II. United States

Key Bridge Disaster Was Preventable, Reflects 50 Years' Looting of Economy

by Richard Freeman

April 12—This past March 26, at 1:29 a.m., the Francis Scott Key Bridge in Baltimore, Maryland, a critical link in highway transportation on Interstate 95 along the U.S. East Coast, and also a critical avenue of trucking to the Baltimore port, collapsed into the Patapsco River. The Singapore-chartered cargo ship *Dali*, 985 feet long and weighing 115,000 tons, had its engine fail, only a few miles out of port—which is completely unexplained. The *Dali* lost its steering power and rammed into one of the two main pylons of the bridge, bringing it down in seconds (**Figure 1**). Six construction workers working on the bridge, who, *USA Today* reported, came from Guatemala, Honduras, El Salvador, and Mexico, were killed.

Over the past 50 years, the U.S. has experienced bridge tragedies time and again. In a previous major case on Aug. 6, 2007, the Interstate 35W bridge over the Mississippi River near downtown Minneapolis was loaded with rush-hour traffic creeping through a construction project when, without warning, the bridge collapsed, taking with it 111 vehicles; 13 people died and 145 were injured.

FIGURE 1

M/S *Dali* Collides with Francis Scott Key Bridge Pylon

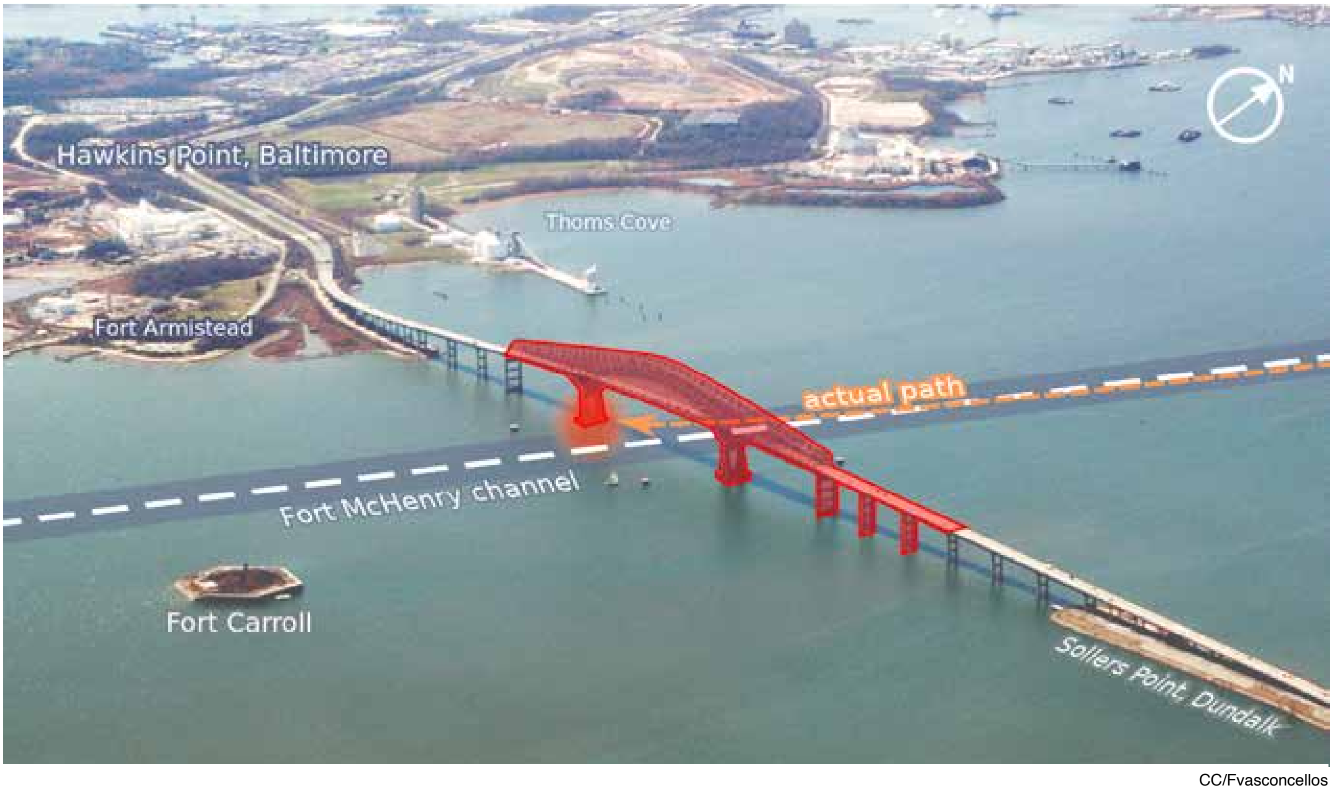

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Diagram of the path taken by the M/S Dali *(dashed orange line) when it collided with one of the two main pylons of the Francis Scott Key Bridge in Baltimore, causing its collapse.*

In the United States, bridge infrastructure, and that of railroads, electricity grids, power stations, and water management systems, are in a phase of collapse. This long-term decay was set into motion when President Richard Nixon decoupled the dollar from the gold reserve system on August 15, 1971; it gained force with U.S. Federal Reserve Board chairman Paul Volcker's policy, beginning 1979, of "controlled disintegration of the economy," forcing up the U.S. prime interest rate to 21.5% by February 1980. The speculative bubbles that have dominated economic decision-making since then, have siphoned off funds for economic infrastructure above all. New infrastructure—high speed rail, fission and fusion power—has been suppressed; regular maintenance abandoned for existing infrastructure; rational regulation standards rejected; and redundancy—whereby indispensable back-up systems are built into infrastructure in order to prevent disasters—ignored. It is overall policy, not a single incident, that causes disaster.

The Francis Scott Key Bridge collapse was eminently preventable. In many facets of this story, the addition of pieces of infrastructure, or even the utilization of existing infrastructure, would have eliminated the disaster. This article investigates several crucial "singularities" in the manifold of the causes of the catastrophe. Conceptualizing the key features of the series of singularities permits a higher idea of what actually happened, and the protective steps that should now be taken.

M/S *Dali* Engine Failure: More Profound Questions

Let us start with the vessel. The M/S *Dali* was built by Hyundai Heavy Industries of South Korea in 2014, and commissioned in 2015. The container vessel is owned by Singapore-based Grace Ocean Pte Ltd, and sails under a Singapore flag (more on this below).

The *Dali* is a big ship (300 meters long), weighing, without cargo, 95,000 tons, according to the April 11 *Spectrum News*. At maximum, it can carry 10,000 standard TEU metal shipping containers (twenty-foot-long equivalent units), although at the time of the accident, it was carrying about 4,700. (The world's largest container ships can carry more than 24,000 TEU containers.) Physically, the *Dali* is propelled by a single low-speed, two-stroke crosshead diesel engine, capable of 55,000 horsepower, which powers the ship's single large propeller.

The *Dali* left port at about 12:30 a.m. March 26, headed toward the Key Bridge. It should be noted that the Baltimore port consists of more than 10 terminals, most of them in parts of the harbor now completely blocked by the collapsed bridge. The *Dali* was escorted—and perhaps towed—by tugboats for safety purposes. As it approached the bridge, the *Dali*'s engine failed. Even though the ship has a range of automation and computerized monitoring, without its engine operating it is very difficult to steer. The captain appeared to switch on the ship's four back-up generators; the vessel's lights flashed back on and off again. But the generators by themselves could not—and according to one report, cannot—restart the engine.

There was a cascading collapse of the vessel's most crucial operating systems that left it adrift. The March 30 *New York Times,* in an article, "Baltimore Investigation Turns to Ship's Deadly Mechanical Failure," reported:

> Maritime engineers say an electrical chain reaction could also have caused the generators to go down. When one generator fails, it can create a situation in which there is too much demand for too little supply of electricity. Other generators are then at risk of being damaged, so the system will shut them down, too, said Richard Burke, a professor of marine engineering at SUNY Maritime College in New York. "It's as if you and I are both holding up a heavy weight and I let go," Burke said. "You can't hold it by yourself, so you drop the weight."

With the engine not working and the generators off, the rudder, which depends on electricity, stopped working. The *Dali* was literally drifting; the outgoing tide pulled it along. It sounded its emergency horn, and then crashed into the bridge.

On April 11 Jennifer Homendy, chair of the National Transportation Safety Board (NTSB), whose remit is to investigate transportation accidents, told a U.S. Senate Committee that in its investigation, the NTSB is focusing on the *Dali*'s power system, and that it has asked builder Hyundai Heavy Industries of South Korea for assistance in examining the ship's circuit breakers. Homendy said,

> We have had the manufacturer of the equipment in the engine room to look closely at the electrical power system. We're continuing to look at that.

This leads to two points. First, the breakdown of the *Dali's* electrical and engine system was so significant, how it could have passed any basic inspection while undergoing maintenance in the Port of Baltimore? Inspections have to be performed on a regular schedule. Coast Guard Rear Admiral Shannon Gilreath told CNN March 28,

> We were informed that they were going to conduct routine engine maintenance on [the *Dali*] while it was in port. That's the only thing we were informed about the vessel in that regard.

An airplane must undergo a comprehensive checklist of its auxiliary fuel pump, altimeter, directional gyro, and so on, each time it is allowed to leave the ground. The *Dali* was scheduled to make a 14,300 km trip from Baltimore to Sri Lanka; how could it have been cleared to leave port when its electrical grid and engine functioning were such that they broke down in less than nine miles?

The second point: Large cargo ships can—and should—have multiple engines arranged in a configuration known as a "twin-screw" or "multi-engine" set-up. These ships have two or more engines—some have four—each driving a separate propeller or a propulsion unit, providing *redundancy*. The *Dali* only had one engine. Had it had two engines: If both were in use, and one failed, then the engine still functioning would have propelled the ship by itself; if only one engine was in use, and failed, the commander would have activated the other one.

The likely reason that the *Dali* had only one engine, is cost-cutting. One source calculated that each engine takes up the space of about 150 containers: Having only one engine leaves more space for cargo containers on which money could be made. And a ship's engine can cost millions of dollars.

This gets to the fundamental issue of essential *redundancy*. Infrastructure must have built-in redundancy, whether it be a water management system, electricity grid, a transport vehicle, etc. But many infrastructure operators, ship owners, etc. reject "too costly" redundancy.

Regulation and law should require vessels to have two engines. Had the *Dali* had a second engine, the chance is very great that there would not have been a ruinous accident.

The Central Function of Tugboats

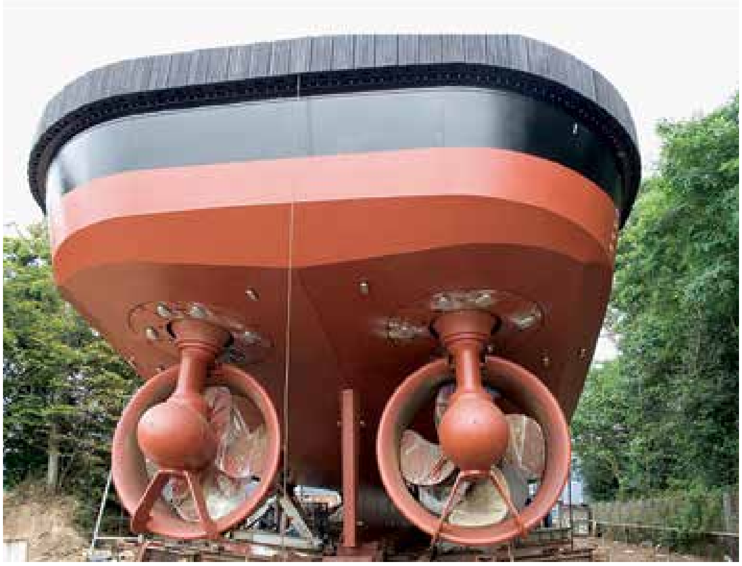
Tugboats can either tow a large vessel (see photo), or run alongside it, usually in teams, to push or direct it in a desired direction. A towing tugboat usually has a high-strength steel cable attached to its stern, which runs to the bridge of the vessel it is towing.

Tugboats can be thought of as powerful engines that connect to and power large propellers that generate a lot of thrust (see photo). These are placed within a vessel, with operators on board.

Picryl

A small, powerful tugboat tows a large container ship.

A March 29 Associated Press article, "Could Tugboats Have Helped Avert the Bridge Collapse Tragedy in Baltimore?" reported that the *Dali* was moved out of the tight spaces of the docks at the Port of Baltimore, and then escorted toward the Francis Scott Bridge, by two "muscular machines"—the tugboats *Eric McAllister* and *Bridget McAllister*. However, the tugboats withdrew from the vessel in the channel, just a few miles before reaching the bridge. Why not escort



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The large, powerful propellers of a tugboat.

it into open waters, normally an 18-minute journey? Reported AP:

> Such extended tugboat escorts aren't required or even customary in Baltimore or at many other U.S. ports, mostly because of the costs they would add for shippers…. But with the increasing size of cargo ships and the threat they pose to bridges and other critical infrastructure, some are questioning whether they should be.

The Port of Baltimore, like other East Coast ports, represented by their port authorities, say the extra cost for tugs to escort vessels through bridges makes them uncompetitive. "Business will go elsewhere," they say. But there are various mechanisms that could be discussed and implemented, similar to the National Highway Trust Fund, that could equalize costs.

Joseph Ahlstrom, a member of the Board of Commissioners of Pilots of the State of New York, emphasized safety:

> I'm a big fan of tug escorts. If applied early and effectively, yes, a tug escort could prevent a collision with a bridge or another ship.

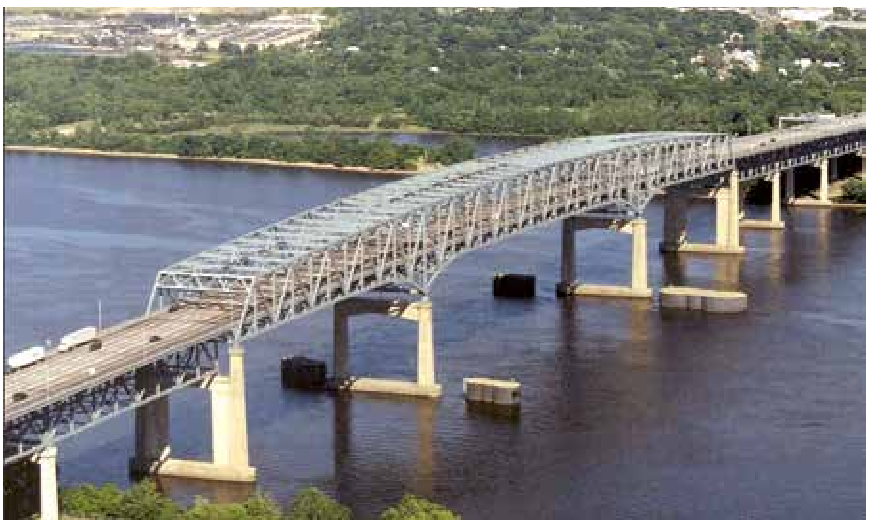
Tugs should become mandatory by law for ports located close to bridges, or channels of stirred up currents.

Structures Shielding Bridges' Supports

Seconds before the *Dali* hit the Key Bridge, it sailed past a structure called a "dolphin," designed to prevent that kind of disaster. But the 1.6-mile-long Key Bridge, built in 1977, had a dolphin system built that same year, adequate to protect against ships of that time, which were one-half the length, and one-tenth the weight of current behemoth container vessels. The dolphin system was scarcely updated by the Maryland Transportation Authority; the *Dali* was unimpeded when it crashed into the Key bridge.

Dolphins are circular or oblong concrete constructions located near a bridge's central support pylons. Vessels are meant to crash into them if they veer off track in the shipping channel, diverting them from collision with the bridge. The Betsy Ross Bridge in Philadelphia, built in 1969, which is of a continuous truss bridge construction—like the Francis Scott Key Bridge—has four modern dolphins around it and is protected. This is because in 2003, the Delaware Port Authority conducted a vulnerability study and determined that physical updates were needed to protect the Ross bridge (see photo).

Further, last year, Delaware announced that it



Delaware Port Authority

"Dolphins" in the river protect the Betsy Ross Bridge against collision.

would spend $22.3 million to improve the Delaware Memorial Bridge pier protection system. The new "ship collision protection system" will include eight barriers measuring 80 feet in diameter each. The Delaware Memorial is only 71.5 miles from the Key Bridge.

The Key Bridge, along with many others in the United States, has an antiquated system. An April 4 article on Wisconsin Public Radio's homepage, "Concrete Structures Meant to Protect Baltimore Bridge Appear Unchanged for Decades," noted this aged protection system, and asserted:

National Archives and Records Administration

Bethlehem Steel's Sparrows Point steel complex, the largest steel mill in the world in the 1950s, with a rated capacity of 7.3 million long tons of ingot steel per year and 30,000 skilled workers. It ceased to exist in 2012.

> Experts said if the Baltimore bridge had been outfitted with more robust collision-prevention structures, it may not have been struck.

Other protection systems for bridges are shields known as "fenders" near bridge support pylons, made of everything from concrete and steel to polymers.

A robust dolphin protection system, a second engine on the *Dali*, and the intelligent use of tugboats through the bridge, would each have had a very high chance of preventing the March 26 Baltimore bridge disaster. A rational U.S. infrastructure policy, in which all three were used, would have made it an impossibility.

Danger Spreading to All the Nation's Bridges

The American Society of Civil Engineers (ASCE), in its 2021 Infrastructure Report Card report—its latest—warned:

> There are more than 617,000 bridges across the United States. Currently, 42% of all bridges are at least 50 years old, and 46,154, or 7.5% of the nation's bridges, are considered structurally deficient, meaning they are in "poor" condition. Unfortunately, 178 million trips are taken across these structurally deficient bridges every day.

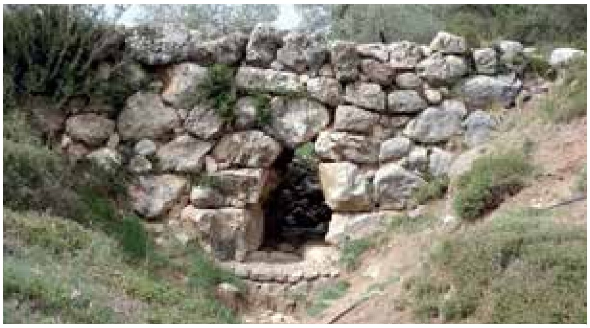
While the ASCE says that the number of structurally deficient bridges has been declining over the last few years, it reports that the number of bridges that have fallen from "good" condition to "fair" condition has increased. In 2012, there were 280,817 bridges classified in good condition, and 231,225 in fair condition; in 2019 the bridges in good condition dropped to 277,582, and those in fair condition rose considerably to 291,339. More bridges in "fair" than in "good" condition may be a first in the nation's history. Without a fundamental change of policy, tens of bridges will collapse, producing untold deaths, and destruction in the economy.

Collapse Worsens Baltimore's Deterioration

The crumbling of the Francis Scott Key Bridge takes a chunk out of once-industrial Baltimore's economy. In a huge area to the east of Baltimore Harbor, once stood Bethlehem Steel's Sparrows Point steel complex. In the mid-1950s, the plant operated 10 blast furnaces and had a rated capacity of 7,321,000 long tons of ingot steel per year—the world's largest steel mill, employing 30,000 skilled workers. Most of the iron ore it consumed then came via ship, imported from mines in South America and Labrador, through the Port of Baltimore. The Bethlehem plant has been demolished.

In that same general area stood the General Motors Plant on Broening Highway, known as the GM Baltimore Assembly plant. In the 1970s it employed 7,000 workers, but it closed in 2005.

Now Baltimore, which as late as 1990 had 735,000



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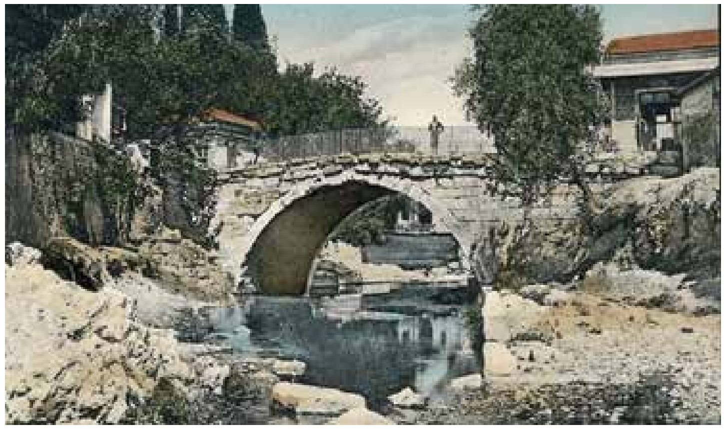
Arkadiko Bridge in Mycenae, Greece, thought to be the world's oldest bridge still in use, was built at the end of the Bronze Age.



The bridge over the River Meles in İzmir, Türkiye, older than Homer, was built with a stone arch span design.

people, is down to a population of 570,000. The port, founded in 1706, is one of America's oldest. It is the largest American port for the export of coal, and according to *Farm Equipment News*, a key hub for agricultural equipment imports and exports. Its closure could have a notable impact on the import of high horsepower tractors needed in the American Midwest. Since the bridge collapse, the port has been closed "until further notice," and another chunk of the shrinking Baltimore physical economy is being knocked out.

The Civilizational Importance of Bridges

Bridges are a crucial element in the development of civilization. Think of early man first bridging a stream by cutting a tree and placing it over the stream. Thus a man could cross, but could one bring a wheel-barrow of goods across this log? Look at some of what are considered to be mankind's earliest bridges. The Arkadiko Bridge (see photo), thought to be the world's oldest, built approximately 1300–1190 BCE in Mycenae on the Peloponnesian Peninsula in Greece. Notice that while primitive, some proto-engineer has figured out a way to arrange the stones to enable it to stand, and support people. Nearly as old is the bridge over the River Meles in İzmir, Turkey, built approximately in the year 850 BCE (see photo). Here some engineer or group of engineers figured out to build a stone arch span, which required a knowledge of how to distribute stress and forces.

Mankind needed to gain knowledge of how to build bridge structures that could handle—and indeed utilize—the four principal types of forces (stress) that act upon a bridge: compression, tension, torsion, and shearing force. And while learning to support large loads of vehicles, trains, and pedestrians, we have developed the knowledge to construct bridges of majesty and great beauty.

Bridges are markers of civilization's development. Rather than presiding over their collapse, we should be figuring out how to advance this tradition.

Why the Key Bridge Disintegrated

The National Transportation Safety Board's investigation into the failure of the electrical system and circuit breakers onboard the *Dali* may point up some information on the proximate cause of the failure of the *Dali*'s power system and engines. That will add localized knowledge and should be strongly pursued; state and city police investigations are also underway.

But within the limited scope of the NTSB investigation, the real generative cause of the Key Bridge catastrophe will never be found, nor identified, and therefore not corrected. Think more broadly. The reason an onboard electrical system failure should have produced a collapsed bridge, the loss of six lives, and the further knock-down of the Baltimore economy will be found in the larger picture: Every rational concept of infrastructure policy—safety, protective structures, abundant investment, and regulation—was violated, producing the fatal March 26 events.

That is the method of thinking that a population must employ if it is seeking to end catastrophes not only in bridge failures, but in every type of infrastructure (and occurring every week!).

An economic-financial system, superintended by the City of London and Wall Street, that gouges ever greater loot from an underlying physical economy, infrastructure, and human life, and which produces the policy that causes the infrastructure breakdown, bears responsibility. This system is collapsing under its own weight. Cancel this system, move toward a new physical-economic, financial, and security architecture. This will end the cycle that resulted in the bridge calamity.