IT’S THE SPEED OF TRUST

What do we know, what don’t we know, and what will it take to trust autonomous vessels?
MIDDLE WAY?

IGNORE?

A MIDDLE WAY?

ALL IN?

DIGITAL TRANSFORMATION

The U.S. Navy seems to be choosing “Invest.”

DEFENSE NEWS
“With billions planned in funding, the US Navy charts its unmanned future.”
May 6, 2019

UNMANNED SYSTEMS
“Budget Confirms Navy UxV Boost”
July-August 2019

USNI News
“Navy to Contract New Class of Unmanned Surface Vehicles by Year’s End”
March 6, 2019

VADM MERZ (N9)
“With respect to the technology, we [the Navy] are ‘all in.’”
May 15, 2019
But, it’s also true that we’ve seen this before.

Will this time be different?

https://www.technologystories.org/ai-evolution/
So, what drives the boom/bust cycle?

**ALL IN: Inappropriate “Positive Trust”**
- Assuming that “the government wouldn’t let them sell it if it wasn’t safe.”
- Assuming that because a system is good at one thing, it is good at something else.

**IGNORE: Inappropriate “Negative Trust”**
- “Machines can’t do that.”
- “Regulators will never allow that.”
- “Never again.”
So, How Do we REPLACE INAPPROPRIATE Trust WITH APPROPRIATE TRUST?

It’s the speed of trust.
What do we know? What don’t we know? And, what will it take to trust autonomous vessels?

THE INSIDE VIEW
How do autonomous vessels trust themselves?

THE OUTSIDE VIEW
How do autonomous vessels trust other vessels?

THE HUMAN VIEW
How do we learn to trust autonomous vessels?
Before we go any further...

...let’s set some expectations.

- Who is Gibbs & Cox?
- Why can’t I sell you (or even talk about) specific autonomous vessel solutions today?
- When I say *What do we know?*, who do I mean by “we?”

Gibbs & Cox is the largest independent and privately-owned Naval Architecture and Marine Engineering Firm in the United States, and has been serving government, commercial, and recreational markets worldwide since 1929.
Let’s Level-Set

Incorporating Automation & Autonomy into the Architecture

Architecture

Operator Layer

Network Layer

Device Controller Layer

Device Layer

PLC

PLC

PLC

PLC

Propulsion

Steering

Energy Storage

Etc.
Let’s Level-Set
Incorporating Automation & Autonomy into the Architecture

Architecture

Operator Layer

Network Layer

Device Controller Layer

Device Layer

Propulsion  Steering  Energy Storage  Etc.

Crudely speaking...

...we add sensors, remote actuators, etc. here to get “automation”

...we add AI here to get “autonomy”
## Let’s Level-Set
Incorporating Automation & Autonomy into the Architecture

<table>
<thead>
<tr>
<th>Architecture</th>
<th>Automation</th>
<th>Decision Support</th>
<th>Autonomy</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Operator Layer</strong></td>
<td>Auto-Tuning</td>
<td>Voyage Management System (VMS)</td>
<td>Platform Autonomy</td>
</tr>
<tr>
<td><strong>Network Layer</strong></td>
<td>Power, fuel, etc. management</td>
<td>Diagnostics &amp; Maintenance Systems</td>
<td>HM&amp;E Autonomy</td>
</tr>
<tr>
<td><strong>Device Controller Layer</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Device Layer</strong></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

- **Reduce operator workload**
- **Improve operator performance**
- **Replace operators**
Inside View: How do autonomous vessels trust themselves?

Dealing with trust issues at the Platform Level

**RELIABILITY PART 1**

Sometimes it’s cheaper to over-engineer than to automate.

**REALIABILITY PART 2**

- Condition Based Maintenance (CBM) and other applications of Machine Learning (ML)
- Watchdog Systems (D.D.S.O.P.)

**GIGO (Data Quality)**

Deciding “what is” is a more challenging problem than deciding “what to do” about it.
Inside View: How do autonomous vessels trust themselves?
Dealing with trust issues at the Platform Level

**CYBERSECURITY (c.f. IMO MSC-FAL.1/C)**

<table>
<thead>
<tr>
<th>No Electronics</th>
<th>No threat</th>
</tr>
</thead>
<tbody>
<tr>
<td>SOME Electronics</td>
<td>Threat to disable navigation aids</td>
</tr>
<tr>
<td>HIGHLY AUTOMATED</td>
<td>Threat to disable you.</td>
</tr>
<tr>
<td>AUTONOMOUS</td>
<td>Threat to commandeer you.</td>
</tr>
</tbody>
</table>
### The Outside View: How autonomous vessels “trust” other vessels

#### Sharing the Water: Good Actors

- **Not surprisingly**, rules-based systems are actually very good when everyone is following the rules.

#### Sharing the Water: Bad Actors

- **Best Case**: They just don’t follow the rules.
- **Worst Case**: They exploit behaviors to “herd” an autonomous vessel.
- Implies the need for connectivity / infrastructure to escalate to remote control stations.
- Implies the need for high-level autonomy when connectivity isn’t possible / jammed.
  - ...to re-prioritize “the mission”
  - ...to break the rules to save the rules (COLREGS Rule 2)

#### Sharing the Water: Interoperability Problems

- Autonomous vessels come with the promise of truly optimized traffic flow... if they can all work together.
- **Standards** can help, but are not a perfect solution.
- **Fortunately**, autonomous vessels could bring some new tools to the game (c.f. Noblis “Pieces of Eight (Po8) Orchestrated Autonomy Concept”)

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The Human View: How do *we* learn to trust autonomous vessels?

<table>
<thead>
<tr>
<th>Machines Do Some Things</th>
<th>Machines Do MOST Things</th>
<th>OPERATORS &amp; Machines Do Things TOGETHER</th>
<th>OPERATORS GIVE ORDERS, UNMANNED VESSELS DO THE WORK</th>
</tr>
</thead>
<tbody>
<tr>
<td>Where we’ve been.</td>
<td>Where we were yesterday: HM&amp; Automation, Auto-Pilot / VMS, etc.</td>
<td>Where we are today (whether in the name of safety or efficiency / convenience): Predictive Maintenance, Weather Re-Routing, auto-docking, etc.</td>
<td>...a destination that we will arrive at at the speed of trust.</td>
</tr>
</tbody>
</table>
DIGITAL TRANSFORMATION
BUILD TRUST WITH INCREMENTAL ADOPTION

CONSIDER THE VALUE OF AN INDEPENDENT SYSTEM INTEGRATOR

DEVELOP / TAILOR A FRAMEWORK THAT IS HOLISTIC & Lifts the CURTAIN ON THE