

# UT AUSTIN RESEARCHERS SPOOFS \$US80,000,000 SUPERYACHT INTO COURSE CHANGE AT SEA

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**This northern summer, assistant professor Todd Humphreys, in the Department of Aerospace Engineering and Engineering Mechanics, and his research team, graduate students Jahshan Bhatti and Ken Pesyna, spent time aboard the *White Rose of Drachs*, successfully performing GPS spoofing attacks on the 213-foot super yacht while it travelled on the Mediterranean Sea.**

A radio navigation research team from The University of Texas at Austin set out to discover whether they could subtly coerce a 213-foot (65 metre) yacht off its course, using a custom-made GPS device.

Led by assistant professor Todd Humphreys of the Department of Aerospace Engineering and Engineering Mechanics at the Cockrell School of Engineering, the team was able to successfully spoof an \$80 million private yacht using the world's first openly acknowledged GPS spoofing device. Spoofing is a technique that creates false civil GPS signals to gain control of a vessel's GPS receivers. The purpose of the experiment was to measure the difficulty of carrying out a spoofing attack at sea and to determine how easily sensors in the ship's command room could identify the threat.

The researchers hope their demonstration will shed light on the perils of navigation attacks, serving as evidence that spoofing is a serious threat to marine vessels and other forms of transportation. In 2012 Humphreys and a group of students led the first public capture of a GPS-guided unmanned aerial vehicle (UAV), or drone, using a GPS device created by Humphreys and his students.

"With 90 percent of the world's freight moving across the seas and a great deal of the world's human transportation going across the skies, we have to gain a better understanding of the broader implications of GPS spoofing," Humphreys said. "I didn't know until we performed this experiment, just how possible it is to spoof a marine vessel and how difficult it is to detect this attack."

In June, the team was invited aboard the yacht, called the *White Rose of Drachs*, while it traveled from Monaco to Rhodes, Greece, on the Mediterranean Sea. The experiment took place about 30 miles off the

## Cockrell School Researchers Demonstrate First Successful "Spoofing" of UAVs

**In 2012, Todd Humphreys and his research team received national and international attention for successfully demonstrated for the first time that the GPS signals of an unmanned aerial vehicle (UAV), or drone, can be commandeered by an outside source — a discovery that could factor heavily into the implementation of a new federal mandate to allow thousands of civilian drones into the U.S. airspace by 2015. The experiment was performed on a civilian drone owned by the university.**

coast of Italy as the yacht sailed in international waters.

From the *White Rose's* upper deck, graduate students Jahshan Bhatti and Ken Pesyna broadcasted a faint ensemble of civil GPS signals from their spoofing device — a blue box about the size of a briefcase — toward the ship's two GPS antennas. The team's counterfeit signals slowly overpowered the authentic GPS signals until they ultimately obtained control of the ship's navigation system.



***White Rose of Drachs***

Unlike GPS signal blocking or jamming, spoofing triggers no alarms on the ship's navigation equipment. To the ship's GPS devices, the team's false signals were indistinguishable from authentic signals, allowing the spoofing attack to happen covertly.

Once control of the ship's navigation system was gained, the team's strategy was to coerce the ship

onto a new course using subtle manoeuvres that positioned the yacht a few degrees off its original course. Once a location discrepancy was reported by the ship's navigation system, the crew initiated a course correction. In reality, each course correction was setting the ship slightly off its course line. Inside the yacht's command room, an electronic chart showed its progress along a fixed line, but in its wake there was a pronounced curve showing that the ship had turned.

"The ship actually turned and we could all feel it, but the chart display and the crew saw only a straight line," Humphreys said.

After several such manoeuvres, the yacht had been tricked onto a parallel track hundreds of meters from its intended one — the team had **successfully** spoofed the ship.

The experiment helps illustrate the wide gap between the capabilities of spoofing devices and what the transportation industry's technology can detect, Humphreys said.

Chandra Bhat, director of the Center for Transportation Research at UT Austin, believes that the experiment highlights the vulnerability of the transportation sector to such attacks.

"The surprising ease with which Todd and his team were able to control a (multimillion) dollar yacht is evidence that we must invest much more in securing our transportation systems against potential spoofing," Bhat said.

It's important for the public and policymakers to understand that spoofing poses a threat that has far-reaching implications for transportation, Humphreys said.

"This experiment is applicable to other semi-autonomous vehicles, such as aircraft, which are now operated, in part, by autopilot systems," Humphreys said. "We've got to put on our thinking caps and see what we can do to solve this threat quickly."

As part of an ongoing research project, funding and travel expenses for this experiment were supported by UT Austin's Wireless Networking and Communications Group through the WNCG's Industrial Affiliates program.



The University of Texas team, from left to right Ken Pesyna, Jahshan Bhatti and Professor Todd Humphreys beside yacht *White Rose of Drachs* in Port de Cap d'Ail.



The bridge of the *White Rose of Drachs*.



**WHERE AND WHAT IS ACTUALLY THE BIGGEST SHIP?  
DO THE SPIN-DOCTORS MAKE THE RULES?  
SO WHAT DO WE THINK?**

US Defence is touting the new USS *Gerald Ford* (first of the 10 FORD-class aircraft carriers) will be the largest, most lethal ship ever built when it joins the US fleet in 2016.

<http://blogs.defensenews.com/intercepts/2013/11/go-aboard-uss-gerald-r-ford-cvn-78-the-newest-aircraft-carrier/>

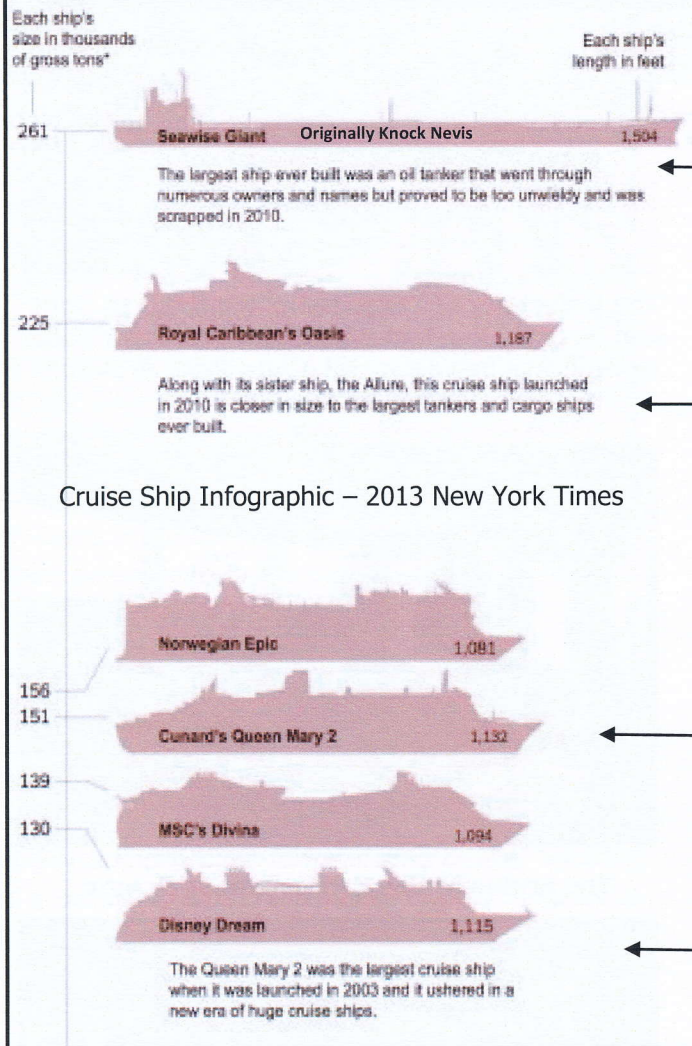
Maersk Line also touts their new-build *Triple E* class of 20 container ships as worlds largest vessels, [http://en.wikipedia.org/wiki/Maersk\\_Triple\\_E\\_class](http://en.wikipedia.org/wiki/Maersk_Triple_E_class)

**USS *Gerald E Ford***  
**Dimensions (rounded)**  
**Length: 1106' (337m)**  
**Beam: 256' (78m) over flight deck sponsons**  
**Depth: 250' (76m)**  
**DWT: 112,000US (101,605 tonnes)**  
**Cost: 14 Billion**

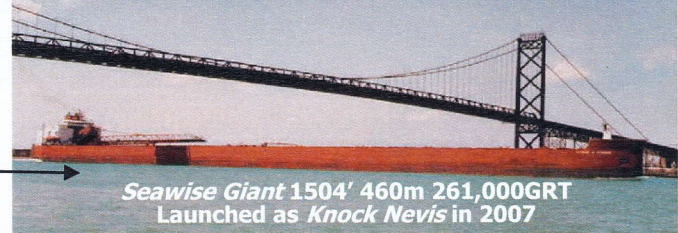
**Maersk *Triple E* box-ships**  
**Dimensions (rounded)**  
**Length: 1312' (400m)**  
**Beam: 196' (59m)**  
**Depth: 240' (73m)**  
**DWT: 184,800US (165,000tonnes)**  
**Cost: 2 Billion**

# ARE CRUISE SHIPS BECOMING TOO BIG?

JAD MOUAWAD, NEW YORK TIMES



Cruise Ship Infographic – 2013 New York Times



## Giants of the Sea

One of the largest cruise ships in 1985 was the 46,000-ton *Carnival Holiday*. Ten years ago, the biggest, the *Queen Mary 2*, was three times as large. Today's record holders are two 225,000-ton ships whose displacement at 110,000 tonnes, a measure of a ship's weight, is about the same as that of a US Nimitz class aircraft-carrier 100,000 tonnes.



Cruise ships keep growing bigger, and more popular. The Cruise Lines International Association said that last year its North American cruise line members carried about 17 million passengers, up from seven million in 2000. But the expansion in ship size is worrying safety experts, lawmakers and regulators,

who are pushing for more accountability, saying the supersize craze is fraught with potential peril for passengers and crew.

"Cruise ships operate in a void from the standpoint of oversight and enforcement," said James E. Hall, a safety management consultant and the chairman of the (US) National Transportation Safety Board between 1994 and 2001. "The industry has been very fortunate until now."

The perils were most visible last year when the *Costa Concordia*, owned by the Carnival Corporation, which is based in Miami, capsized off the coast of Italy. The accident killed 32 people and revealed fatal lapses in safety and emergency procedures.

In February, a fire crippled the *Carnival Triumph*, stranding thousands without power for four days in the Gulf of Mexico until the ship was towed to shore. Another blaze forced Royal Caribbean's *Grandeur of the Seas* to a port in the Bahamas in May. Pictures showed the ship's stern blackened by flames and smoke.

Although most have not resulted in any casualties, the string of accidents and fires has heightened concerns about the ability of megaships to handle emergencies or large-scale evacuations at sea. Senator John D. Rockefeller IV, Democrat of West Virginia, introduced legislation this northern summer (2013) that would strengthen federal oversight of cruise lines' safety procedures and consumer protections.

Cruise operators point out that bigger ships have more fire safety equipment, and contend they are safer. After a fire aboard the *Carnival Splendor* three years ago, Carnival adopted new training procedures and added safety features that it says helped with the rapid detection and suppression of the fire on the *Carnival Triumph*.

After the *Carnival Triumph* fire, Carnival also announced it would spend US\$700 million to improve its safety operations, including US\$300 million on its fleet of 24 Carnival Cruise Lines ships. Carnival is the largest cruise operator, owning about half of all cruise ships worldwide.

"We have over time improved the safety of our vessels by better training and better technology and learning from incidents that have happened over the years," said Mark Jackson, Carnival's vice president for technical operations, who joined the company in January, 2013 after 24 years with the Coast Guard.



Some experts doubt that ships can grow much larger than the current behemoths, marvels of naval engineering that combine the latest technology and entertainment. Today's biggest ship, Royal Caribbean's *Allure of the Seas*, has 2,706 rooms, 16 decks, 22 restaurants, 20 bars and 10 hot tubs, as well as a shopping mall, a casino, a water park, a half-mile track, a zip line, mini golf and Broadway-style live shows. It can accommodate nearly 6,300 passengers and 2,394 crew members — the equivalent of a small town towering over the clear blue waters of the Caribbean Sea. It measures 1,188 feet long. Its sister ship, the *Oasis of the Seas*, is two inches shorter.

Experts point out that larger ships have larger challenges. For instance, they have fewer options in an emergency, said Michael Bruno, dean of the engineering school at the Stevens Institute of

Technology in Hoboken, N.J., and former chairman of the National Research Council's Marine Board.

"Given the size of today's ships, any problem immediately becomes a very big problem," he said. "I sometimes worry about the options that are available."

A recent report by the Coast Guard on the *Splendor* fire revealed glaring problems with the crew's fire-fighting abilities as well as failures in fire safety equipment.

The investigation did not address the size of the ship, which carried 3,299 passengers. But it showed that big vessels can quickly become crippled by small fires that disable complex systems. No passengers were hurt, but the damage to the engine room was severe, disabling the ship's power and forcing it to be towed to port in San Diego.

The investigation found a wide range of problems with the engine's maintenance history as well as missing fire safety records. No fire drills had been conducted in the engine room for six months. Emergency sprinklers were turned off by mistake and then doused the wrong parts of the engine room. Believing the fire had been contained, the captain vented the engine room to clear out the smoke. He reignited the fire instead.

These incidents have brought new attention to the behavior of cruise operators. Rear Admiral Joseph Servidio, the Coast Guard's assistant commandant for prevention policy, said at a Senate hearing in July 2013 that the three fires, including the one aboard the *Splendor*, "highlight serious questions about the design, maintenance and operation of fire safety equipment on board these vessels, as well as their companies' safety management cultures."

In July last year the Coast Guard said cruise ships would need to conduct periodic engine-room fire drills.

The risks of building bigger ships became apparent over a decade ago, as cruise companies pushed the limits of naval architecture. The head of the International Maritime Organization (IMO), the United Nations agency in charge of marine regulations, warned in 2000 of the growing hazards of building larger ships and called for a comprehensive review of safety rules, known as Safety of Life at Sea, or (SOLAS). William O'Neil, the group's secretary general at the time, said the industry could not "rely on luck holding indefinitely."

One result was a set of new global regulations in 2010 called the Safe Return to Port rules. Those require

new ships to have sufficient redundant systems, including power and steering, to allow them to return to port even in the worst emergency. Only about 10 ships built since then comply with this new rule.

"The idea is that a ship is its own best lifeboat," said John Hicks, the vice president for global passenger ships at Lloyds Register, the largest ship classification society. "The idea is to do everything to keep the crew and passengers on a vessel."



**Costa Concordia. Was she the first harbinger of the writing on the wall?**

Bud Darr, the senior vice president for technical and regulatory affairs at the Cruise Lines International Association, the industry's trade group, said today's ships operated under layers of oversight.

The Coast Guard inspects each ship that calls at United States ports at least once a year and enforces national and international norms. Private auditors, hired by cruise operators, perform frequent safety reviews, including comprehensive annual checks that last seven to 10 days, he said, and flag countries like the Bahamas or Panama, where most cruise ships are registered, provide their own oversight.

"We are subject to very close scrutiny," Mr. Darr said. "The standards are universal."

But incidents like the *Costa Concordia* grounding

have raised questions about whether evacuation regulations are still applicable in the age of megaships. Under the Solas regulations, for instance, passengers grouped at their muster stations must be able to evacuate on lifeboats within 30 minutes of an evacuation alarm.

The investigation into the *Costa Concordia* revealed that the crew and its captain failed to sound the general evacuation alarm for more than an hour after rocks had breached the hull. As a result, some lifeboats could not be lowered once the ship started to list.

After the accident, cruise operators said they would change muster drill procedures. Instead of holding a drill for passengers within 24 hours of departure, cruise ships said they would do so before ships leave a port.

While ships are becoming bigger, the burden on crew members is growing. The *Queen Elizabeth 2*, which was launched in 1969, had one crew member for about 1.8 passengers. On the *Triumph*, the ratio was one crew member for every 2.8 passengers. The issue is also complicated by language and communication problems, and a high crew turnover rate that can reach 35 per cent a year.

The International Transport Workers' Federation, which represents seafarers and crew members, has expressed concerns about the evacuation time and suggested the need to limit the number of people aboard ships, depending on where they operate and what search-and-rescue facilities are available.

"Experience has cast doubt on the adequacy of existing lifesaving appliances," the group said in a report. "The current equipment, especially lifeboats and life rafts, has proved to be inadequate when confronted with high sea states."

Safety rules also state that lifeboats should not carry more than 150 people. But the two largest ships, the *Allure of the Seas* and the *Oasis of the Seas*, have much bigger lifeboats, for 370 people, because of a

