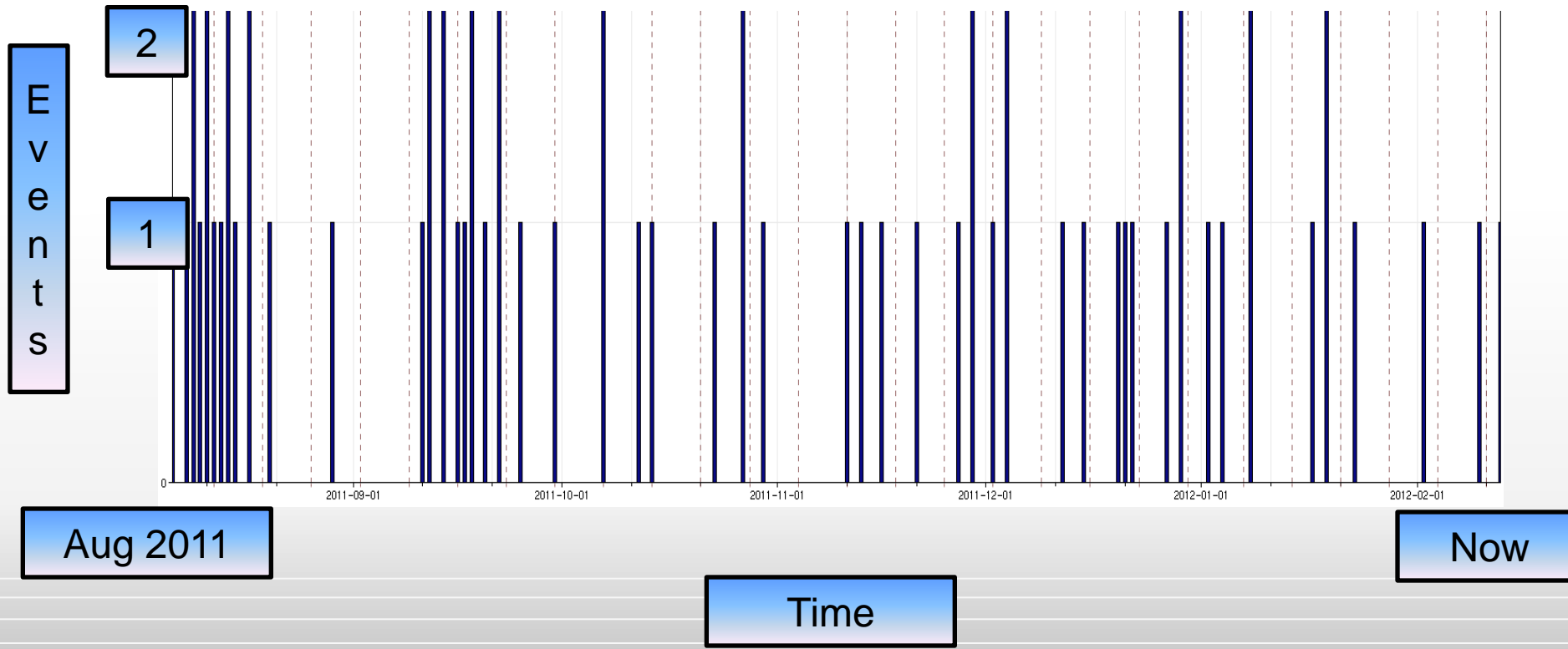
When was the device confiscated?



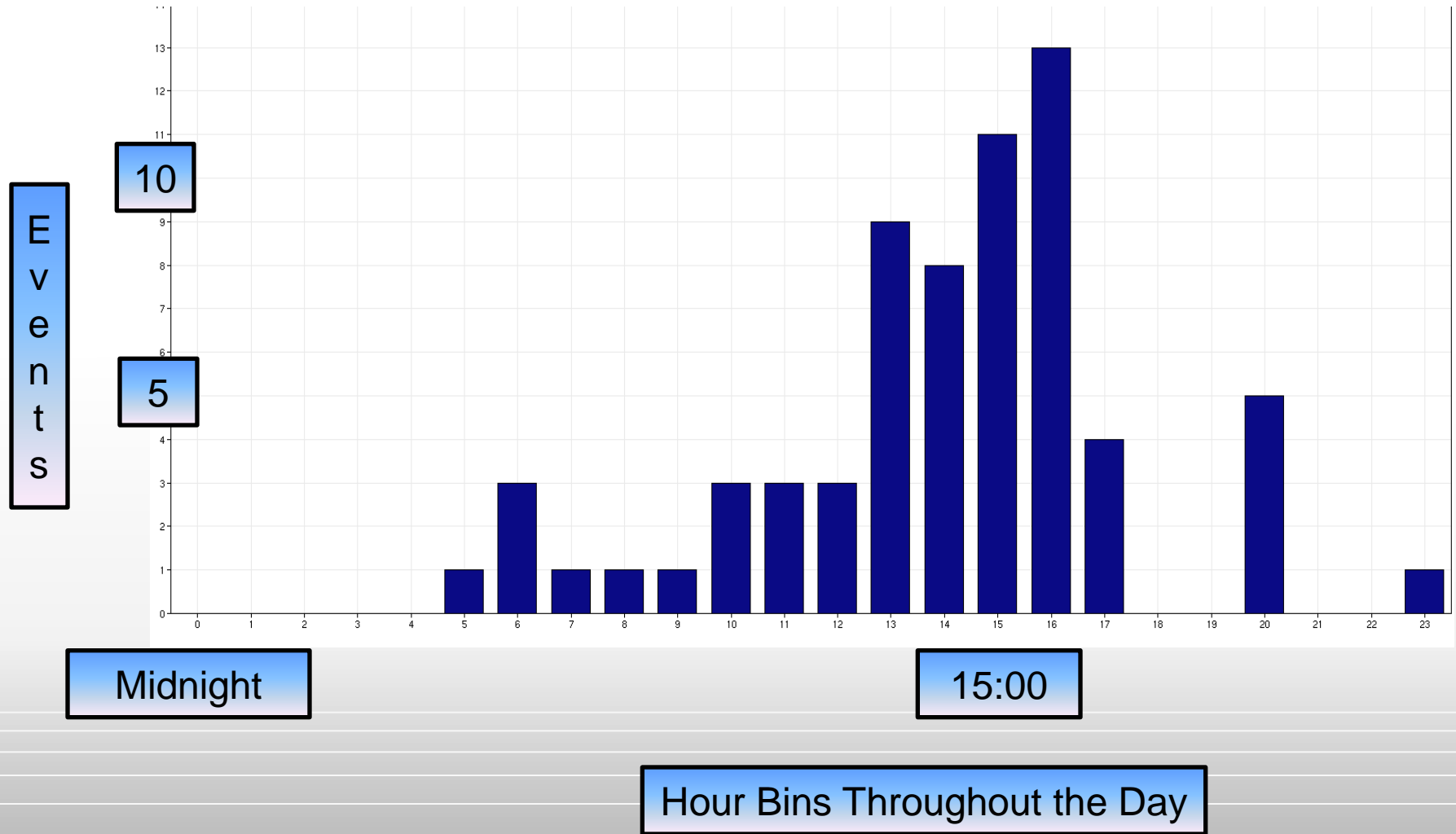
Location "B" – 6 Months of Data



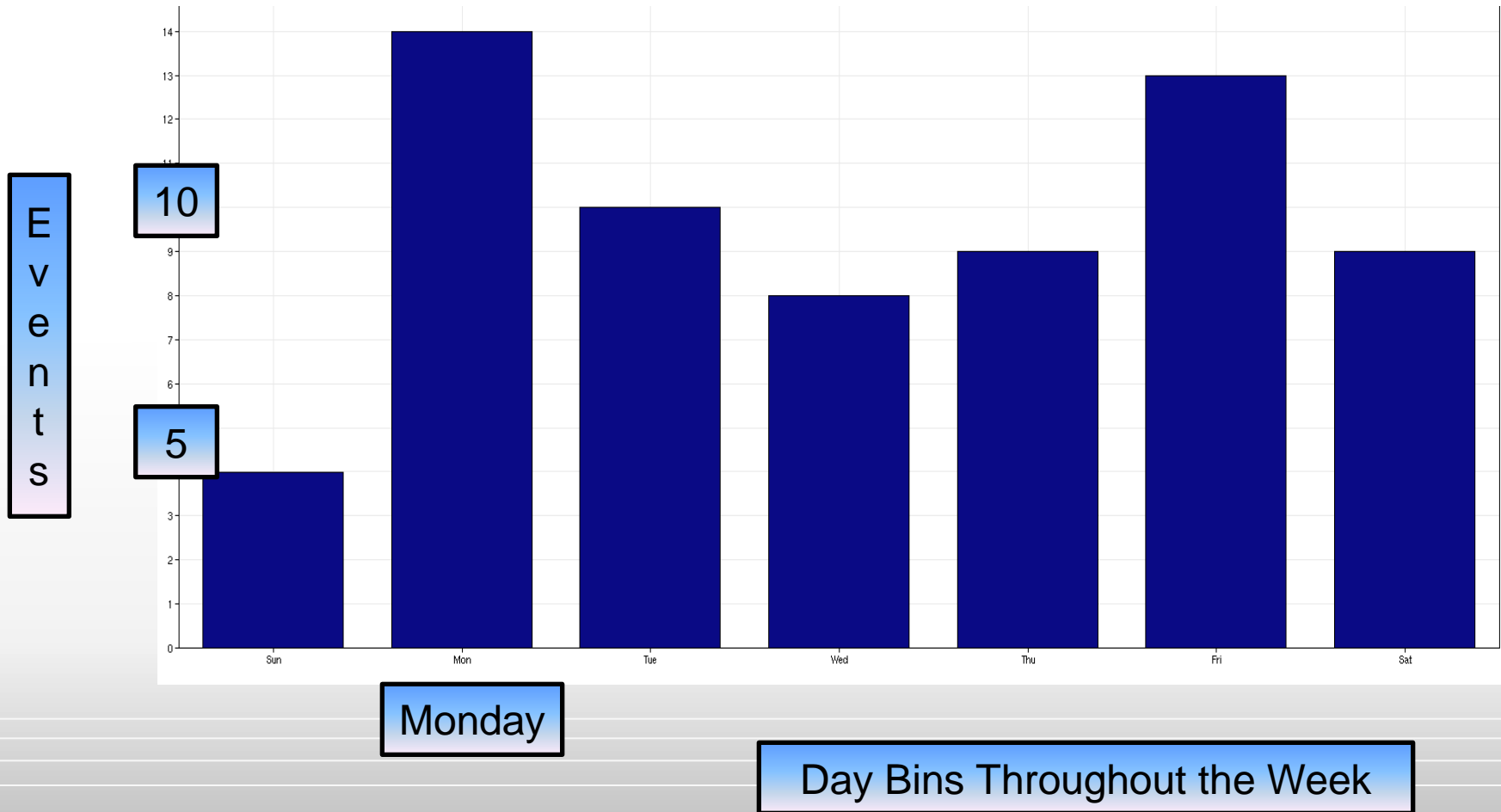
**City & Docks 2 lane link Motorway.
0/1/2 events per day – 67 Total**



Location “B” – Hour Bins



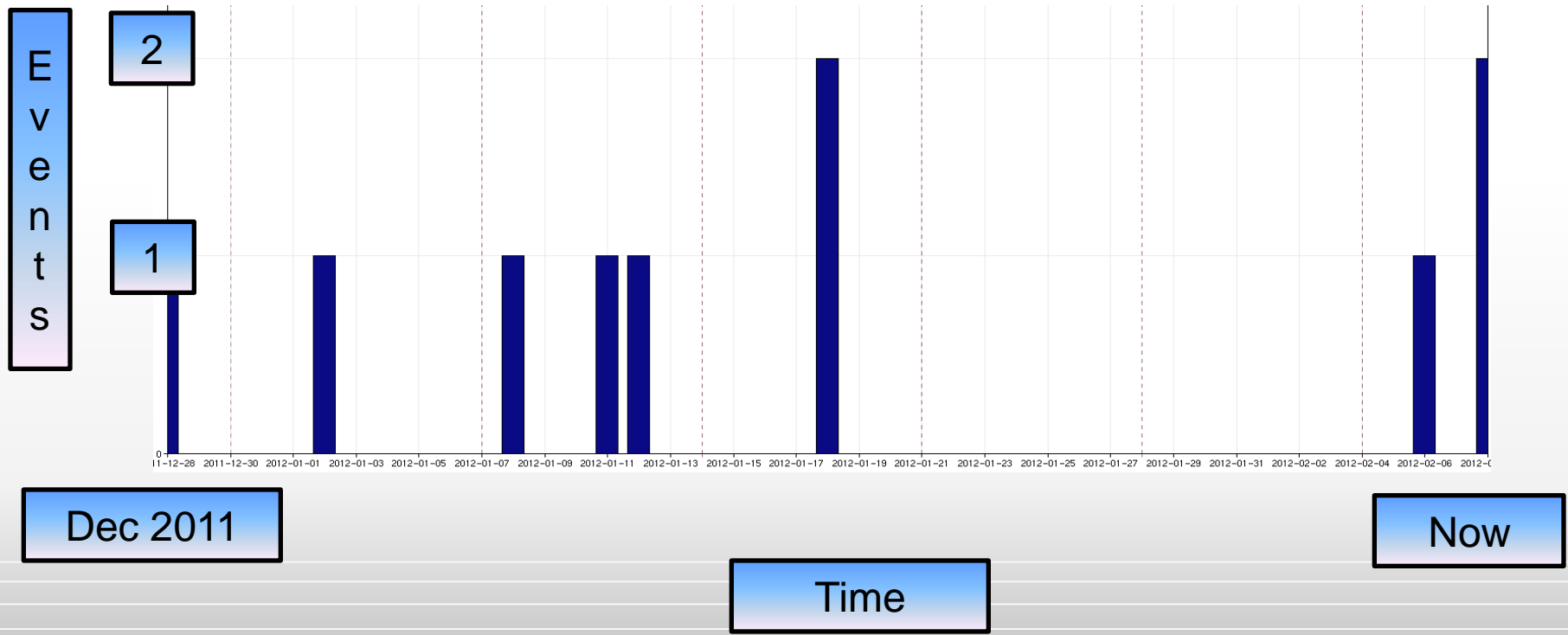
Location “B” – Day Bins



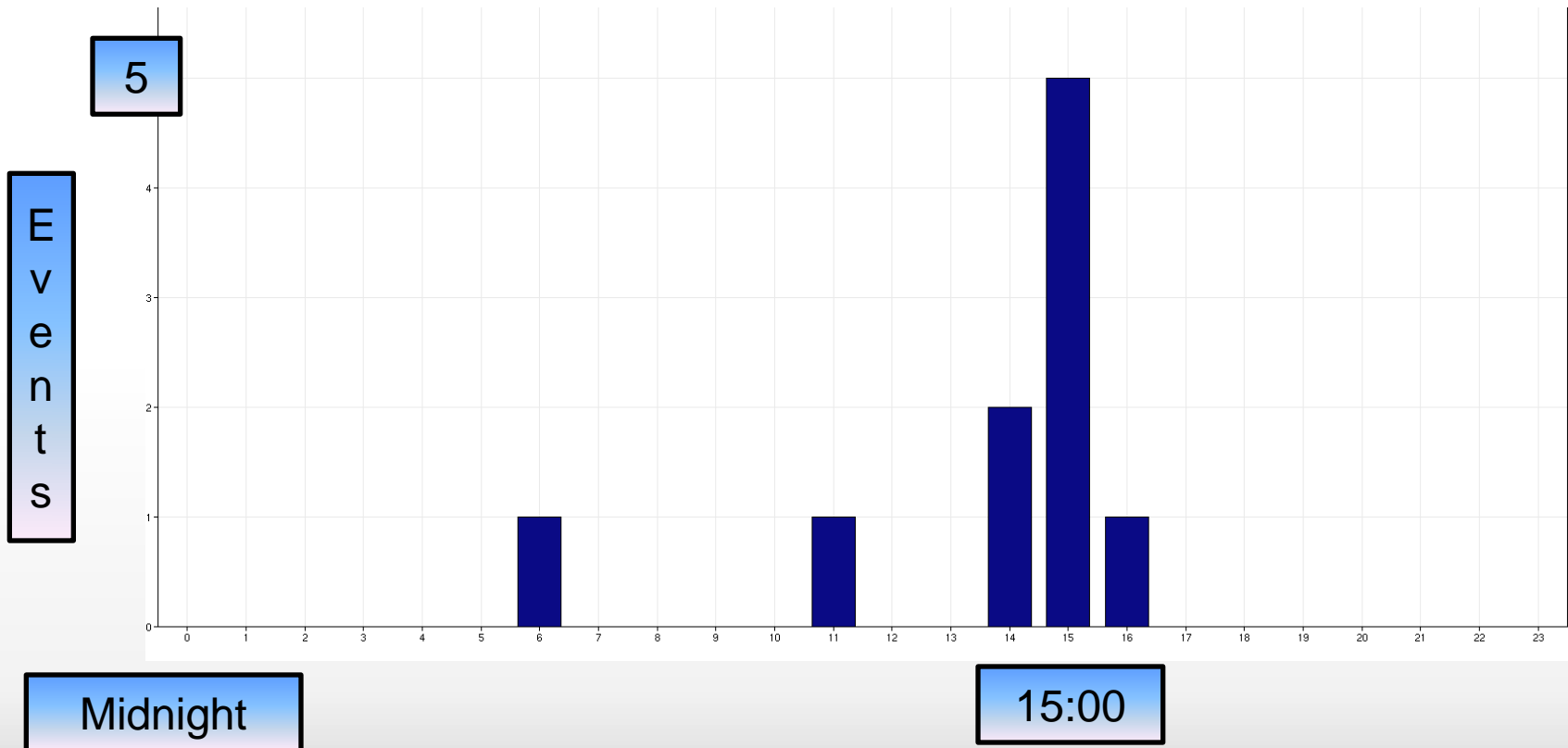
Location “C” – 2 Months of Data



City 2 lane link Motorway
0/1/2 events per day – 10 Total

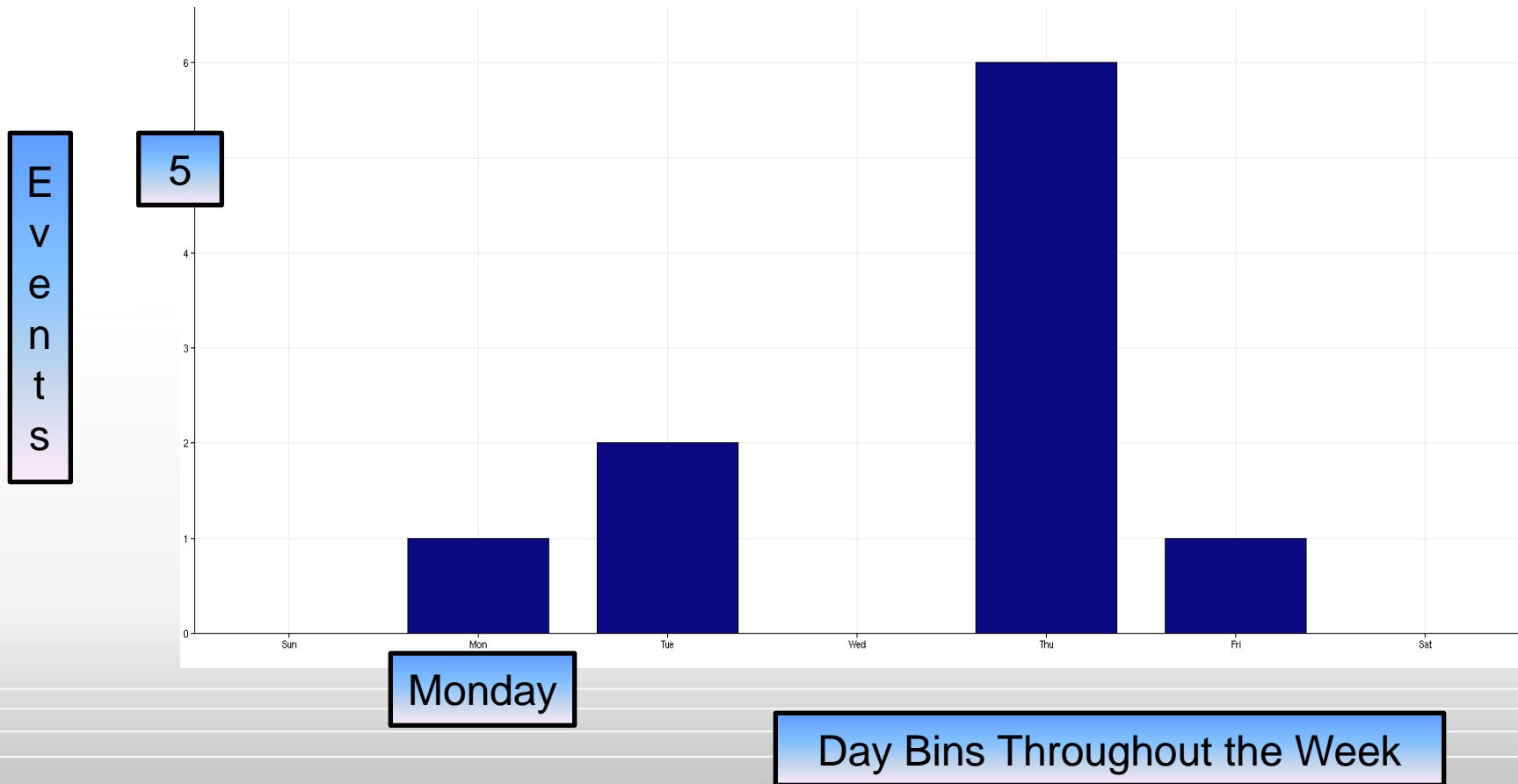


Location "C" – Hour Bins



Hour Bins Throughout the Day

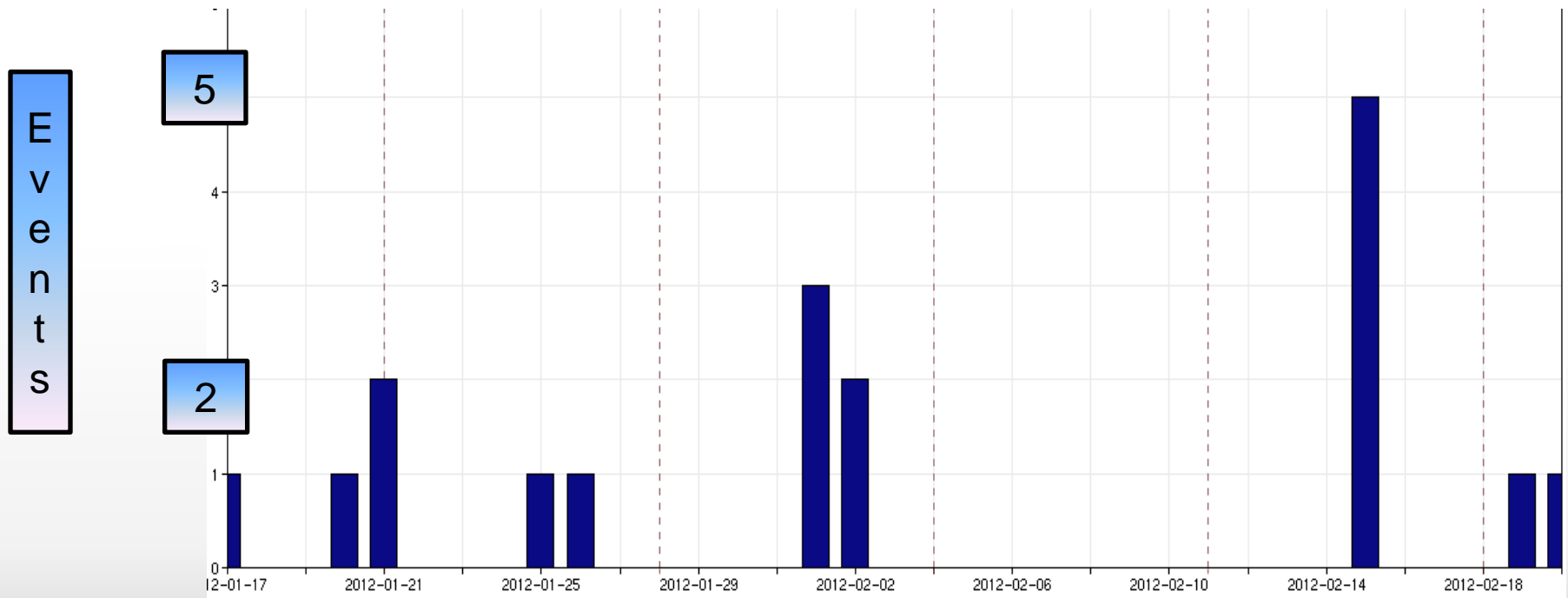
Location "C" – Day Bins



Location “D” – 1 Month of Data



City - Urban A
0/1/2 events per day – 18 Total

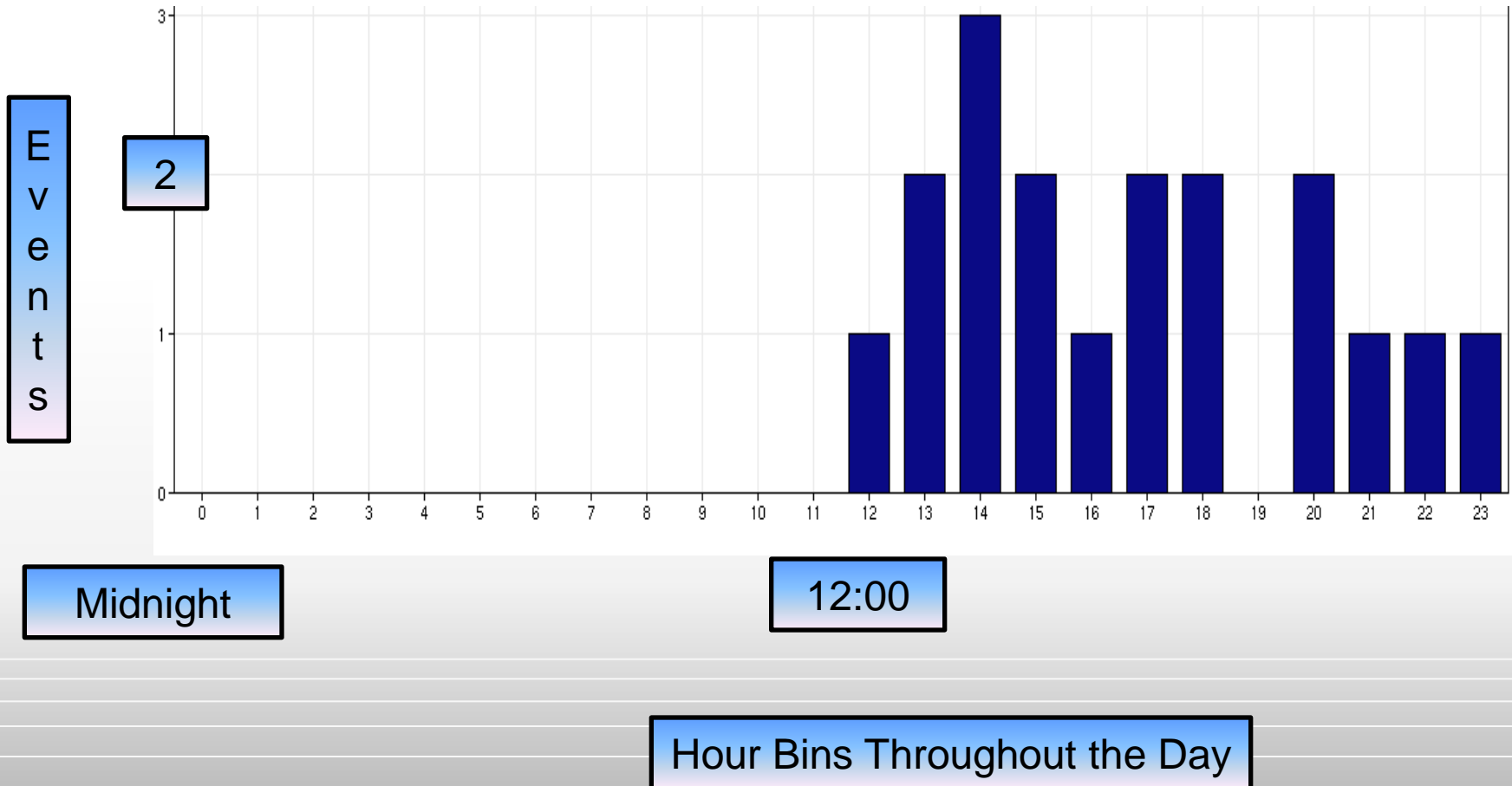


Jan 2012

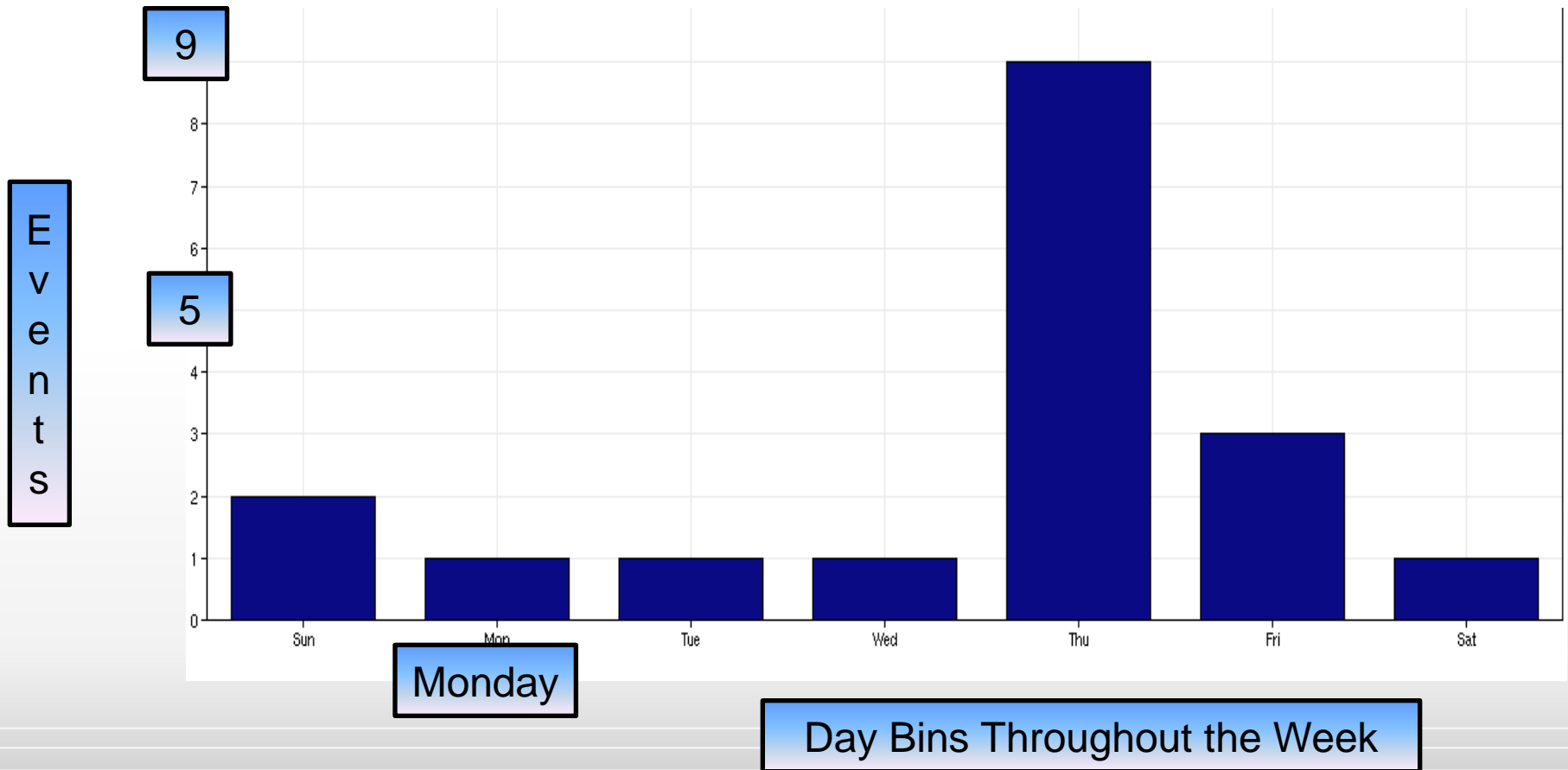
Time

Now

Location “D” – Hour Bins



Location “D” – Day Bins

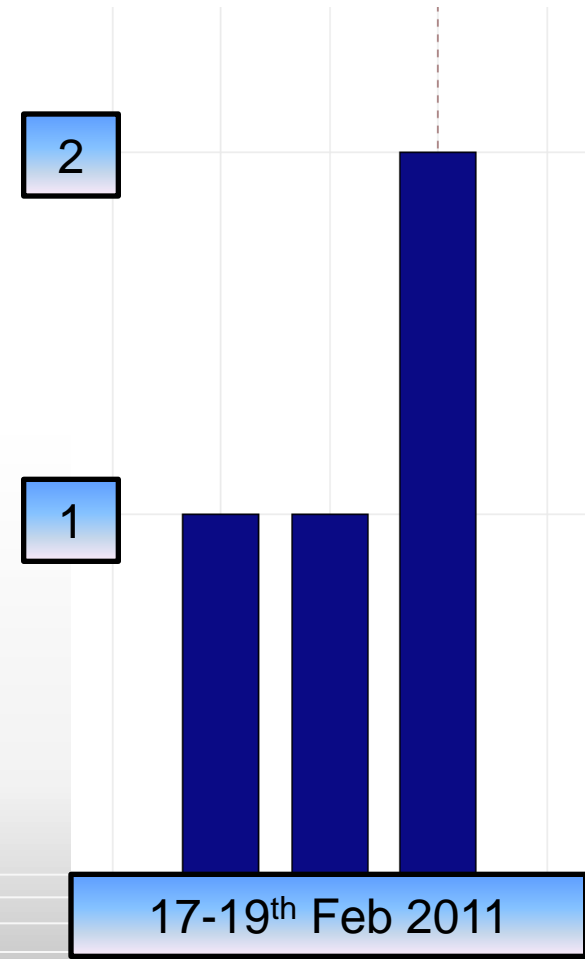
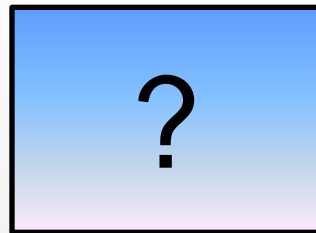


Who are the culprits?

- Evasion of Company Vehicle Tracking
- Evasion of Road User Charging
- Spoofing the Tachograph
- Stealing High Value Cars or Vans
- Stealing High Value Loads
- Stealing High Value Assets
- Evasion of Covert Tracking
- Securing Off-Site Meetings
- Any Other Ideas?

Location “A” – 4 Event Sequence

Date/Time	Duration	Sat PRNs
<u>2011-02-19 21:58:48</u>	00:12	9, 12, 14, 15, 17, 18, 22, 25, 27
<u>2011-02-19 21:56:38</u>	00:18	9, 12, 14, 15, 17, 18, 22, 25, 27
<u>2011-02-18 18:30:35</u>	00:15	5, 7, 8, 15, 21, 26, 27, 28
<u>2011-02-17 18:42:58</u>	00:18	5, 8, 15, 21, 26, 28



Early Data Events Summary

Location	Months	Events	Events/ Month		Road	Comments
Location A	12	36	3	Town	Urban A	Total
Location A	5	5	1	Town	Urban A	Since Confiscation
Location B	6	67	11	City	Urban Motorway	
Location C	2	10	5	City	Urban Motorway	
Location D	1	16	16	City	Urban A	

Build a Model

- Based on data from a growing network of Sensors
 - With additional features
- By expanding SENTINEL network
- With proposals to other private organisations
- Build a Model - Feel a Spreadsheet coming on!
- Validation over coming months as more data comes in
 - and more sensors are deployed

Road Length Stats?

Road lengths statistics – Dept. for Transport

<http://www.dft.gov.uk/statistics/series/road-lengths/>

Total Miles	Principal Single	Principal Dual	Trunk Single	Trunk Dual	Total
Motorway		26		2185	2211
Urban A	5001	1645	96	162	6904
Rural A	15942	1160	3045	1971	22118
					31233

Average Journey Length?

Average Journey Length	Principal Single	Principal Dual	Trunk Single	Trunk Dual
Motorway		25		75
Urban A	10	25	25	75
Rural A	25	50	50	75

Journey Factor

Journey Factor = Total Miles ÷ Average Journey Length

Journey Factor	Principal Single	Principal Dual	Trunk Single	Trunk Dual
Motorway		1.0		29.1
Urban A	500.1	65.8	3.8	2.2
Rural A	637.7	23.2	60.9	26.3
Total	1137.8	90.0	64.7	57.6

Nearly There!

Events per Month	Principal Single	Principal Dual	Trunk Single	Trunk Dual
From Detections	2	8	4	8

Rough Approximation from Events Summary Slide
Next: Journey Factor x Events per Month

Total Events per Month	2276	720	259	461
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Total Events per Month – Approx. 3700 !!!
Inject a Pessimism Factor!
50%

Events per Day = ~60 around the UK

Go Large!



Events per Month	Principal Single	Principal Dual	Trunk Single	Trunk Dual
From Detections	5	20	10	15

**Selecting Higher Rates from Events Summary Slide
Next: Journey Factor x Events per Month**

Total Events per Month	5689	1800	647	864
------------------------	------	------	-----	-----

**Total Events per Month – Approx. 9000 !!!
Inject a Optimism Factor!
150%**

Events per Day = ~450 around the UK

2012 Latest Deployments

- Roads – Co-Located with ANPR
- Tactical ANPR Vans
- Airport Runway
 - Co-located with ILS
 - Near a Motorway
- Electricity Grid Sub-Station Installations
- UK Port Entry Locations with Europe
- Tunnel Entrance under Thames
- London Financial District



Conclusion

- Deliberate Vehicle borne GPS Jamming is here
- Evidence suggests the small portable type
 - Impact radius 200/300m
- Model constructed for on-going investigation of UK impact
- Estimate between ~50 & 450 Events per day
- SENTINEL continues to monitor 24x7...

www.gardian.co.uk



sentinel

Detecting UK GPS Jamming – 24x7



Thankyou

www.chronos.co.uk

www.gpsworld.biz

www.gardian.co.uk

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