

SHIPBOARD COMPUTING SYSTEMS

UBC Marine Systems Workshop



a place of mind

THE UNIVERSITY OF BRITISH COLUMBIA

FACULTY

KONSTANTIN (KOSTA) BEZNOSOV

core expertise:

- systems security
- usable privacy and security
- human and social aspects of privacy and security

research focus:

- mobile security and privacy
- human aspects of cryptocurrency security
- human aspects of social media privacy and security
- identification and protection of vulnerable (device and account) populations from large-scale automated attacks



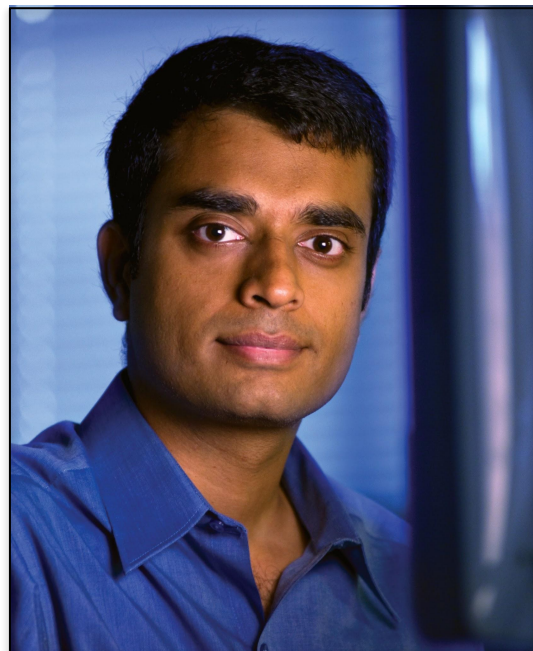
SATHISH GOPALAKRISHNAN

core expertise:

- real-time computing
- cyber-physical systems
- dependable systems

research focus:

- timing guarantees in embedded computing
- task scheduling
- mixed-criticality systems
- probabilistic analysis of systems



MIESZKO LIS

core expertise:

- computer architecture
- hardware design methodology
- domain-specific languages

research focus:

- algorithms and hardware for machine learning
- programmability of GPUs and other accelerators
- hardware and software ecosystem security
- computing for next-generation communications



RYOZO NAGAMUNE

core expertise:

- control engineering
- systems and control theory
- mechatronics

research focus:

- floating offshore wind farm control
- model-based controller design
- data-driven modeling and control
- robust and optimal control



KARTHIK PATTABIRAMAN

core expertise:

- dependable computer systems
- systems security
- software engineering

research focus:

- cyber-physical systems (CPS) security
- dependability of machine learning (ML)
- software error resilience techniques
- web applications' reliability engineering



JULIA RUBIN

core expertise:

- software engineering
- program analysis
- software security, privacy, and energy efficiency

research focus:

- mobile software
- cloud-based software: microservice-based applications
- compositional and collaborative software development: integration, change management, reuse



RESEARCH / EDUCATION OPPORTUNITIES

SECURITY CHALLENGES

- on-board systems increasingly technologically dependent
 - nav (GPS), ident (AIS), charts (ECDIS), ...
 - propulsion / thrust / ballast control, ...
 - on-board, ship-shore, inter-ship networks
 - exploits possible in all of these systems
- existing proofs-of-concept / related events
 - yacht hijacked via GPS hack [1]
 - AIS can be exploited to send false commands [2]
 - ships grounded due to ECDIS errors (photo →)
- security issues *much more complex* in ships



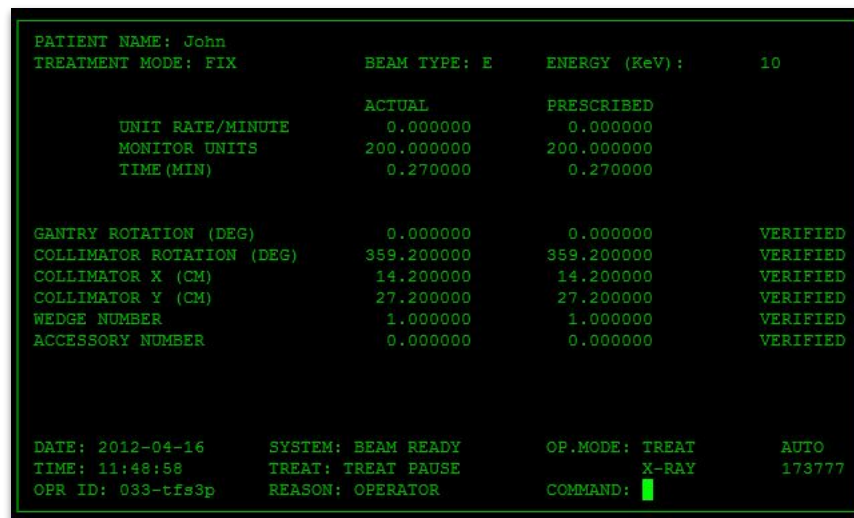
USS Guardian grounded on Tubbataha Reef due to incorrect ECDIS data, 2013

[1] Bhatti & Humphreys. Hostile control of ships via false GPS signals: Demonstration and detection. *NAVIGATION: Journal of the Institute of Navigation*, 64.1: 51-66, 2017.

[2] Balduzzi+. Hey Captain, Where's Your Ship? Attacking Vessel Tracking Systems for Fun and Profit. *Hack in the Box Security Conference in Asia*, 2013.

SAFETY & RELIABILITY

- multiple embedded and safety-critical systems on ships
 - e.g., machinery/reactor control systems, navigation, ...
- needs different software engineering practices
 - e.g., custom memory allocation
- needs predictable real-time operation
 - e.g., limited deadline misses
- needs predictable hardware
 - severely limits performance optimizations
- opportunities at all levels
 - safe software design methodologies
 - domain-specific safety-first languages
 - software-hardware codesign for safety
 - ...



The screenshot displays a text-based interface for the Therac-25 system. It shows patient information, treatment mode, beam parameters, and a status summary. The data is organized into several sections with labels and values.

PATIENT NAME: John	BEAM TYPE: E	ENERGY (KeV):	10
TREATMENT MODE: FIX			
	ACTUAL	PRESCRIBED	
UNIT RATE/MINUTE	0.000000	0.000000	
MONITOR UNITS	200.000000	200.000000	
TIME (MIN)	0.270000	0.270000	
GANTRY ROTATION (DEG)	0.000000	0.000000	VERIFIED
COLLIMATOR ROTATION (DEG)	359.200000	359.200000	VERIFIED
COLLIMATOR X (CM)	14.200000	14.200000	VERIFIED
COLLIMATOR Y (CM)	27.200000	27.200000	VERIFIED
WEDGE NUMBER	1.000000	1.000000	VERIFIED
ACCESSORY NUMBER	0.000000	0.000000	VERIFIED
DATE: 2012-04-16	SYSTEM: BEAM READY	OP.MODE: TREAT	AUTO
TIME: 11:48:58	TREAT: TREAT PAUSE	X-RAY	173777
OPR ID: 033-tfs3p	REASON: OPERATOR	COMMAND: █	

MACHINE LEARNING APPLICATIONS

- off-line ship models / digital twins
 - currently physical models do not include all sensor data
 - expensive to model all systems in detail
 - generate sensor data from realistic distributions to make model more realistic
- monitoring and failure / maintenance prediction
 - want planned / condition-based maintenance but monitoring equipment expensive
- assisted / semi-autonomous control
 - automate complex control systems to reduce crew count
- crew interaction systems
 - virtual assistant able to reason about ship / systems models

EDUCATION OPPORTUNITIES

- key need for security-aware and safety-trained system and software engineers
 - can find engineering talent, but not trained in security engineering, safety engineering, etc.
 - industry lacks training capacity
- UBC has significant expertise
 - security: human factors, software engineering, hardware aspects
 - safety: real-time systems, dependable systems, FPGA/architecture
- education opportunities
 - undergraduate / MEng electives
 - eventually: marine-themed set of computing electives
 - professional education