River & Canal operations improvement and terrorism prevention

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Canals

- Human-made channels for water conveyance, or to service water transport vehicles

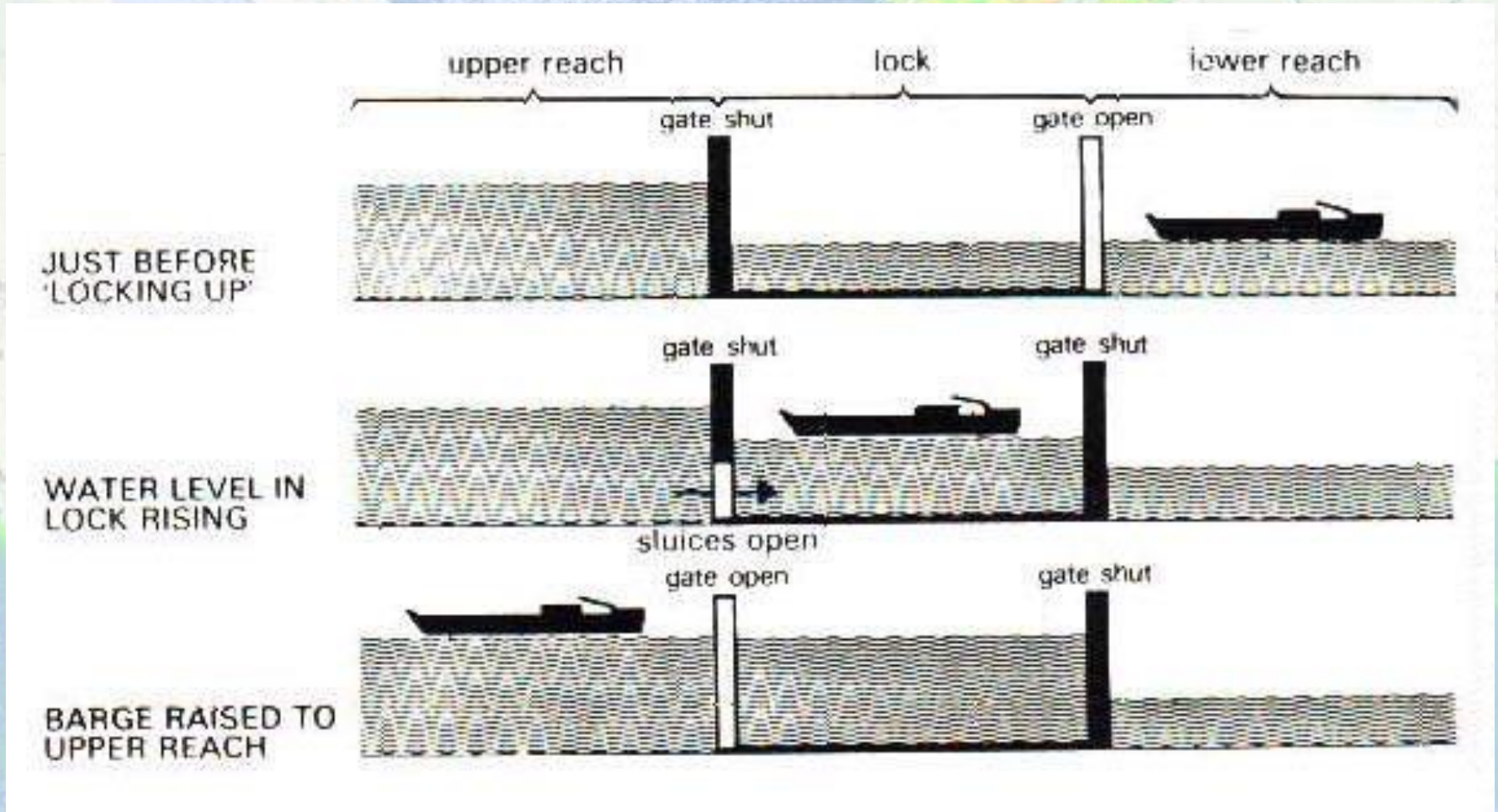
There are two broad types of canal:

- **Waterways**: canals and navigations used for carrying vessels transporting goods and people

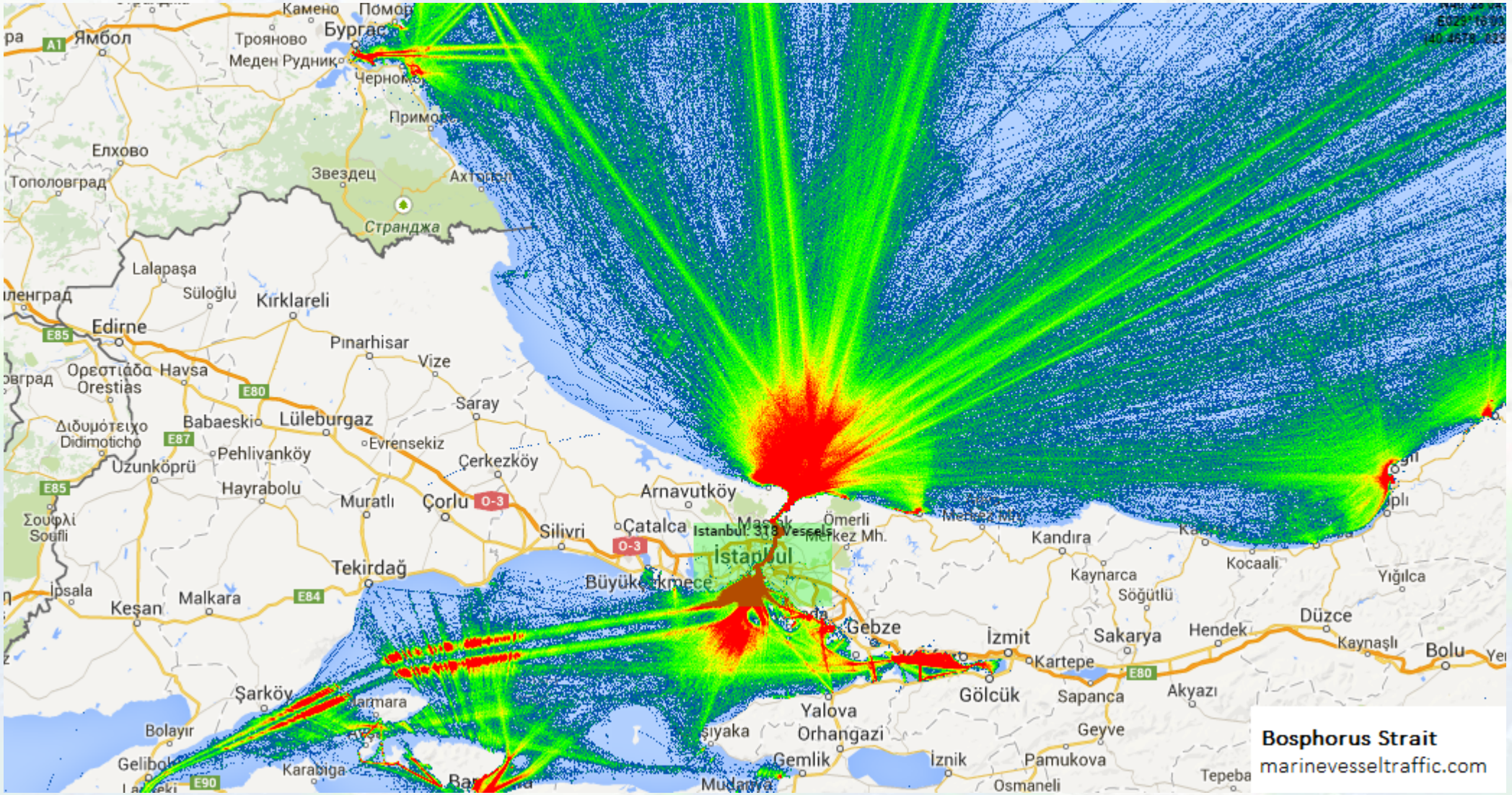
- **Aqueducts**: Watery supply canals that are used for the conveyance and delivery of potable water for human consumption

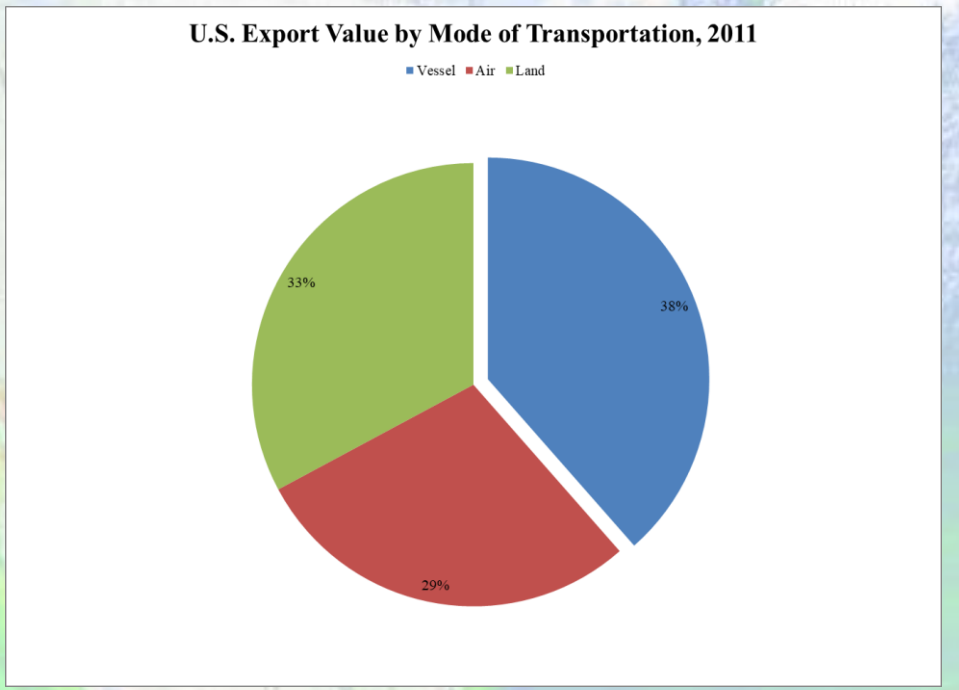
Note:- As a result of the growth in international trade, the number of container vessels calling at U.S. ports has increased. Between 2013 and 2015, vessel calls at U.S. seaports increased by 11.0 percent, from 74,000 in 2013 to 82,000 in 2015. The average displacement of container vessels continued to increase, from 44,601 deadweight tons (dwt) in 2005 to 57,458 dwt in 2015, a 28 percent increase. In 2015 tankers accounted for 40.4 percent of the vessel calls, followed by containerships with 22.8 percent of the more than 82,000 vessel calls

Working principle of Canal



Congestion on the sides of Canal





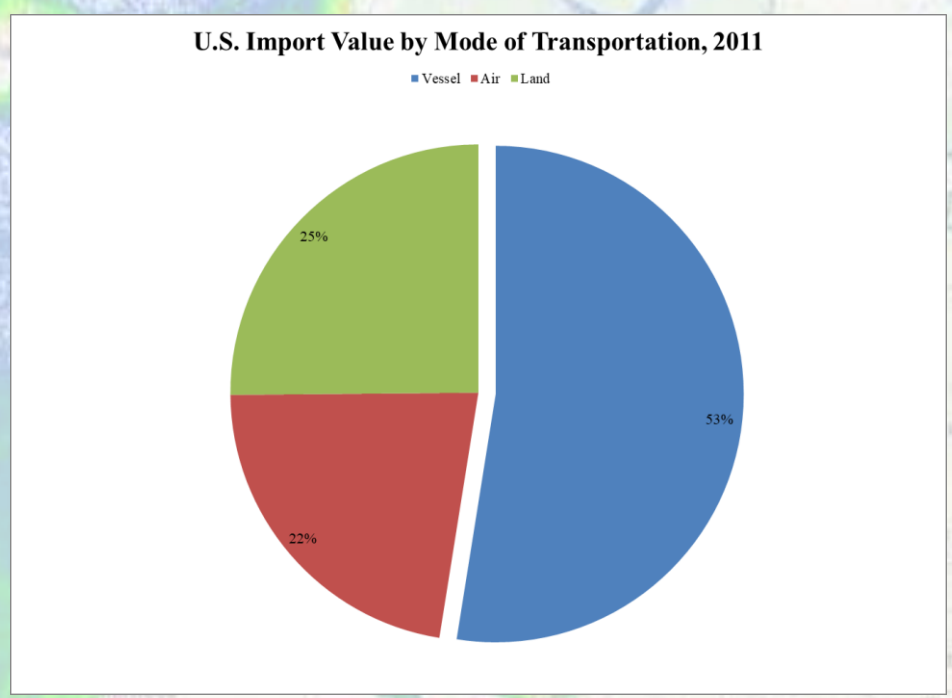
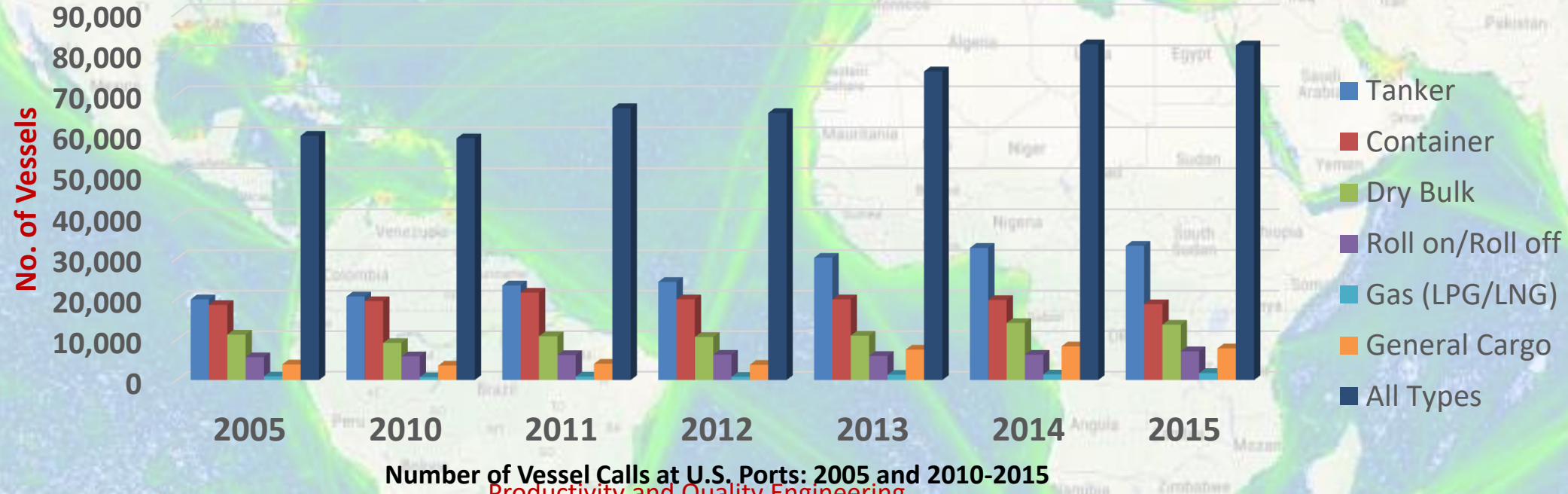


Figure 1-U.S. Imports and Exports Value by Mode of Transportation, 2011

Millions of U.S. Dollars

	Imports	Exports
Vessel	$ 1,159,096	$ 570,286
Air	$ 493,038	$ 424,265
Land	$ 554,822	$ 486,114
Total	**$ 2,206,956.37**	**$ 1,480,665.24**

Year	Tanker	Container	Dry Bulk	Roll on/Roll off	Gas (LPG/LNG)	General Cargo	All Types
2005	19,900	18,532	11,191	5,626	876	3,839	**59,964**
2010	20,621	19,466	9,162	5,838	697	3,544	**59,328**
2011	23,362	21,548	10,799	6,167	827	3,991	**66,694**
2012	24,210	19,911	10,624	6,247	779	3,756	**65,527**
2013	30,167	19,920	10,946	5,909	1,261	7,484	**75,687**
2014	32,582	19,743	14,064	6,233	1,352	8,314	**82,288**
2015	33,106	18,711	13,666	7,065	1,703	7,793	**82,044**
%Change 2005 -2015	66.4	1.0	22.1	25.6	94.4	103.0	**36.8**



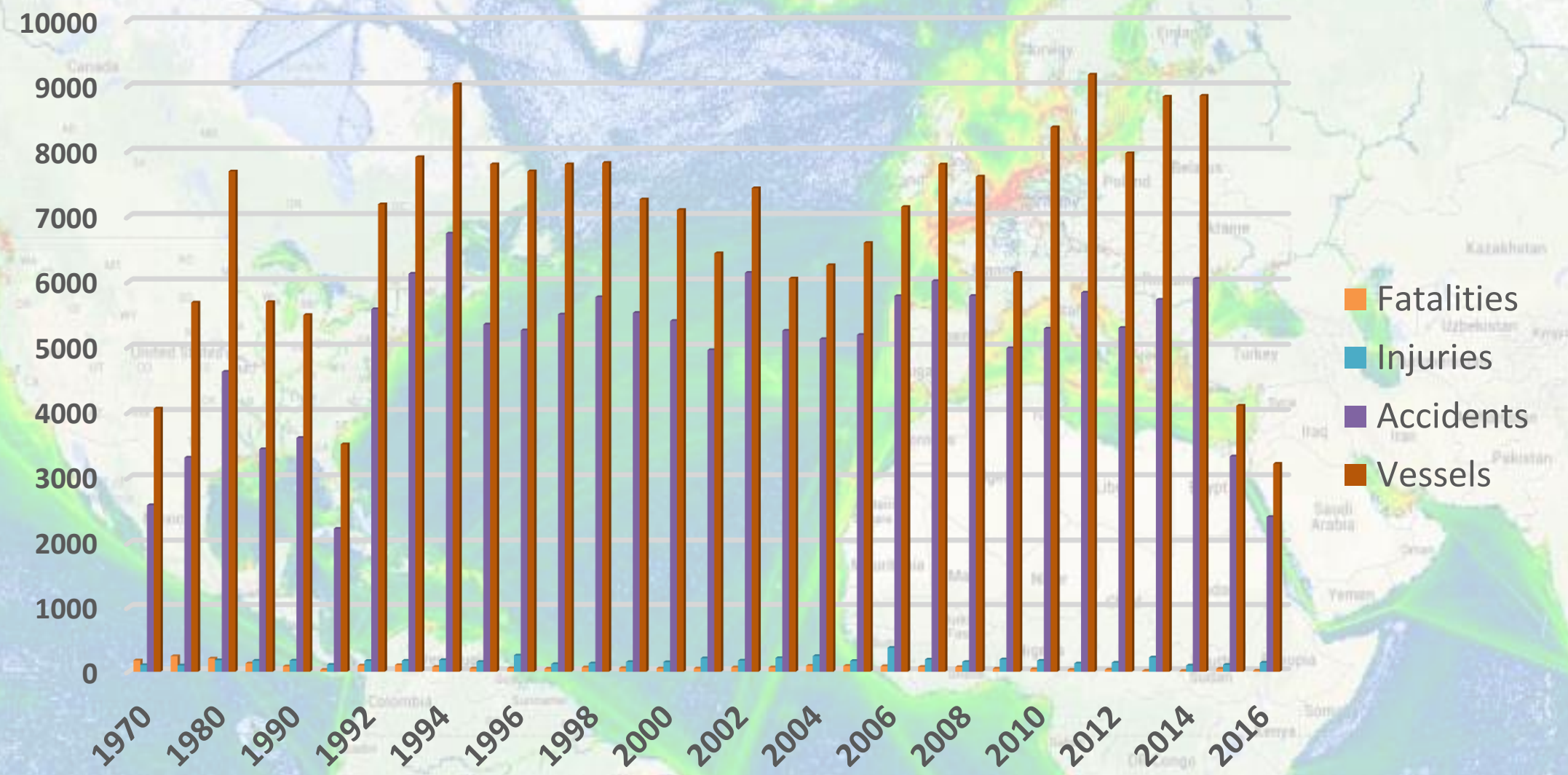
Number of Vessel Calls at U.S. Ports: 2005 and 2010-2015

Year	Fatalities	Injuries	Accidents	Vessels	Property damage (current $ millions)
1970	178	105	2,582	4,063	0
1975	243	97	3,310	5,685	0
1980	206	180	4,624	7,694	0
1985	131	172	3,439	5,694	0
1990	85	175	3,613	5,494	0
1991	30	110	2,222	3,514	0
1992	97	170	5,583	7,190	201.7
1993	105	171	6,126	7,913	181.5
1994	77	182	6,743	9,030	264.4
1995	53	154	5,349	7,802	159
1996	55	254	5,260	7,695	200.8
1997	48	120	5,504	7,802	158.2
1998	69	130	5,767	7,824	234.9
1999	58	152	5,526	7,265	177.1
2000	53	150	5,403	7,103	180.5
2001	53	210	4,958	6,439	100.9
2002	68	175	6,139	7,437	335.1
2003	67	213	5,254	6,054	126.7
2004	94	244	5,125	6,257	151.7
2005	92	169	5,190	6,599	719.5
2006	87	373	5,785	7,149	129.7
2007	76	190	6,014	7,801	85.4
2008	75	154	5,786	7,615	126.4
2009	49	193	4,987	6,139	60.5
2010	41	172	5,285	8,369	436.6
2011	31	131	5,837	9,177	71.9
2012	33	141	5,298	7,972	100.4
2013	16	223	5,727	8,839	122.2
2014	14	98	6,048	8,852	104.8
2015	46	108	3,330	4,106	101.7
2016	18	141	2,400	3,216	65.9
Total	2348	5257	154214	213789	4597.5

Table : Waterborne Transportation Safety and Property Damage Data Related to Vessel Casualties

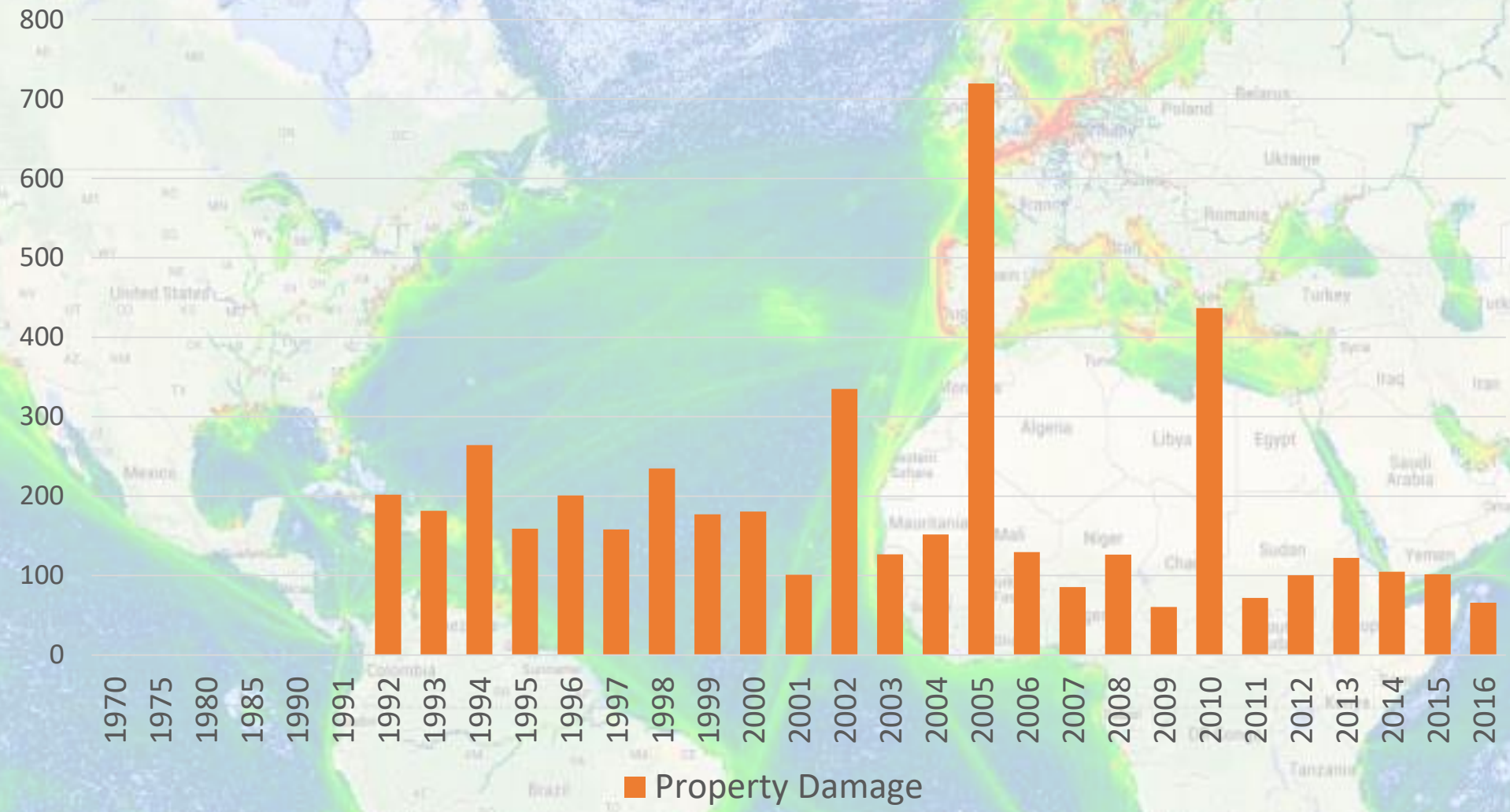
Resources:- 1970-2002: U.S. Department of Transportation, U.S. Coast Guard, Data Administration Division (G-MRI-1), personal communication, November 2008.
2003-16: U.S. Department of Homeland Security, U.S. Coast Guard, Office of Investigations and Analysis (CG-545), personal communication, Nov. 20., 2012, Nov. 13, 2013, Aug. 27, 2015, Apr. 26, 2016, and July 11, 2017.

Waterborne Safety data

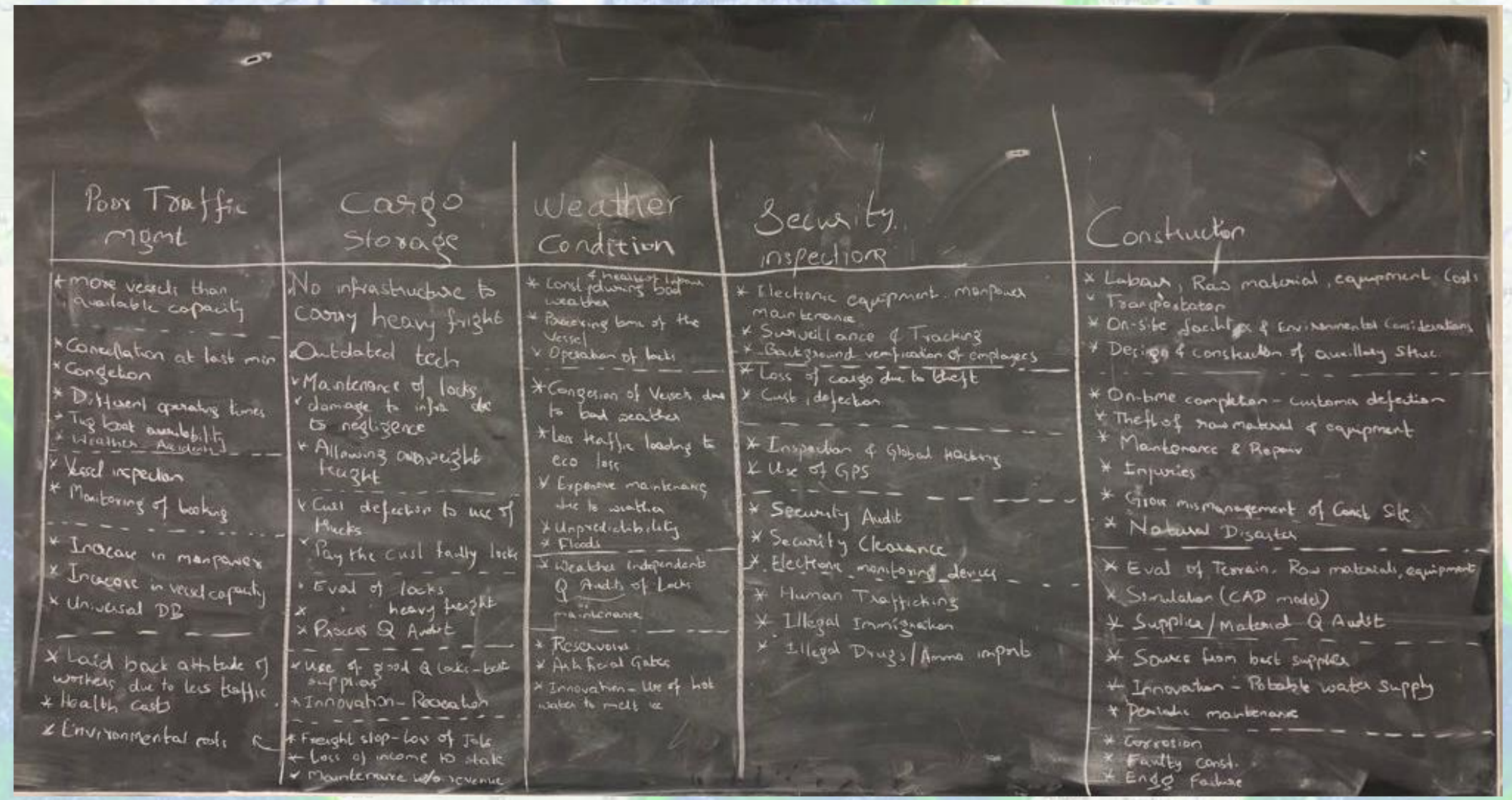


a Fatalities include the number of people who died or were declared missing subsequent to a marine accident.
b Accidents in this table include the number of "marine casualty cases" reported to the U.S. Coast Guard in accordance with 46 CFR Part 4.05-1.
c More than one Vessel may be involved in a marine Accident. Statistics from 1992 to 2011 include Vessels involved in pollution incidents, which the United States Coast Guard considers to be a Vessel casualty.

Property Damage related to vessels ($millions)



Brainstorming



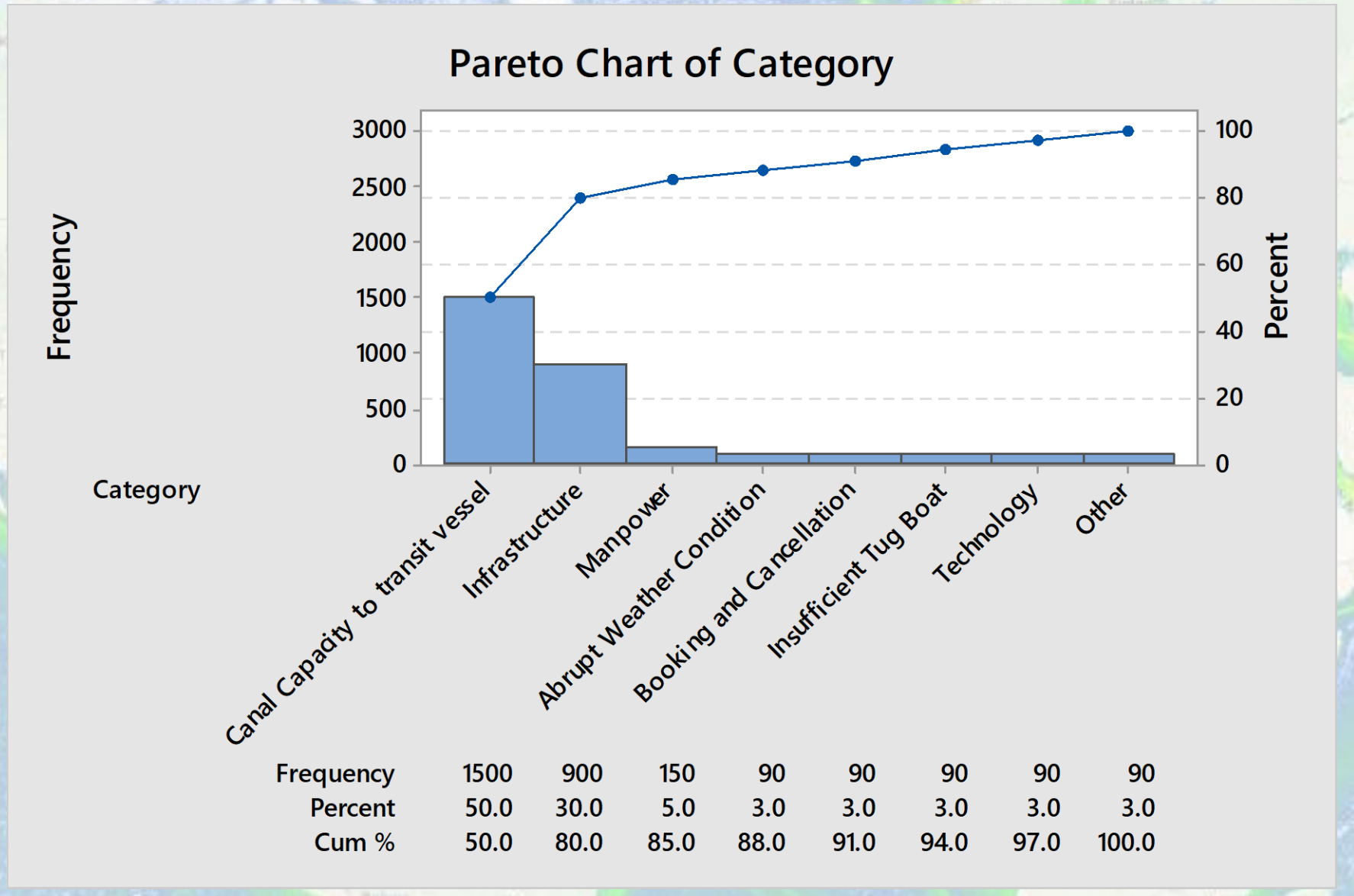
COPQ

Process	Internal Failure	External Failure	Appraisal Cost	Prevention Cost
Poor Traffic Management	1. More Vessels than available capacity of Canal	1. Cancellation at last minute 2. Different operating time of Canal 3. Tug Boat Availability 4. Vessels Accidents	1. Vessel Inspection 2. Monitoring of Online Booking & Cancellation	1. Increase in Manpower 2. Modification of Locks as per Vessel size 3. Health Cost 4. Environmental Cost
Cargo Storage	1. No infrastructure to carry heavy frieght 2.Damage to Infrastructure due to negligence 3. Allowing overweight Freight		1. Evaluation of Locks 2. Evaluation of heavy frieght 3. Process Quality Audit	1. Use of good quality locks 2. More machines to load and unload cargo from vessel 3. Infrastructure to store/keep the cargo
Weather Condition	1. Difficulty in operating locks in bad weather 2. Time taken to fill the canal with water	1. Congestion of vessels near canal in bad weather 2. Increase in process lead time leading to Economical loss 3. Flood 4.Expensive maintenance in bad weather condition	1. Quality audits of the lock	1. Extra resrvoirs to supply water in bad weather 2. Artificial gates to prevent overflow of water in canal 3. Use of hot running water to melt ice 4. Infrastructure to guide Tug boat in low visibilty weather condition
Security Inspections	1.Electronic equipments to monitor the vessels 2.Surveillance & GPS tracking 3.Background verfication o employee	1. Loss of cargo due to theft	1. Security audit 2. Security clearance 3. Electronic monitoring devices	1. Human trafficiking 2.Illegal Immigrants 3.Illegal Drugs
Construction	1. Labour, Raw Material & Equipment cost 2. Onsite facilities& Environmental condition	1. Theft of raw material & equipment 2. Mainenance & Repair 3. Injuries 4. Natural Disaster	1. Evaluation of Terrain 2. Simulation 3. Supplier/Material Q Audit	1. Raw Material from best supplier 2. R&D Cost 3.Periodic Maintenance

List of Concerns from COPQ

- Canal Capacity to transit vessel
- Insufficient Tug Boat
- Infrastructure
- Technology
- Abrupt weather condition
- Construction problems
- Labour Strike
- Equipment availability
- Manpower
- Booking and Cancellation
- Competitors

Pareto Chart

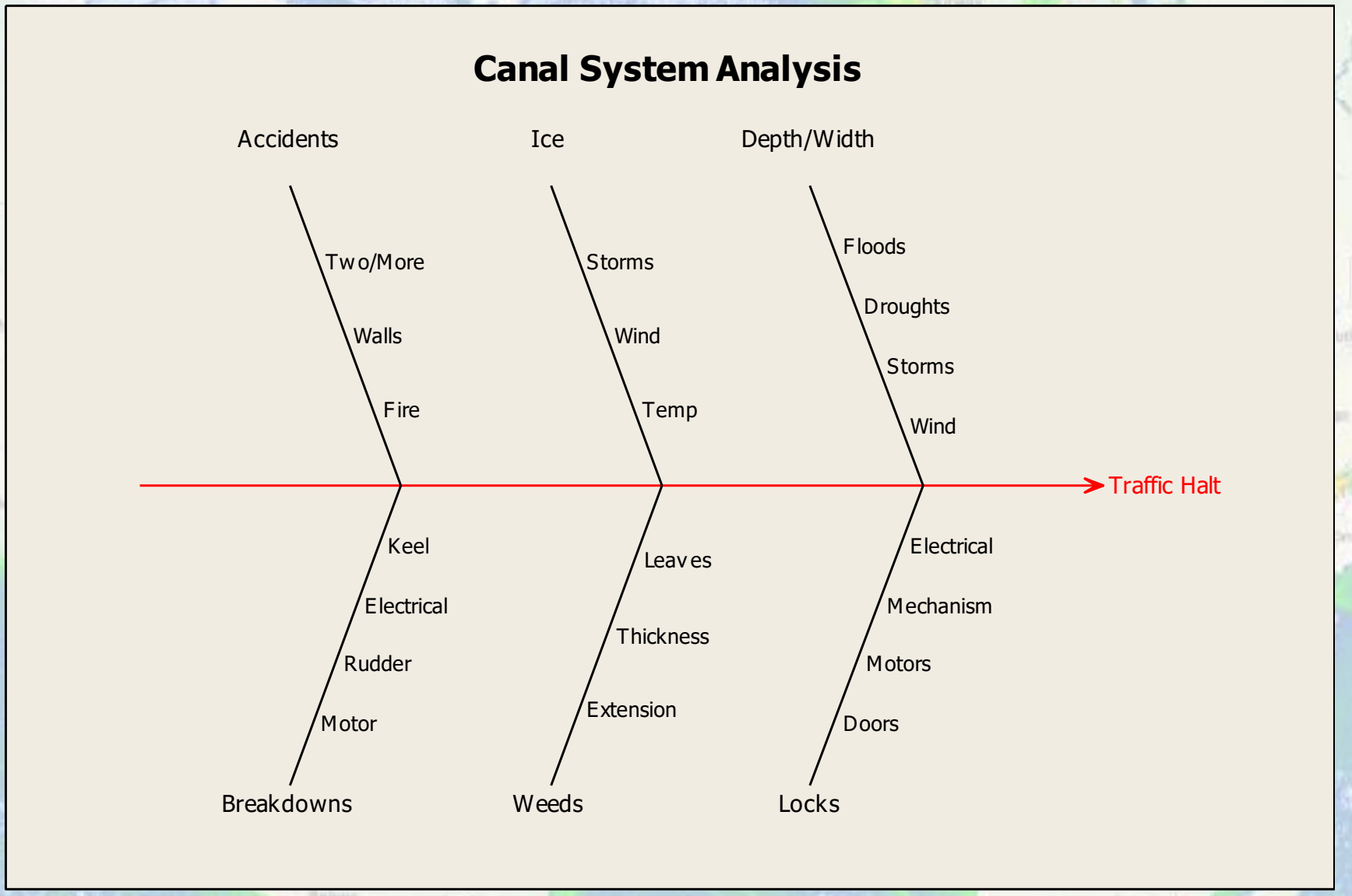


Frequency	1500	900	150	90	90	90	90	90
Percent	50.0	30.0	5.0	3.0	3.0	3.0	3.0	3.0
Cum %	50.0	80.0	85.0	88.0	91.0	94.0	97.0	100.0

Ishikawa Chart for Canal Problems

Depth/Width	Locks	Ice	Weeds	Accidents	Breakdowns
Floods	Doors	Storms	Extension	Two/More	Motor
Droughts	Motors	Wind	Thickness	Walls	Rudder
Storms	Mechanism	Temp	Leaves	Fire	Electrical
Wind	Electrical			Keel	

Fish Bone Diagram



Audit or Survey

- Questions that needs to be answered –

1. What are the regulations in place for the canal/river operations?
2. Who is responsible for the safety of the river/canal and the people using it?
3. Who is responsible for the operations of the river/canal?
4. Are there any security threats that need to be addressed?
5. Are the rivers/canal being properly maintained?
6. Are there enough resources for the proper working of the canal/river?

Whom to ask?

- The Government Authorities
- The River/Canal authorities
- The Security Agencies
- Experts and Engineers

What to hope for

- There are strict regulations in place for the river/canal operations to prevent these from being exploited
- Appropriate security measures are in place
- The rivers/canals are properly maintained
- Enough resources and manpower in place for effective working of the river/canal

Process Capability Analysis

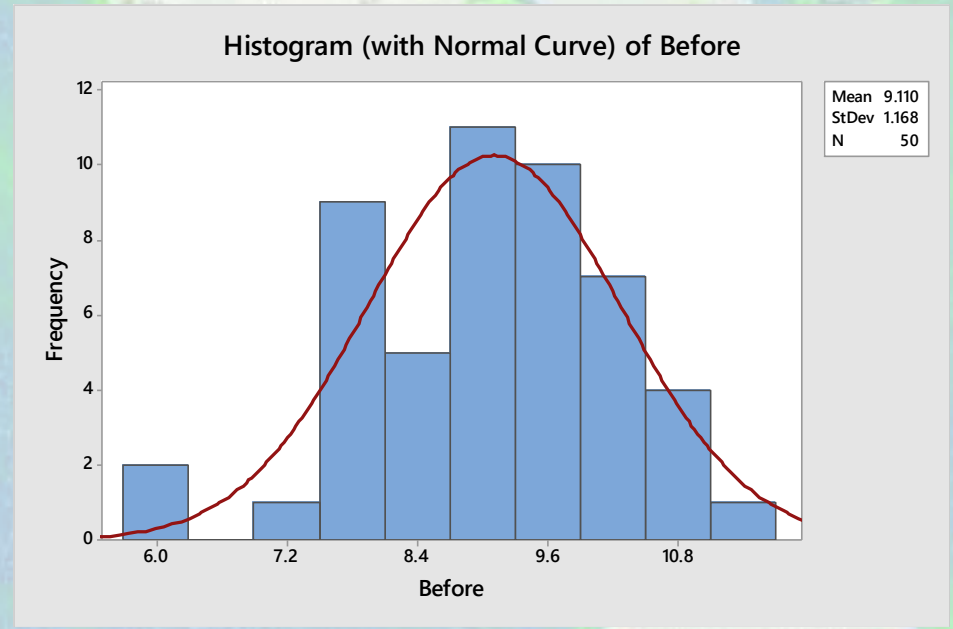
Process:- Time taken for a vessel to pass through the canal

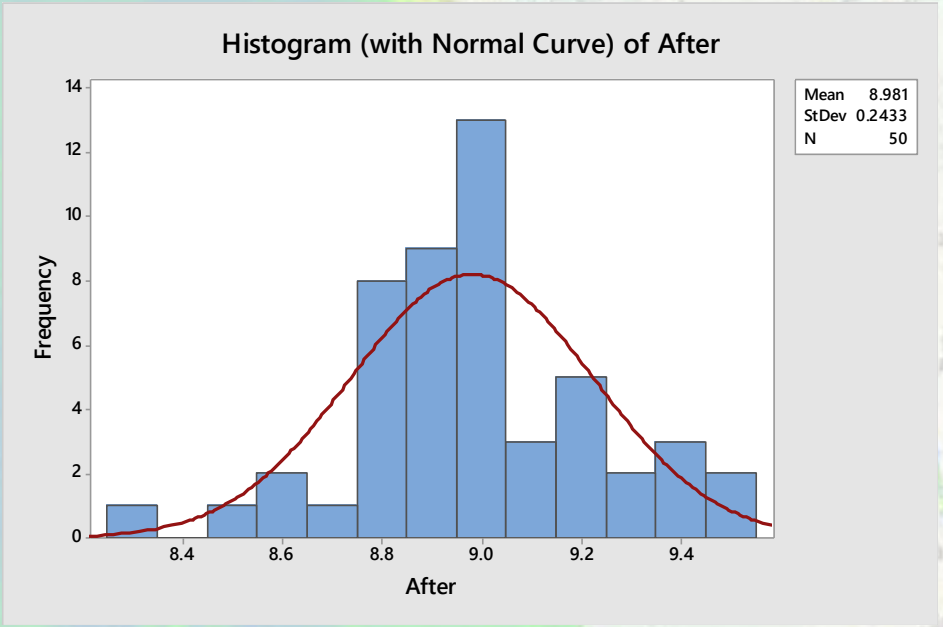
Problem:-

- Traffic Halt
  - ❖ Canal operations issue
  - ❖ Probable reason could be improper scheduling , accidents, weather condition, non-availability of necessary resources, maintenance, Abrupt increase of incoming vessels at canal etc.

Descriptive Statistics: Before, After

Variable	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Before	9.110	1.168	6.077	8.182	9.129	9.896	11.110
After	8.9812	0.2433	8.2548	8.8315	8.9705	9.1360	9.5355

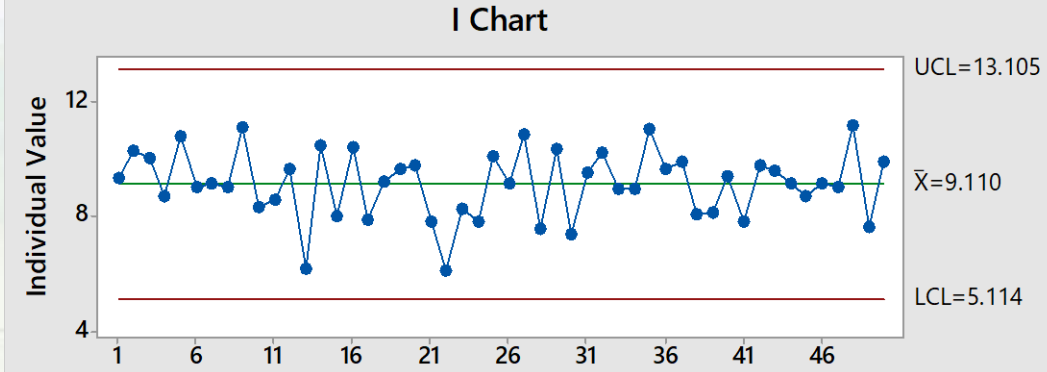


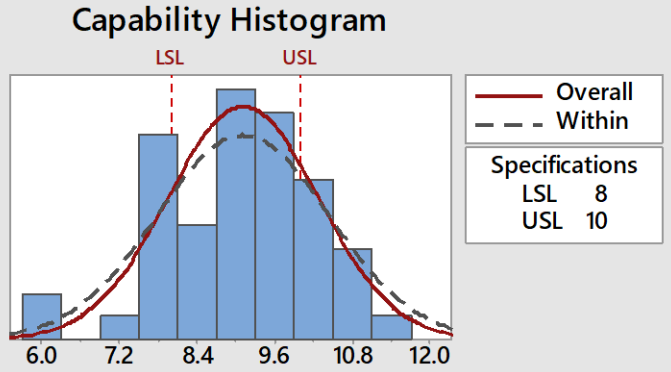


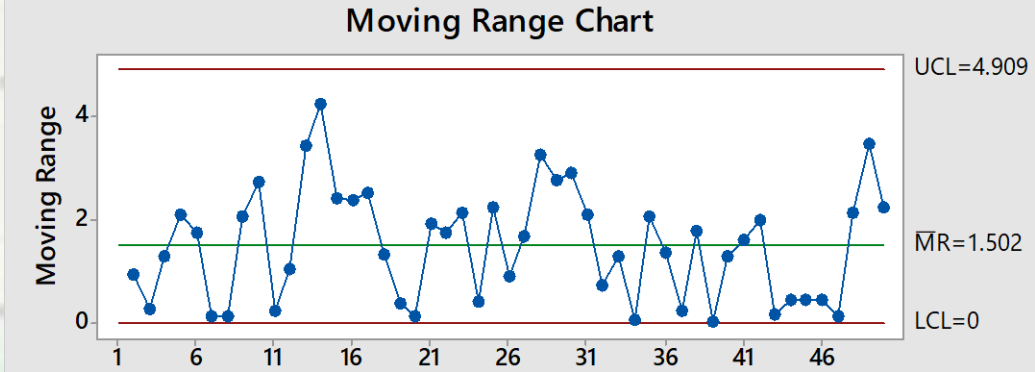
Note:- Normal dataset of 50 data points is generated because the average transit time through the canal takes **eight to 10 hours**

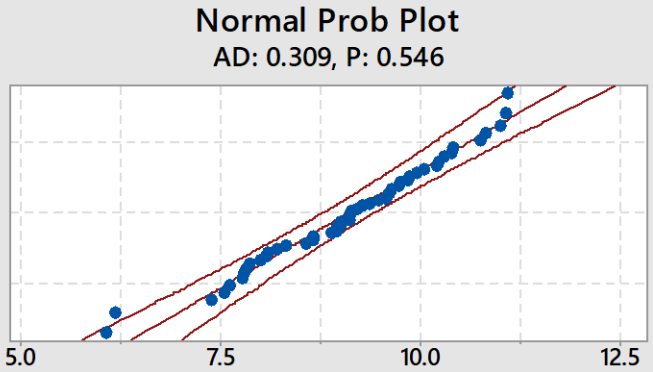
Before		After	
9.28	10.05	8.99	8.72
10.23	9.14	9.18	9.40
9.97	10.82	9.00	8.78
8.67	7.55	9.28	8.93
10.76	10.31	9.50	9.01
9.00	7.39	8.98	8.54
9.12	9.48	9.07	8.89
9.00	10.21	8.96	8.95
11.07	8.90	9.11	9.54
8.33	8.96	8.60	8.80
8.57	11.02	8.83	8.88
9.62	9.65	8.93	8.25
6.19	9.87	8.65	9.00
10.43	8.08	9.13	8.75
8.00	8.10	9.26	8.98
10.41	9.38	9.18	8.89
7.88	7.77	9.01	8.89
9.21	9.75	9.02	8.89
9.60	9.58	9.17	8.96
9.74	9.11	9.16	8.79
7.83	8.67	9.02	8.98
6.08	9.11	9.37	8.95
8.21	8.97	8.78	8.90
7.81	11.11	9.41	8.82
9.85	7.62	9.20	8.77

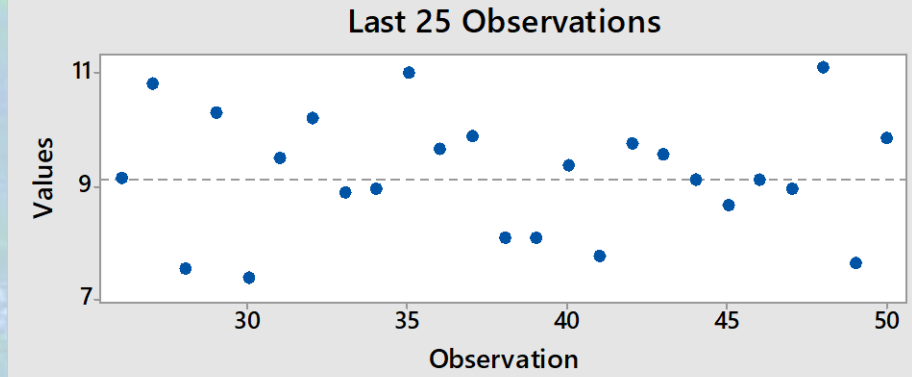
Process Capability Sixpack Report for Before

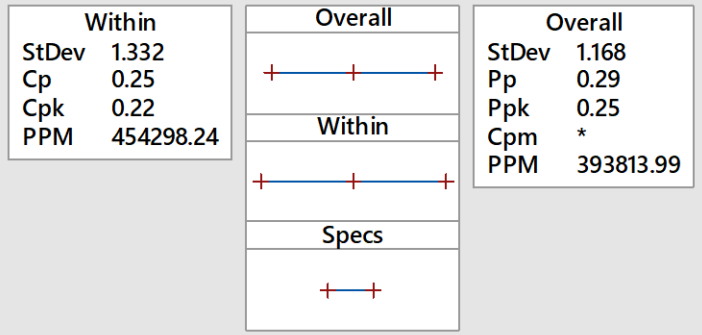




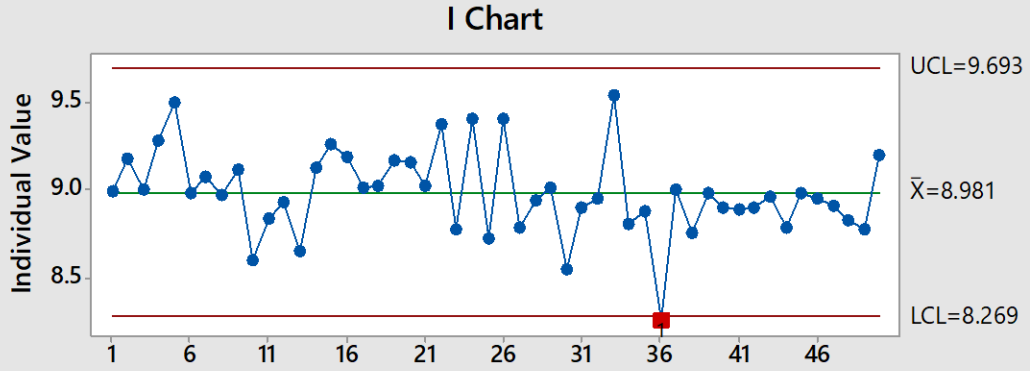


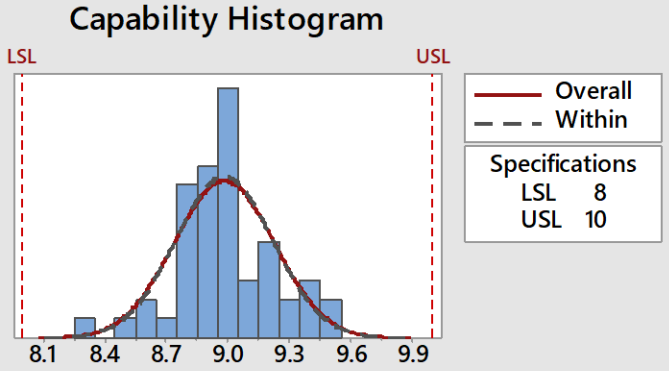


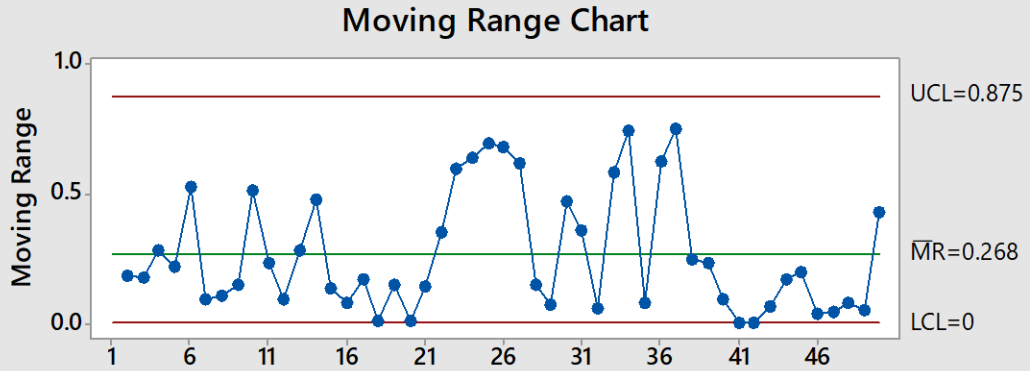


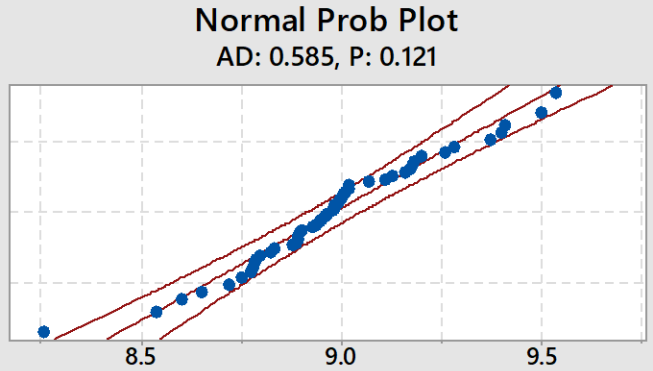


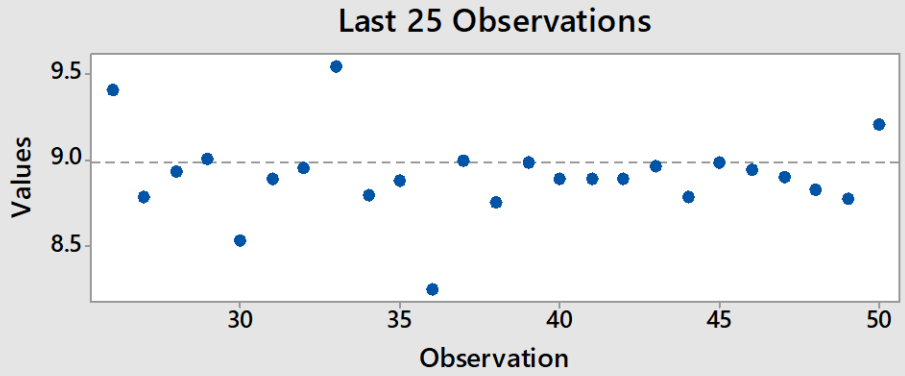
Process Capability Sixpack Report for After

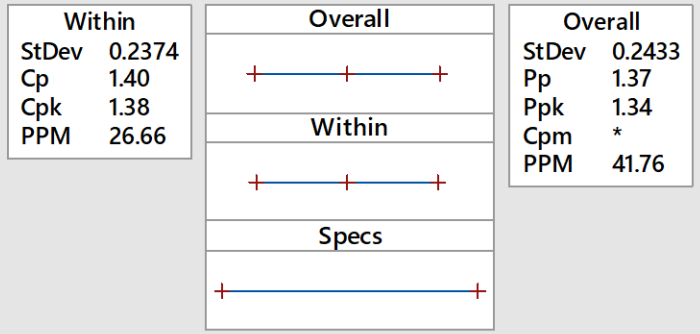












References :-

1. https://www.rita.dot.gov/bts/sites/rita.dot.gov.bts/files/publications/transportation_statistics_annual_report/2016/chapter_3
2. https://www.bts.gov/content/waterborne-transportation-safety-and-property-damage-data-related-vessel-casualties
3. https://www.rita.dot.gov/bts/sites/rita.dot.gov.bts/files/PPFS_Annual_Report.pdf
4. www.marad.dot.gov/resources/data-statistics/