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Distributed situational awareness (DSA) in sociotechnical systems (STS)

Neville A. Stanton, PhD, DSc,
Professor Emeritus of HFE
Human Factors Engineering
Transportation Research Group
Faculty of Engineering and the Environment
University of Southampton
Southampton, UK

www.hfesoton.com

n.stanton@soton.ac.uk

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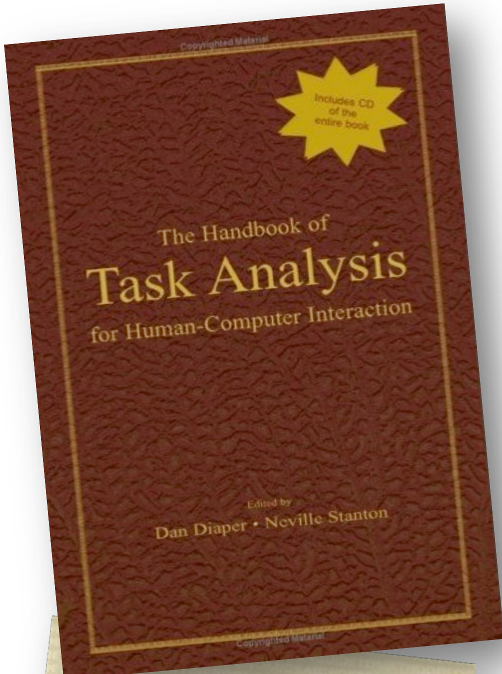
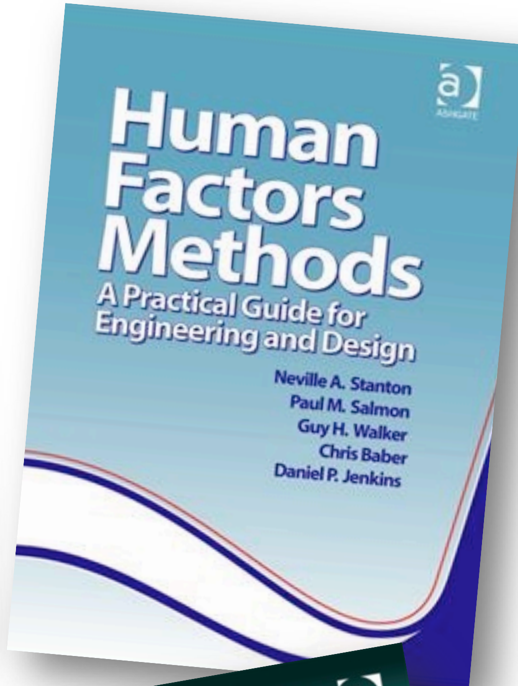
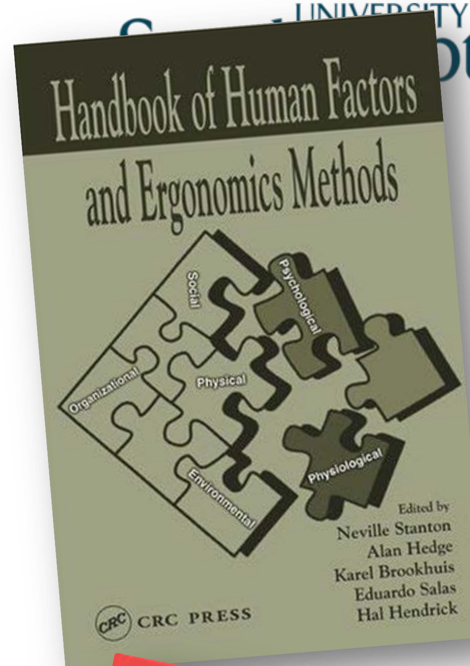
Overview

Sociotechnical Systems perspective
Distributed Situation Awareness
Event Analysis of Systemic Teamwork
Looking back and looking forward
Modelling STS using EAST
Looking back: broken nodes
Looking forward: broken links
Further developments?


Includes CD of the entire book
The Handbook of
Task Analysis
for Human-Computer Interaction
Edited by
Dan Diaper • Neville Stanton


ASHGATE
Human Factors Methods
A Practical Guide for Engineering and Design
Neville A. Stanton
Paul M. Salmon
Guy H. Walker
Chris Baber
Daniel P. Jenkins


Handbook of Human Factors
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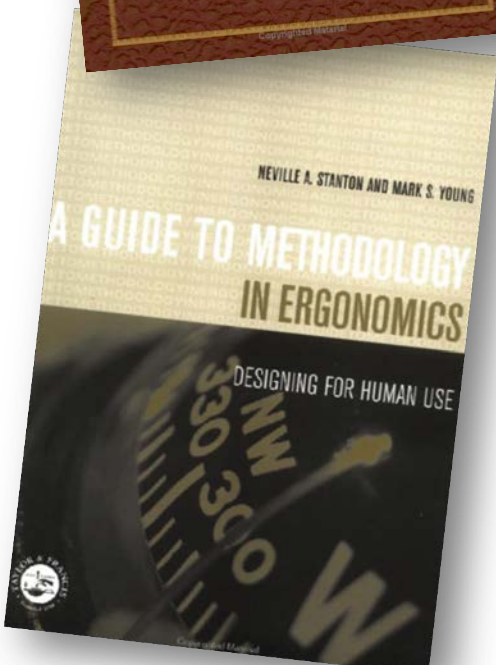
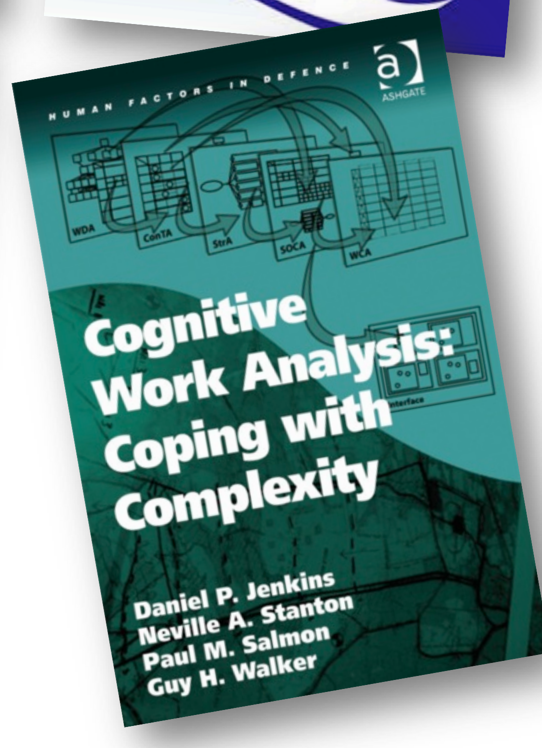

NEVILLE A. STANTON AND MARK S. YOUNG
A GUIDE TO METHODOLOGY
IN ERGONOMICS
DESIGNING FOR HUMAN USE


HUMAN FACTORS IN DEFENCE
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StrA
SOCA
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Cognitive Work Analysis: Coping with Complexity
Daniel P. Jenkins
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Paul M. Salmon
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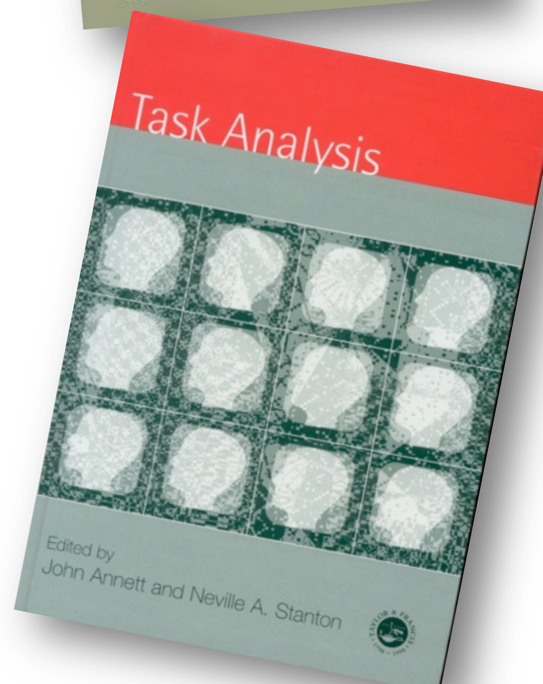
Task Analysis
Edited by
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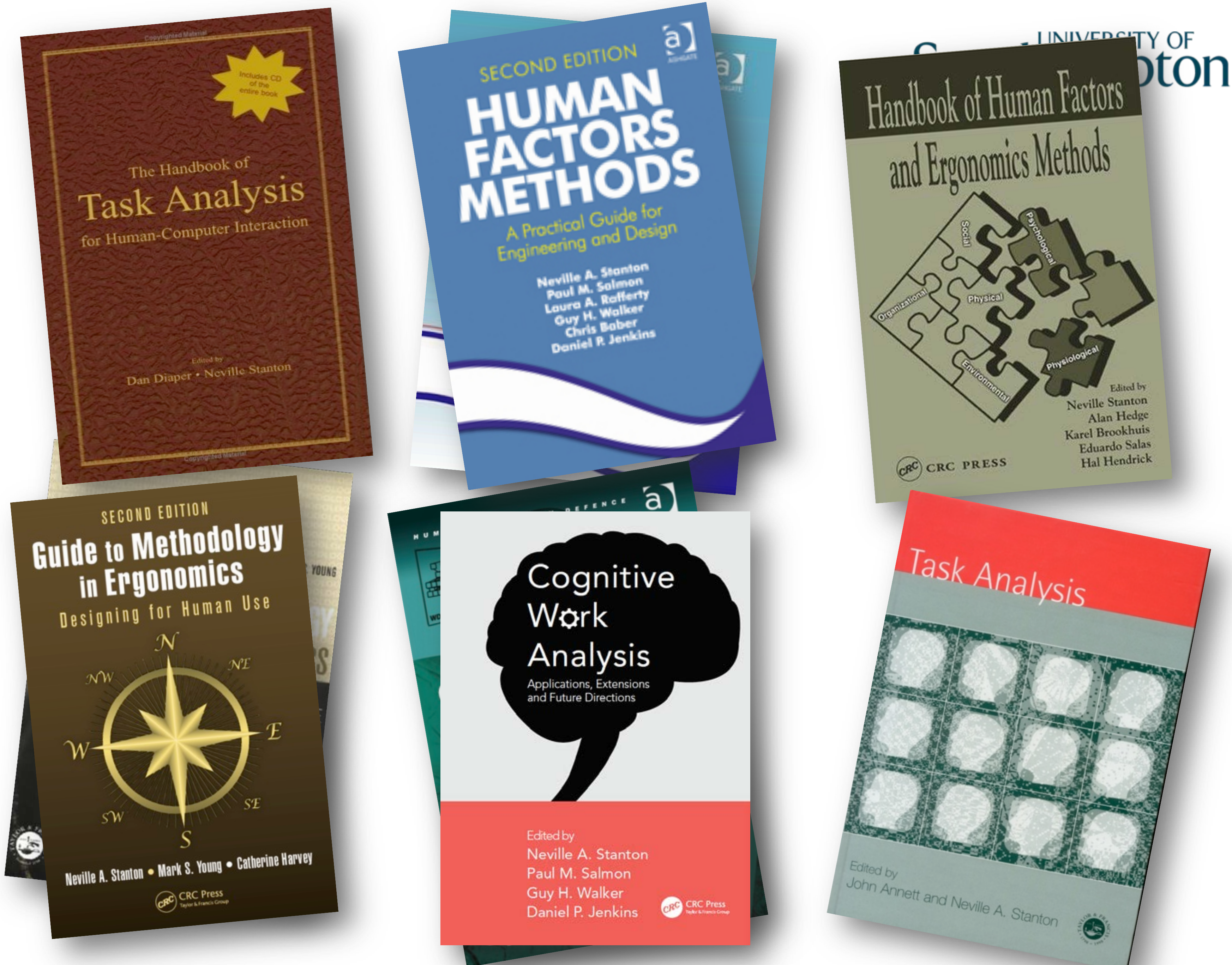
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Neville A. Stanton • Mark S. Young • Catherine Harvey
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Cognitive Work Analysis
Applications, Extensions and Future Directions
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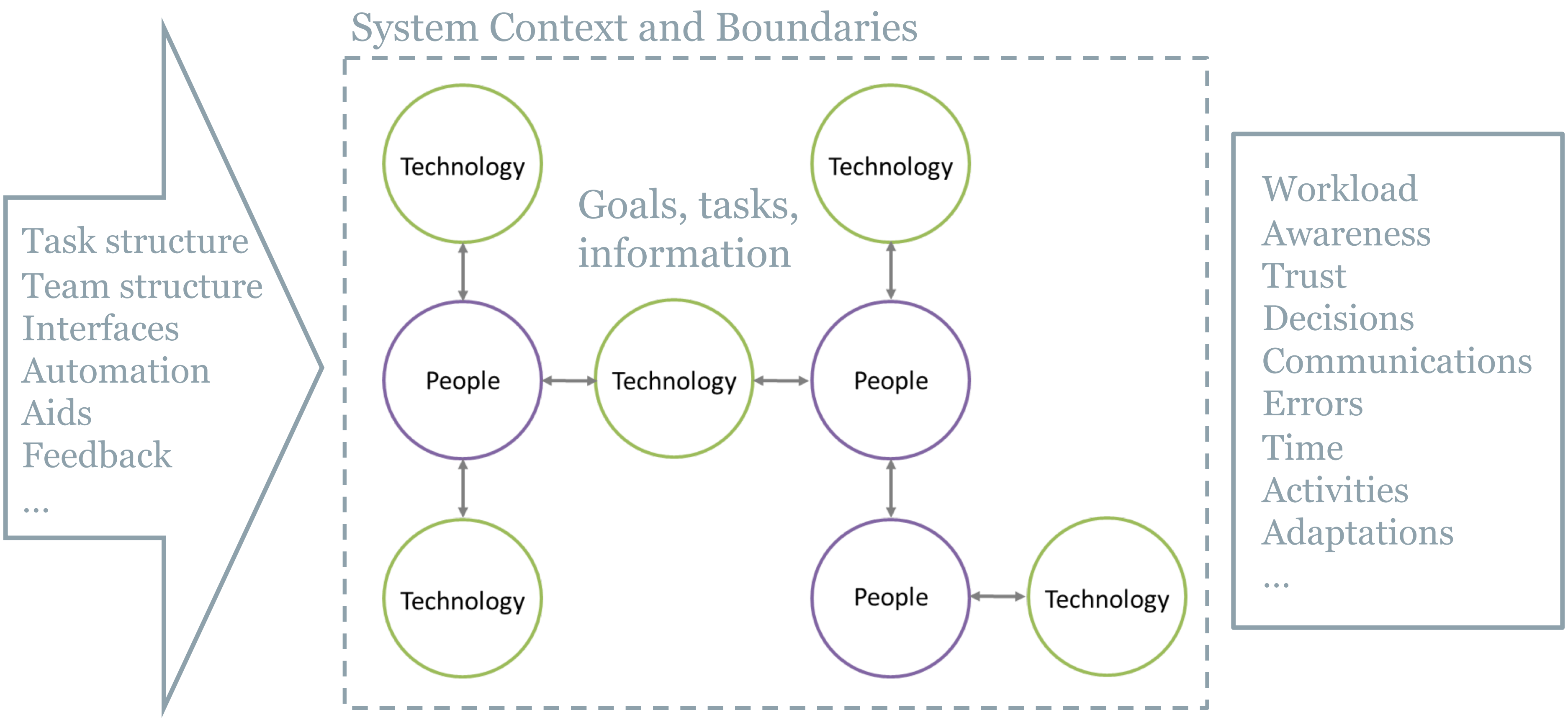
Sociotechnical systems



DSA tenets

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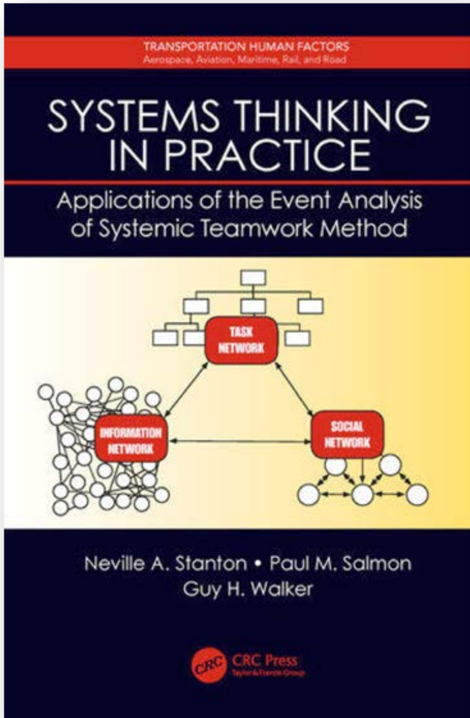
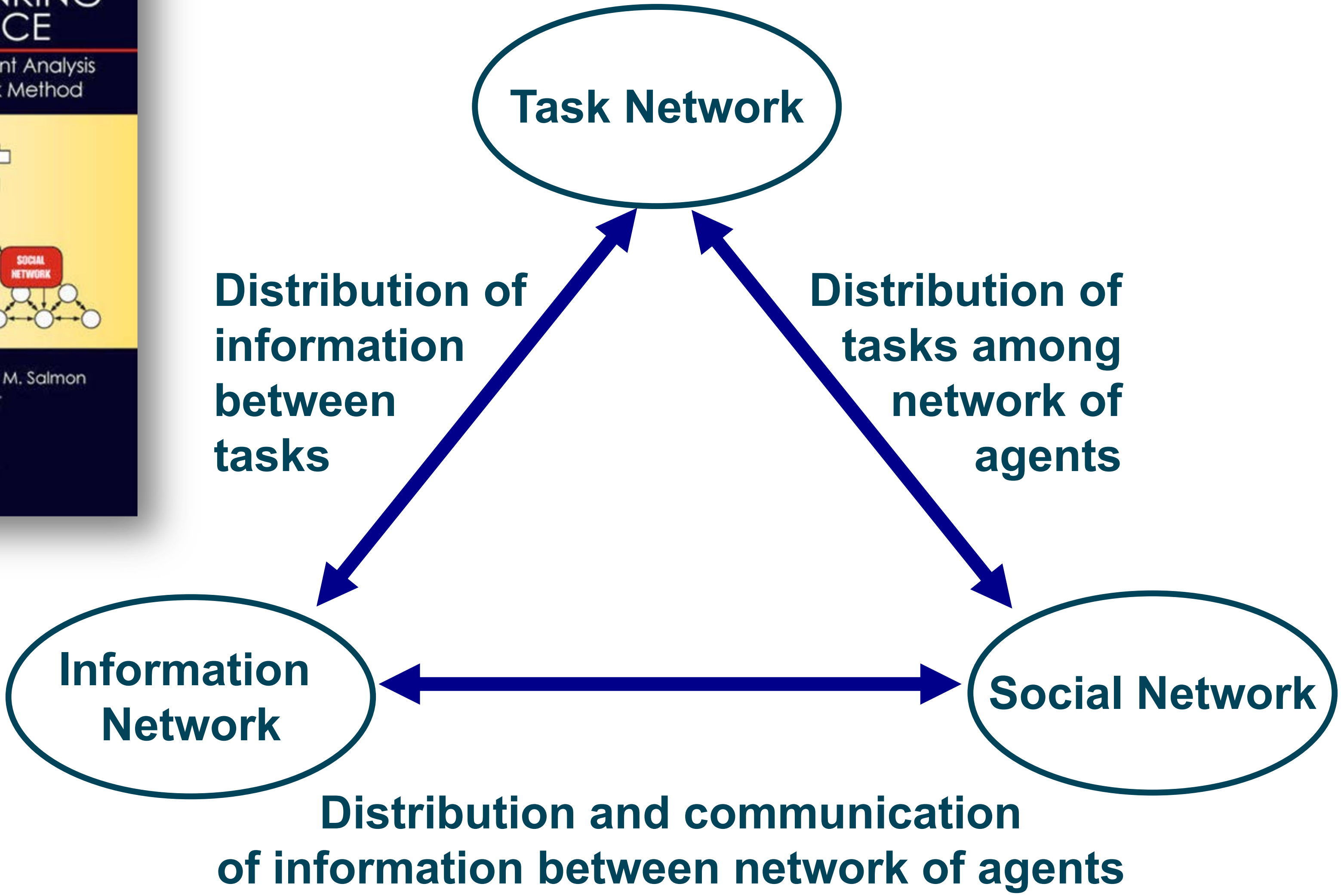
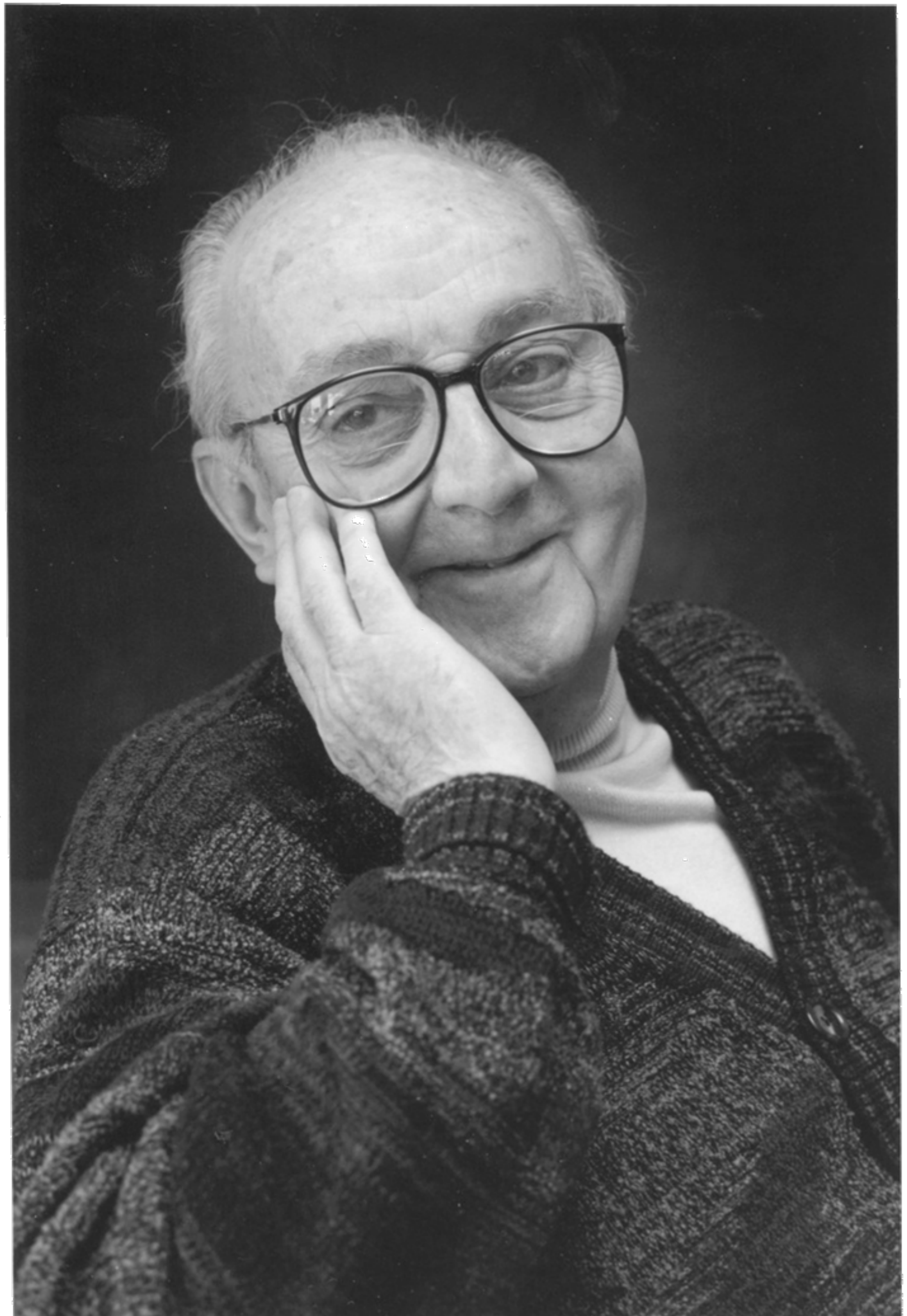
- Situation awareness (SA) is an emergent property of a sociotechnical system;
- Situation awareness is distributed across the human and non-human agents working within the system;
- Systems have a dynamic network of information upon which different agents have each their own unique view;
- Systemic SA is maintained via transactions in awareness between agents;
- Compatible SA is required for systems to function effectively:
- Genotype and phenotype schema play a key role in both transactions and compatibility of SA;
- Dynamical changes in system coupling may lead to associated changes in DSA; and
- One agent may compensate for degradation in SA in another agent.

Stanton, N. A., Salmon, P. M., Walker, G. H., Salas, E. and Hancock, P. A. (2017) State-of-science: Situation awareness in individuals, teams and systems. Ergonomics, 60 (4), 449-466.

Event Analysis of Systemic Teamwork (EAST)



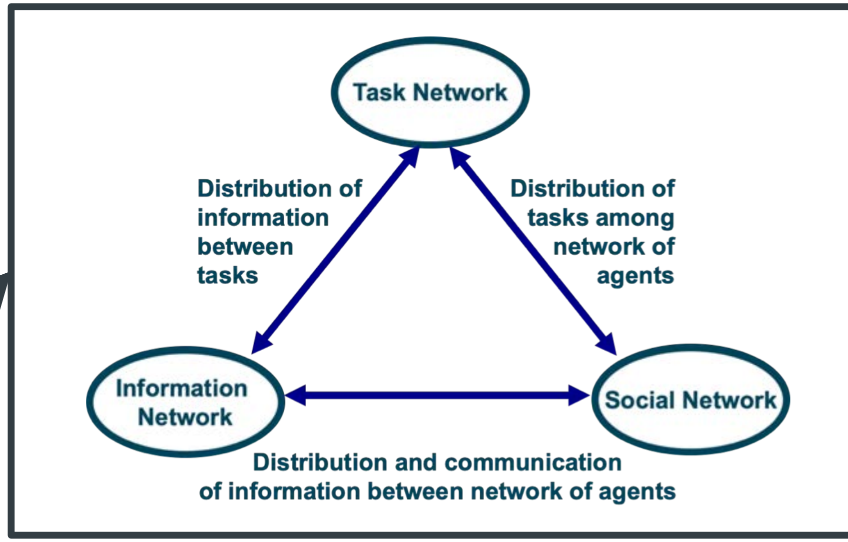




"all models are wrong, ***but some are useful****"*

George Edward Pelham Box FRS (18 October 1919 – 28 March 2013) British statistician, Professor Emeritus of Statistics, University of Wisconsin-Madison

EAST models



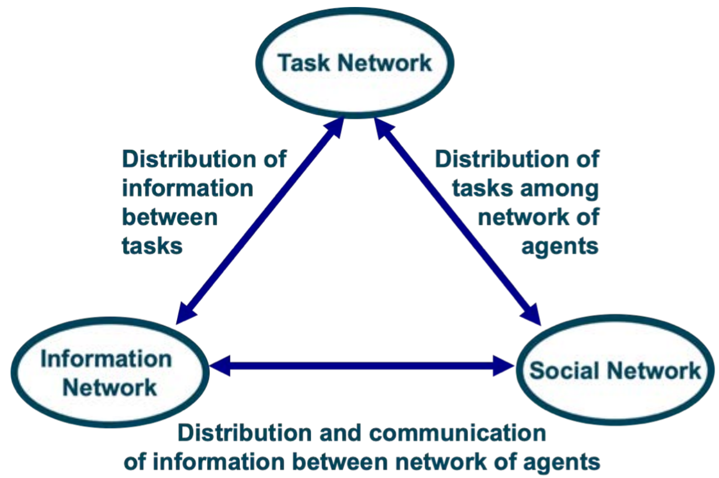
Looking back
Investigating accidents by identify which nodes were broken: Uber collision case study

EAST-BN

Looking forward
Predicting sociotechnical systems safety: Hawk-frigate case study

EAST-BL

EAST



Looking back
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EAST-BN

Looking forward
Predicting sociotechnical systems safety: Hawk-frigate case study

EAST-BL

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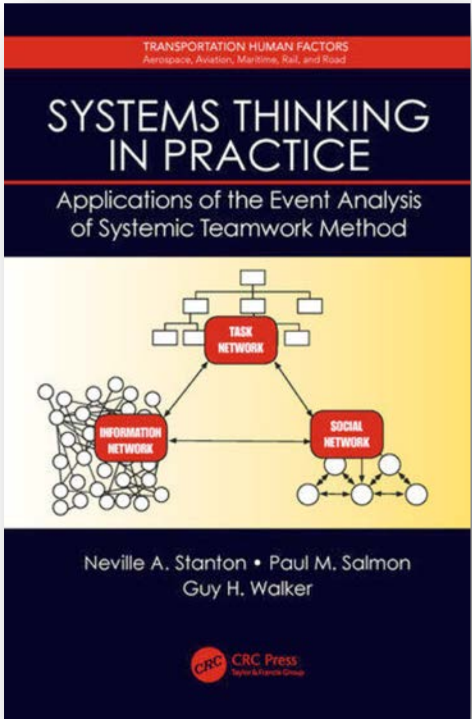
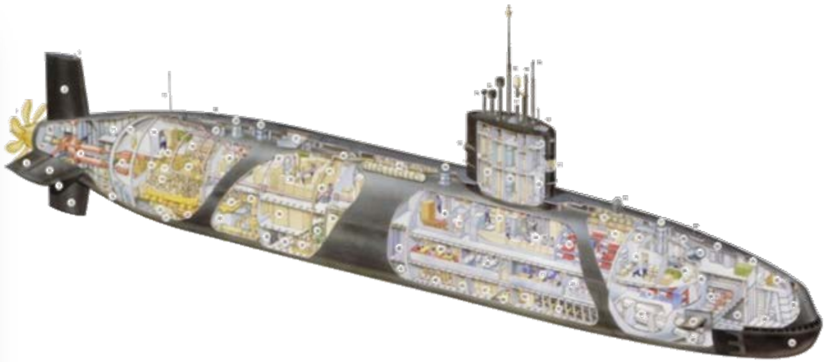
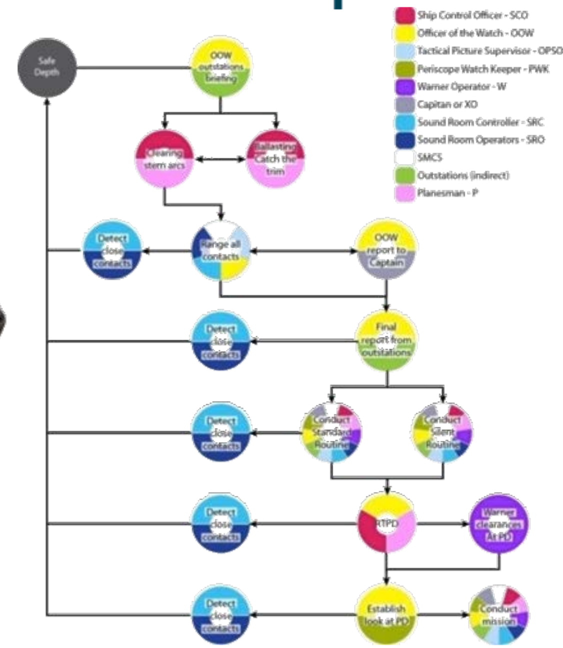


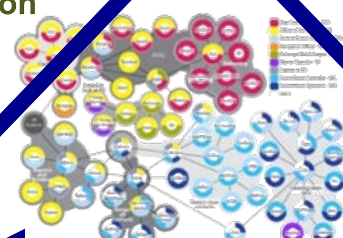




Task Network

Distribution of information between tasks

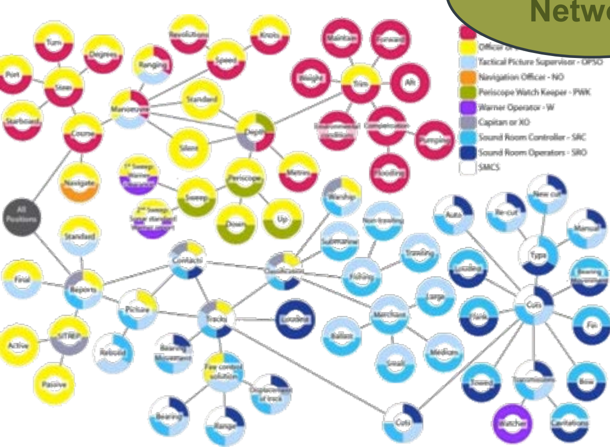
Distribution of tasks among network of agents

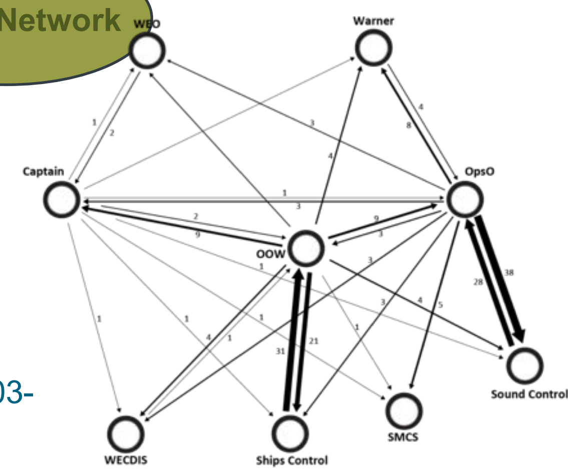


Information Network

Social Network

Distribution and communication of information between network of agents





Stanton, N. A. (2014) Representing Distributed Cognition in Complex Systems: How a submarine returns to periscope depth. Ergonomics, 57 (3), 403-418.

Sound Room Control Room

Stanton, N. A. and Roberts, A. P. J. (2018) Examining task, social and information networks in submarine command and control. IEEE Transactions on Human-Machine Systems, 48 (3), 252-265.

Transcription

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Mission Start: 11:35:18

Time (Rec)	Time (Mis)	To	From	Content
00:00:02	11:35:20	OpsO	SMCS_R	Cut received three nine eight
00:00:05	11:35:23	SC	OpsO	New track three nine eight
00:00:07	11:35:25	OpsO	SC	Roger, track nine eight is also marking faintly on fin
00:00:11	11:35:29	SC	OpsO	Roger, fin range of the day?
00:00:27	11:35:45	???	???	??? …XXX thousand yards
00:00:30	11:35:48	OpsO	SC	Ops, controller
00:00:31	11:35:49	SC	OpsO	Ops
00:00:32	11:35:50	OpsO	SC	New flank contact, green one zero seven, true bearing one zero seven, faint rising background noise, standby cut
00:00:37	11:35:55	SC	OpsO	Ready
00:00:42	11:36:00	SC	OpsO	Cut received, new track three nine nine
00:00:45	11:36:03	OpsO	SC	Roger, analysing now
00:00:53	11:36:11	SMCS_L	OpsO	Left hand side take nine nine, frigate off to the left… ??? …XXX yards… ??? ...it could be a ferry… ???
00:01:10	11:36:28	OpsO	SC	Ops, controller
00:01:13	11:36:31	SC	OpsO	Ops
00:01:14	11:36:32	OpsO	SC	Fin has a new contact in the stern on a bearing of one nine one, standby cut
00:01:18	11:36:36	SC	OpsO	Roger, ready for cut

Stanton, N. A. (2014) Representing Distributed Cognition in Complex Systems: How a submarine returns to periscope depth. Ergonomics, 57 (3), 403-418.

Social Network

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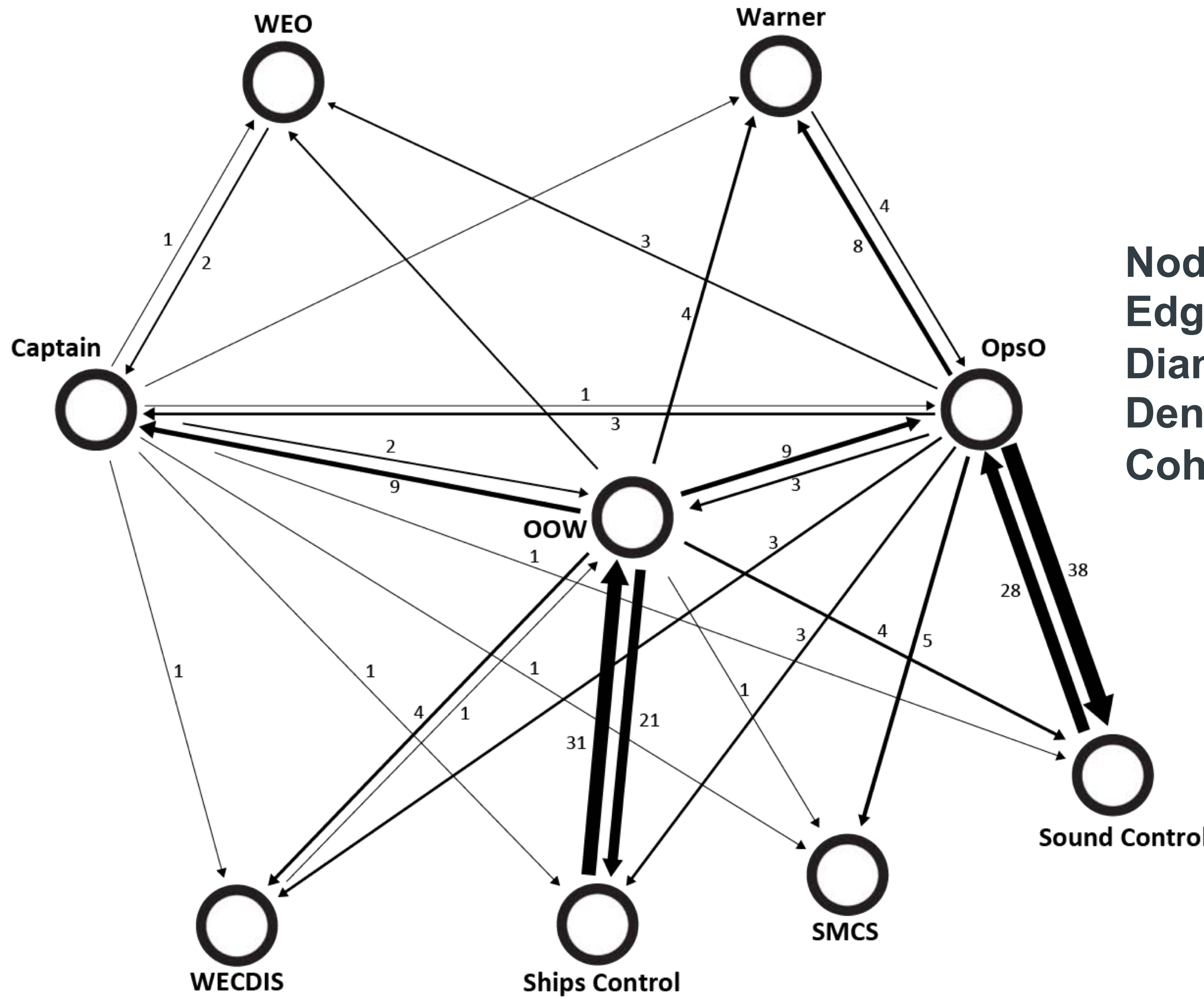


Nodes = 9
Edges = 29
Diameter = 2
Density = 0.4
Cohesion = 0.2

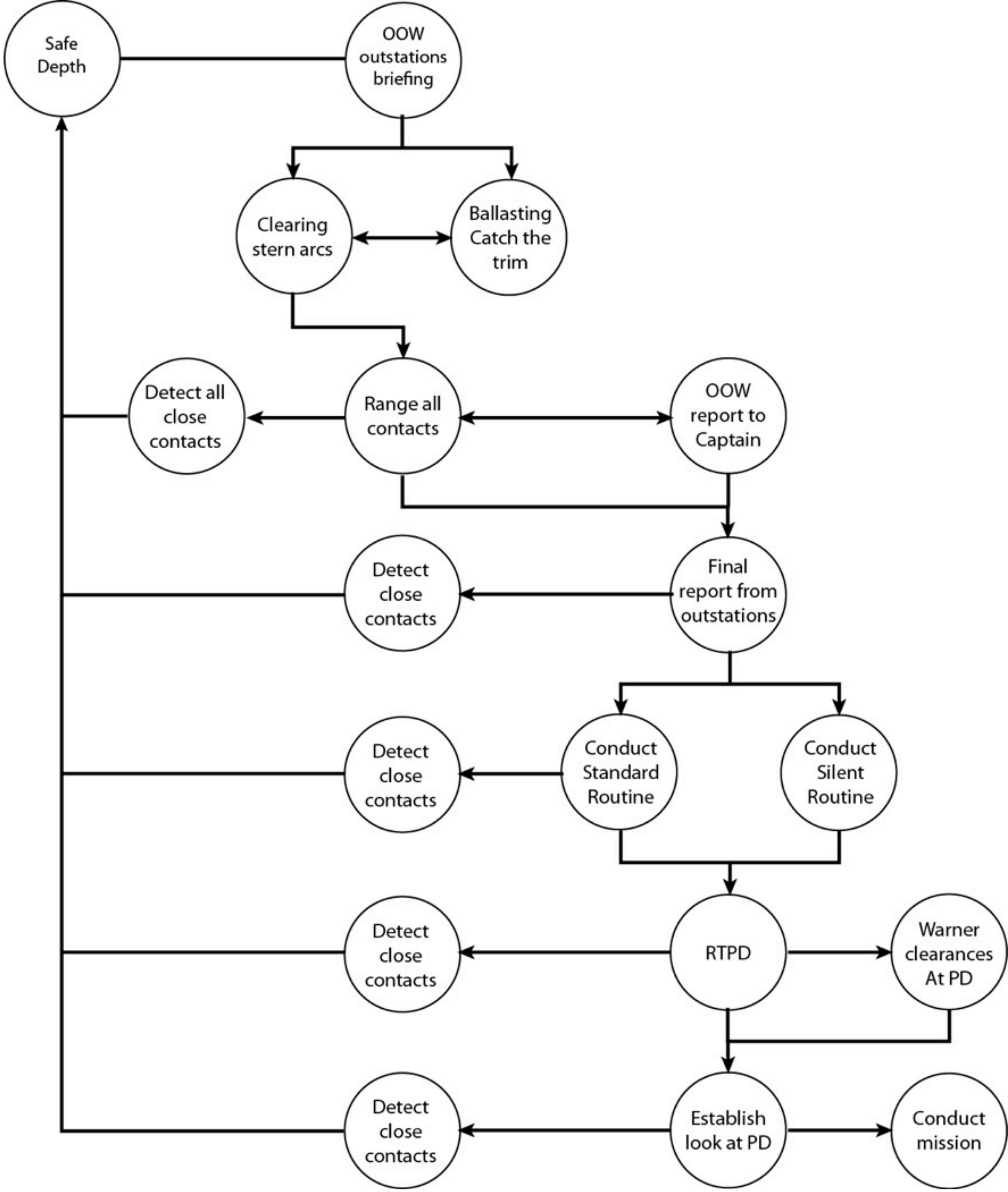
Stanton, N. A. (2014) Representing Distributed Cognition in Complex Systems: How a submarine returns to periscope depth. Ergonomics, 57 (3), 403-418.

Social Network Analysis	Captain	OOW	OpsO	Sound	SMCS	WEO	Ship Cont	Warner	WEC DIS
Reception	**14**	**37**	**37**	**43**	**10**	**9**	**25**	**13**	**8**
Emission	**10**	**54**	**66**	**28**	**0**	**2**	**31**	**4**	**1**
Eccentricity	1	1	1	2	0	2	2	2	2
Sociometric Status	3	11	12	9	1	1	7	2	1
Centrality (B-L)	5.2	5.5	5.5	3.8	7.6	3.8	3.8	3.8	3.8
Closeness	1	1	1	0.5	0	0.5	0.5	0.5	0.5
Farness	8	8	8	15	0	15	15	15	15
Betweeness	7	14	14	0	0	0	0	0	0

Stanton, N. A. (2014) Representing Distributed Cognition in Complex Systems: How a submarine returns to periscope depth. Ergonomics, 57 (3), 403-418.

Task Network

density = 0.14
cohesion = 0.02
diameter = 9



Stanton, N. A. (2014) Representing Distributed Cognition in Complex Systems: How a submarine returns to periscope depth. Ergonomics, 57 (3), 403-418.

Task Network Analysis	Safe depth	OOW outstations briefing	Clear stern arcs	Ballasting	Range all contacts	Detect close contacts	OOW report to Captain	Final report from outstations	Conduct standard routine	Conduct silent routine	Return to periscope depth	Warner clearances at periscope depth	Establish look at periscope depth	Conduct mission
Reception	**2**	**1**	**2**	**2**	**1**	**7**	**1**	**2**	**1**	**1**	**2**	**1**	**2**	**1**
Emission	**1**	**3**	**2**	**1**	**3**	**1**	**1**	**3**	**2**	**2**	**3**	**2**	**2**	**0**
Eccentricity	8	7	6	7	5	9	6	6	7	7	7	8	9	0
Sociometric Status	0.2	0.3	0.3	0.2	0.3	0.6	0.2	0.4	0.2	0.2	0.4	0.2	0.3	0.1
Centrality (B-L)	7.7	7.8	7.9	6.9	7.7	7.5	6.5	7.3	6.4	6.4	6.3	5.7	5.8	10.4
Closeness	0.2	0.3	0.3	0.2	0.4	0.2	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0
Farness	58	46	41	53	36	67	46	39	46	46	49	56	63	0
Betweeness	67	68	70	0	70	65	0	59	17	17	31	0	12	0

Information network

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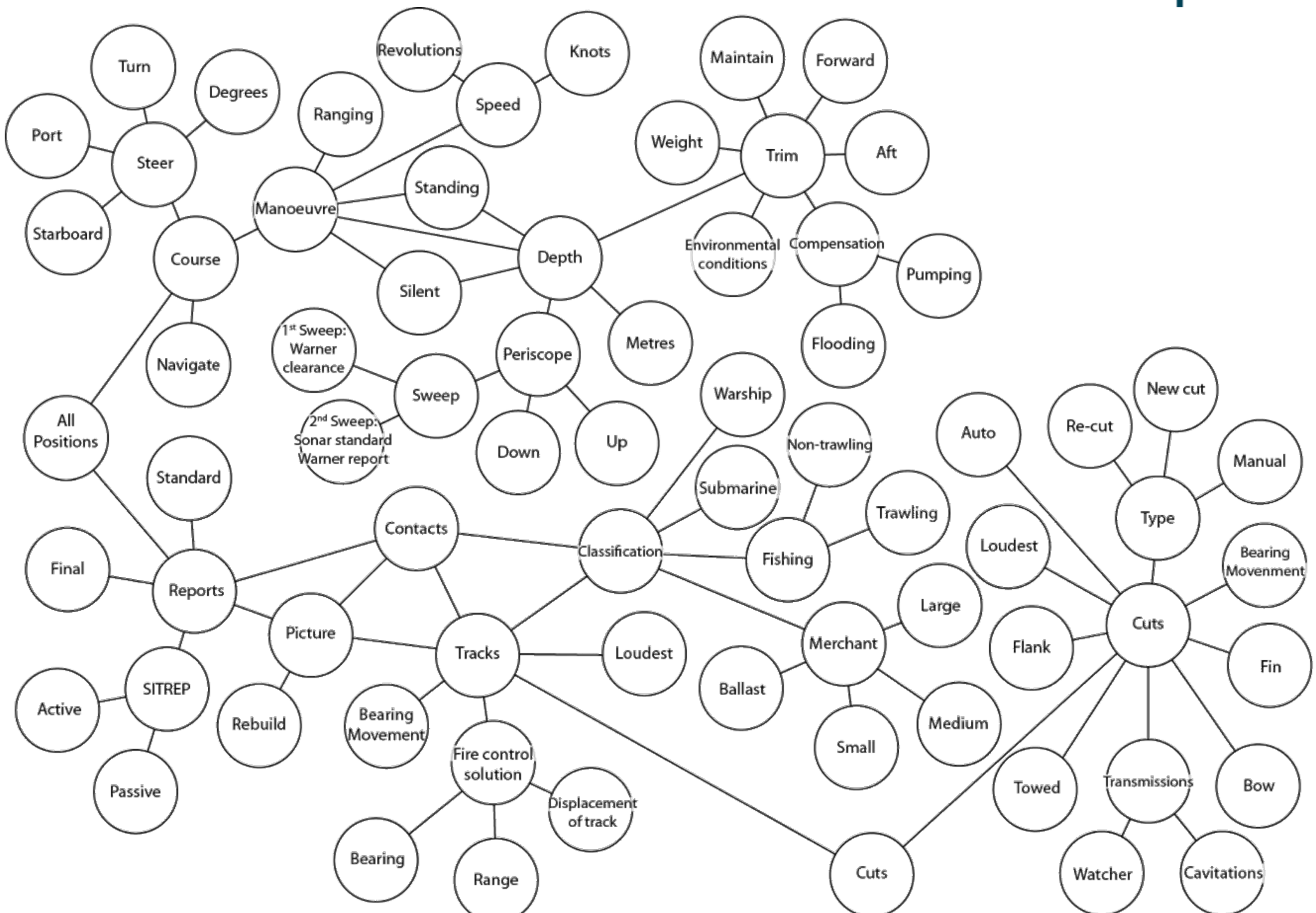

Stanton, N. A. (2014) Representing Distributed Cognition in Complex Systems: How a submarine returns to periscope depth. Ergonomics, 57 (3), 403-418.

Information network (subset)

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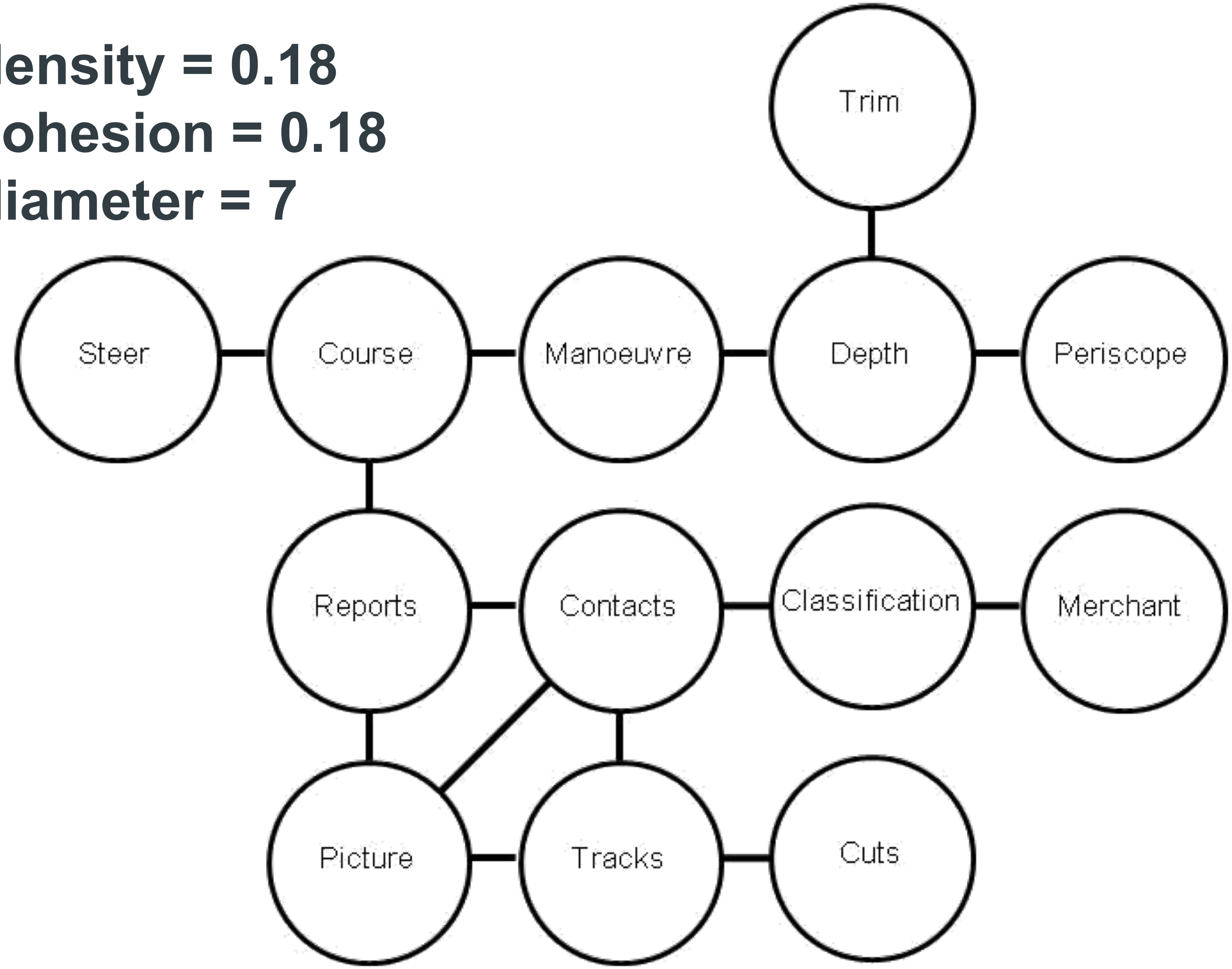
density = 0.18
cohesion = 0.18
diameter = 7



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Information Network Analysis	Periscope	Trim	Depth	Manoeuvre	Course	Steer	Report	Contacts	Classification	Merchant	Picture	Tracks	Cuts
Reception	1	1	3	2	3	1	3	3	3	1	3	3	1
Emission	1	1	3	2	3	1	3	4	2	1	3	3	1
Eccentricity	7	7	6	5	4	5	4	5	6	7	5	6	7
Sociometric Status	0.2	0.2	0.5	0.3	0.5	0.2	0.5	0.6	0.4	0.2	0.5	0.5	0.2
Centrality (B-L)	4.9	4.9	6.2	7.5	8.8	6.4	9.1	8.2	6.7	5.2	8.0	6.8	5.3
Closeness	0.2	0.2	0.3	0.3	0.4	0.3	0.4	0.4	0.3	0.,2	0.4	0.3	0.2
Farness	52	52	41	34	29	40	28	30	39	50	32	37	48
Betweeness	0	0	42	54	78	0	72	42	23	0	22	23	0

EAST framework

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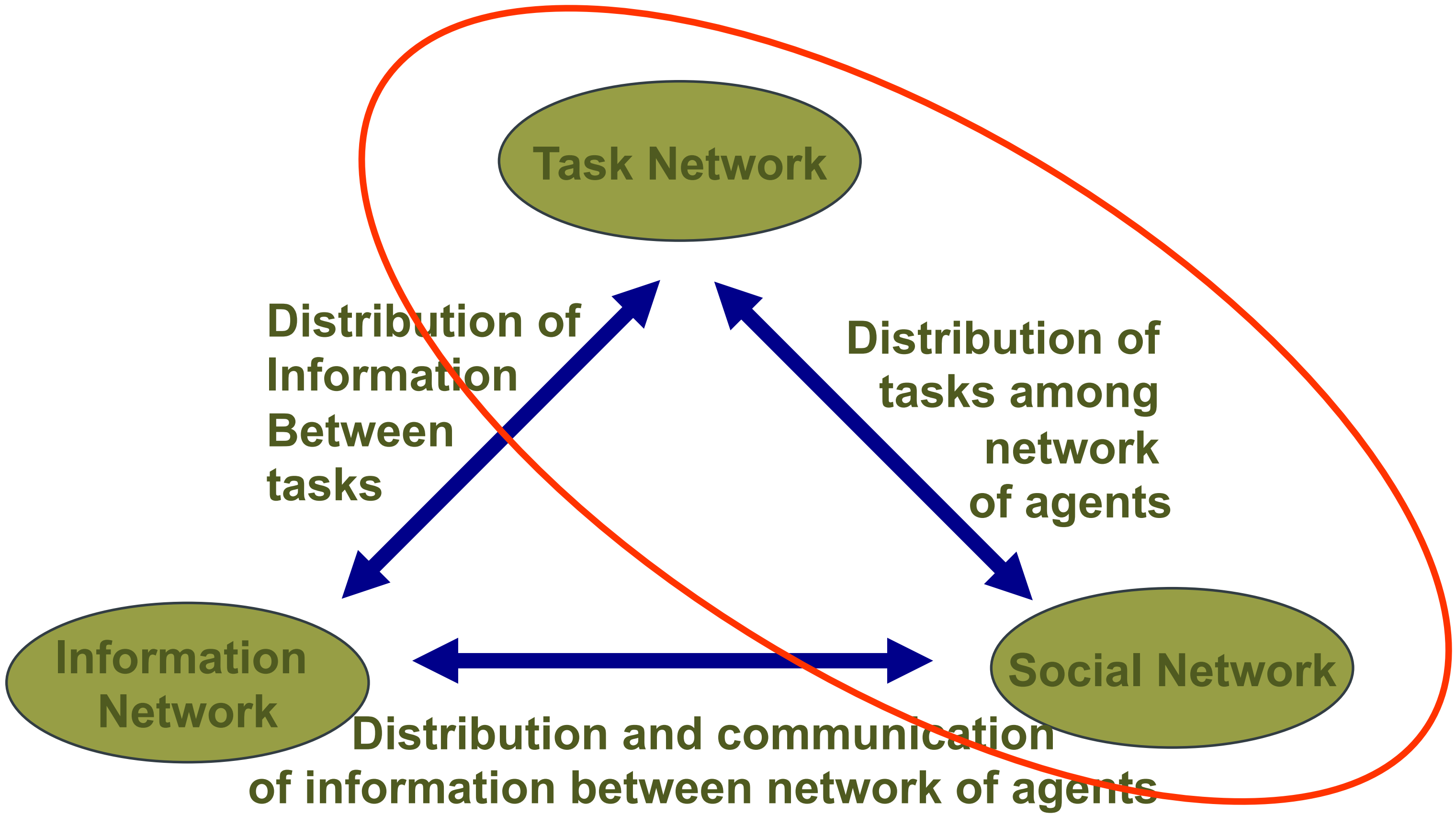

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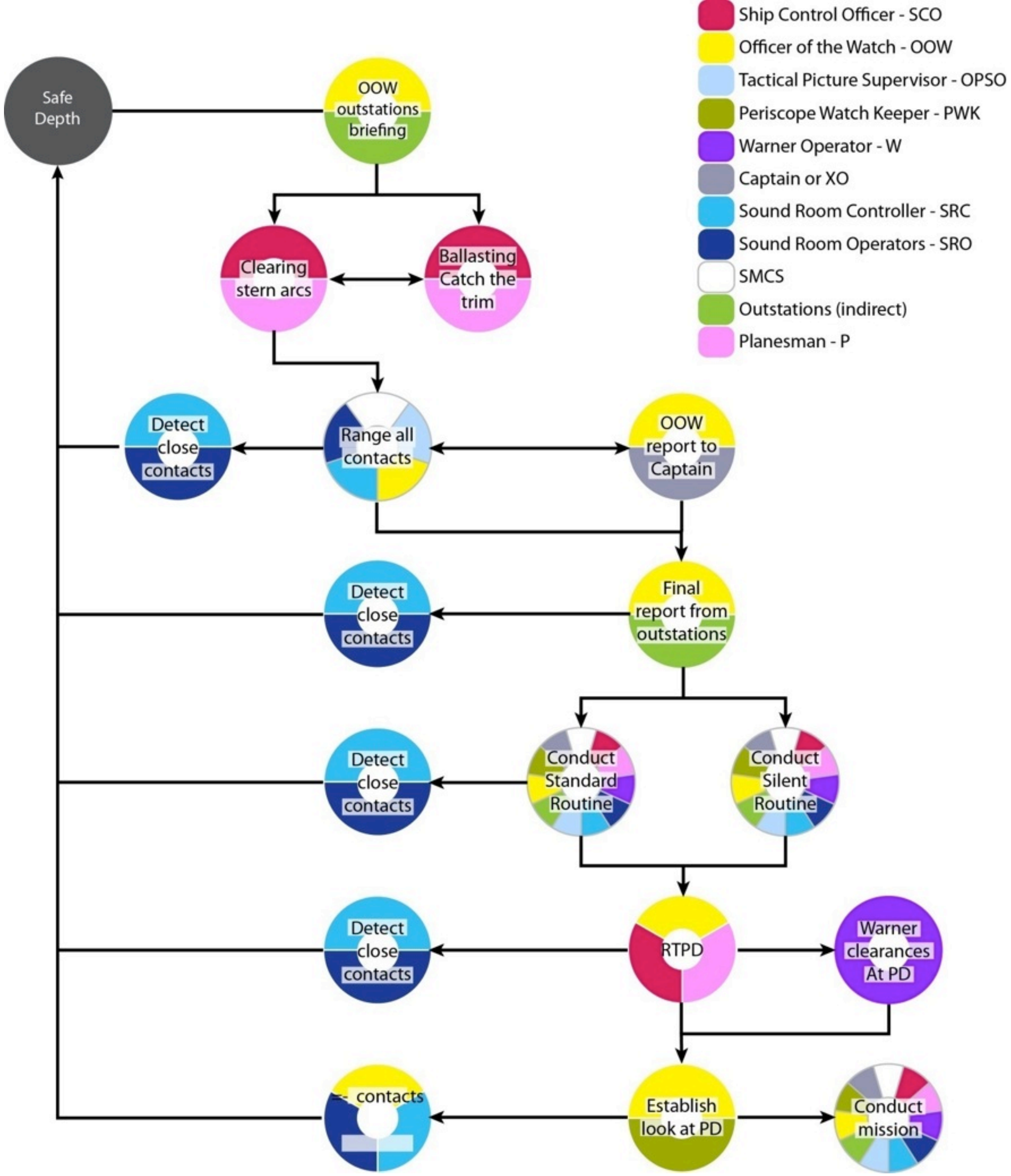

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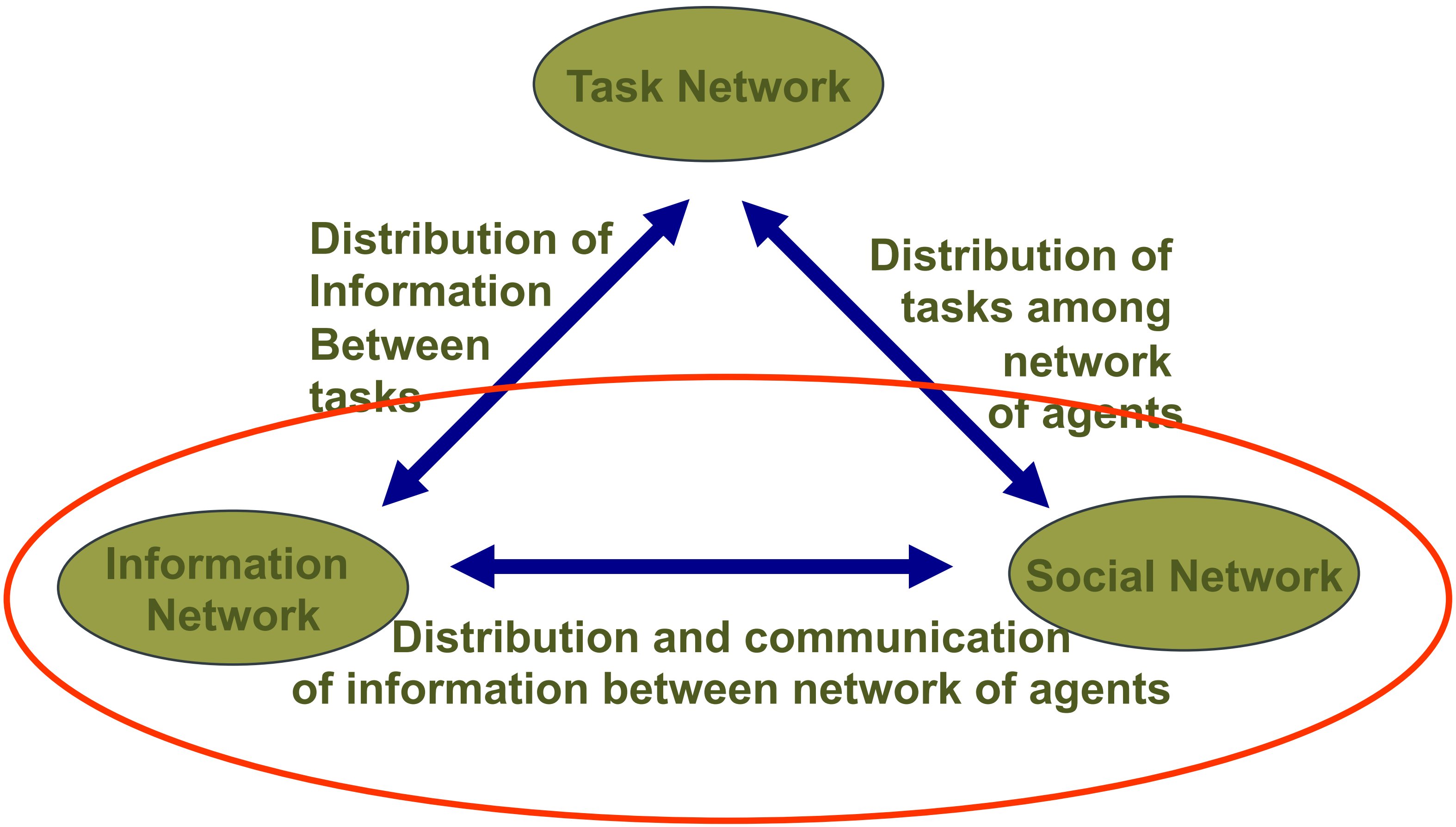

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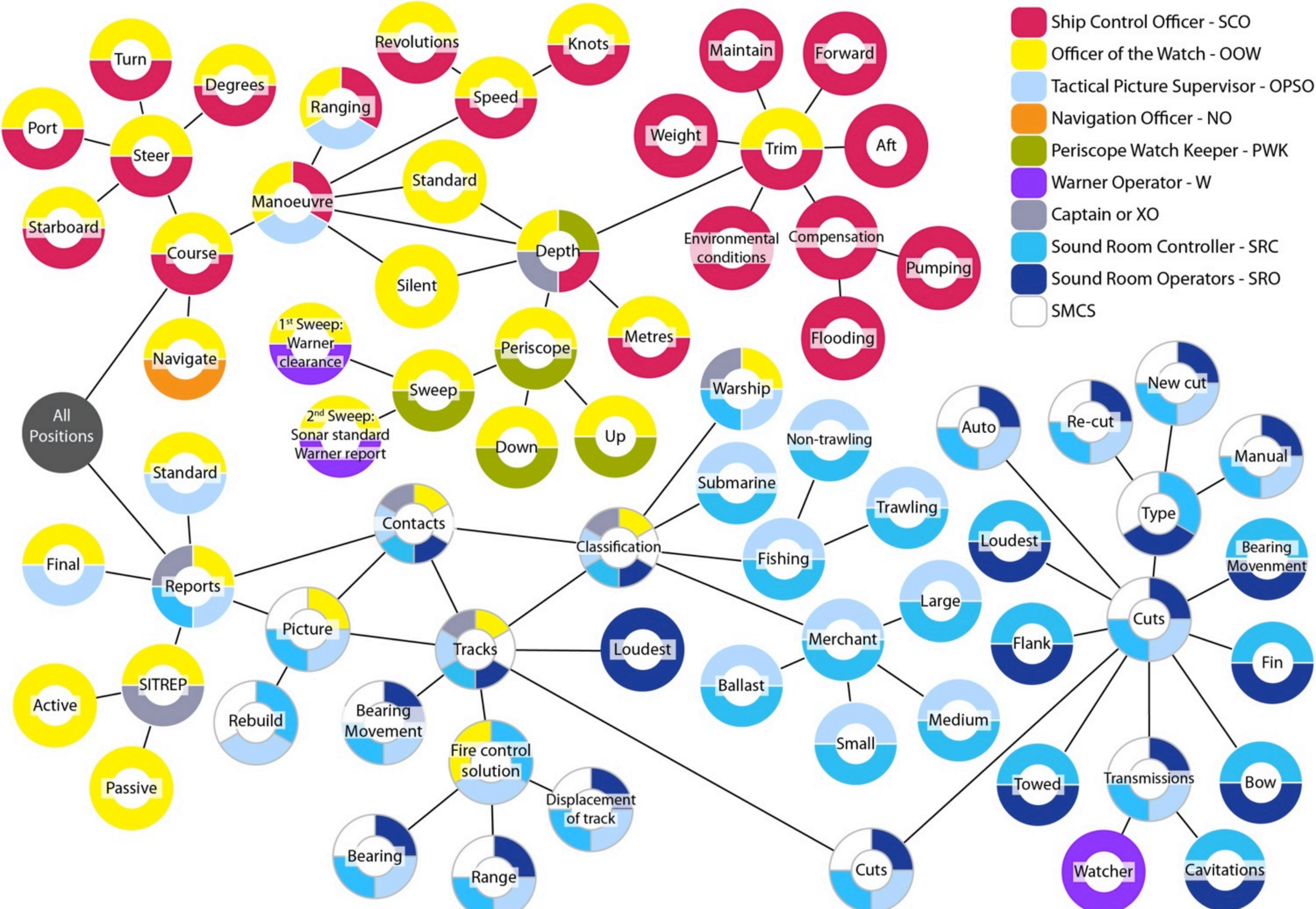

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Ownership of key concepts

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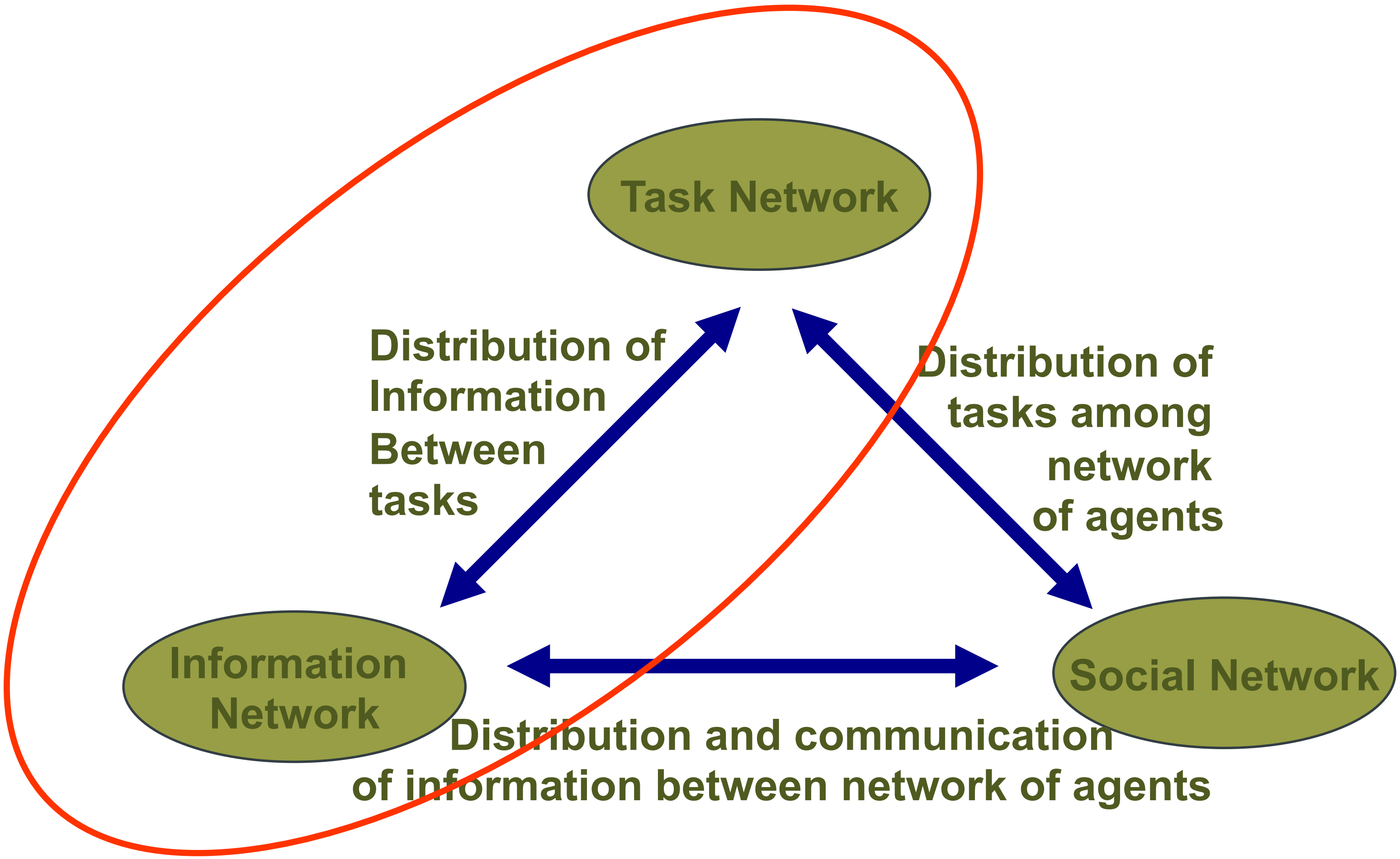
Key concept	XO	OOW	SCO	OPSO	SMCS	SRC	SRO	PWK
Cuts				■	■	■	■	
Tracks	■	■		■	■	■	■	
Picture		■		■	■	■		
Merchant				■		■		
Classification	■	■		■	■	■	■	
Contacts	■	■		■	■	■	■	
Reports	■	■		■		■		
Steer		■	■					
Course		■	■					
Manoeuvre		■	■	■				
Depth	■	■	■					■
Trim		■	■					
Periscope		■						■

Stanton, N. A. (2014) Representing Distributed Cognition in Complex Systems: How a submarine returns to periscope depth. Ergonomics, 57 (3), 403-418.

EAST framework



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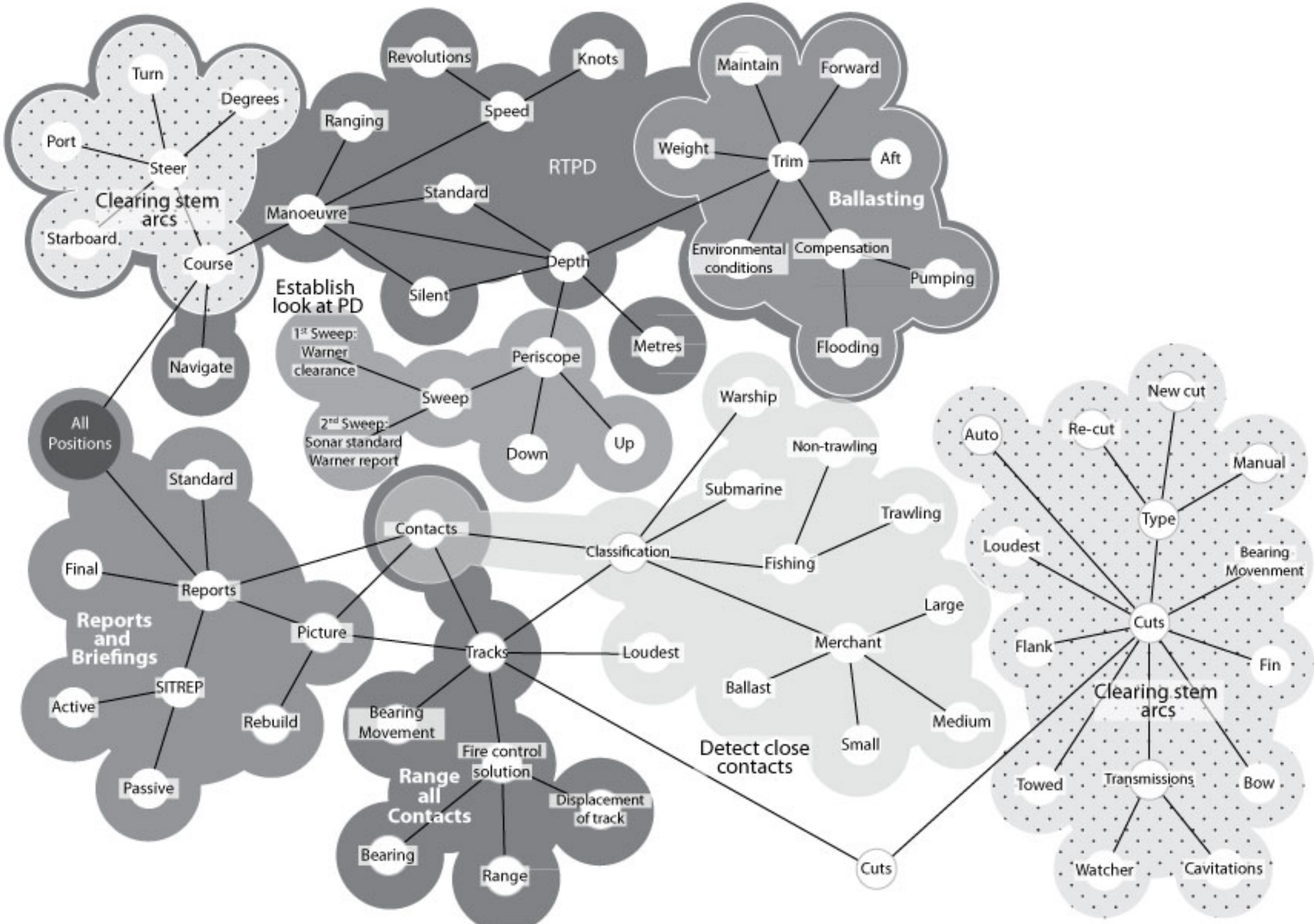

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EAST framework

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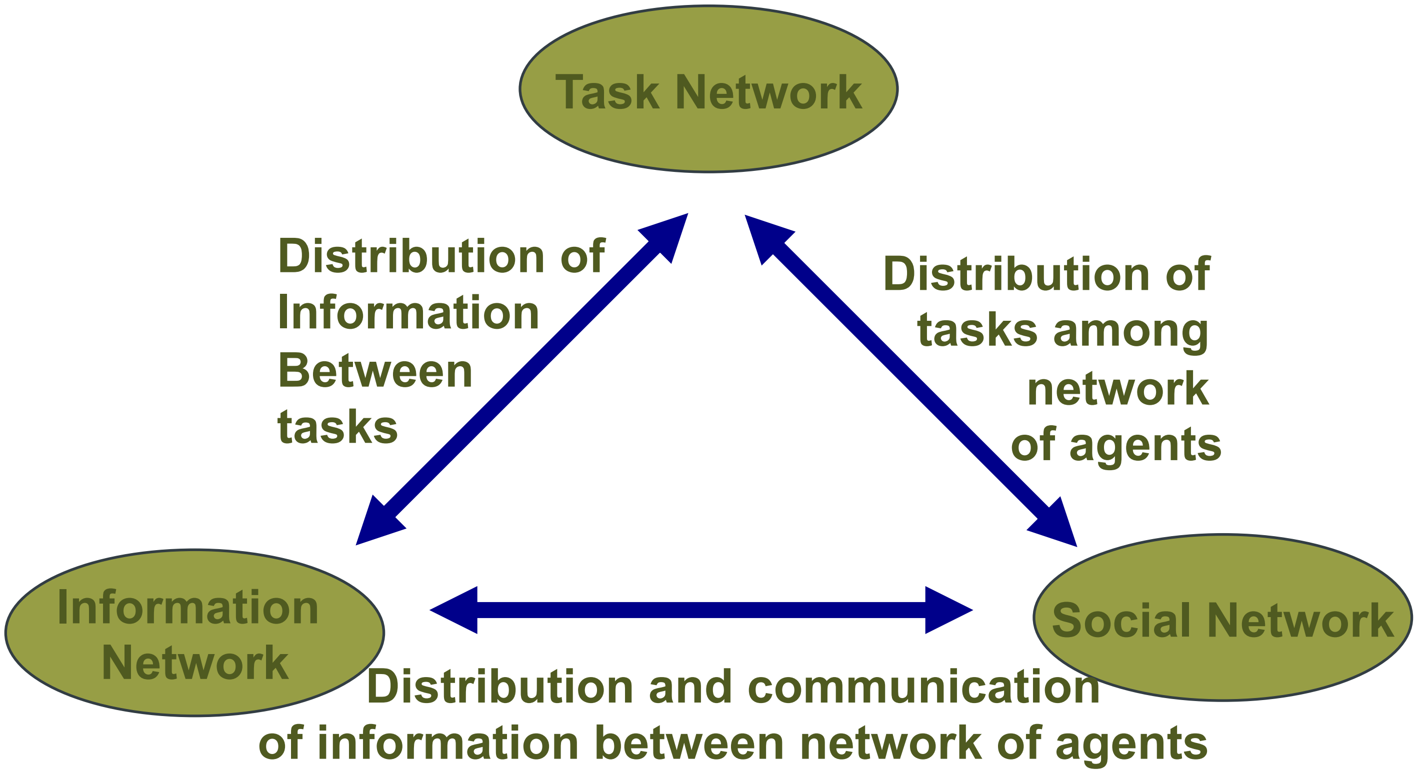

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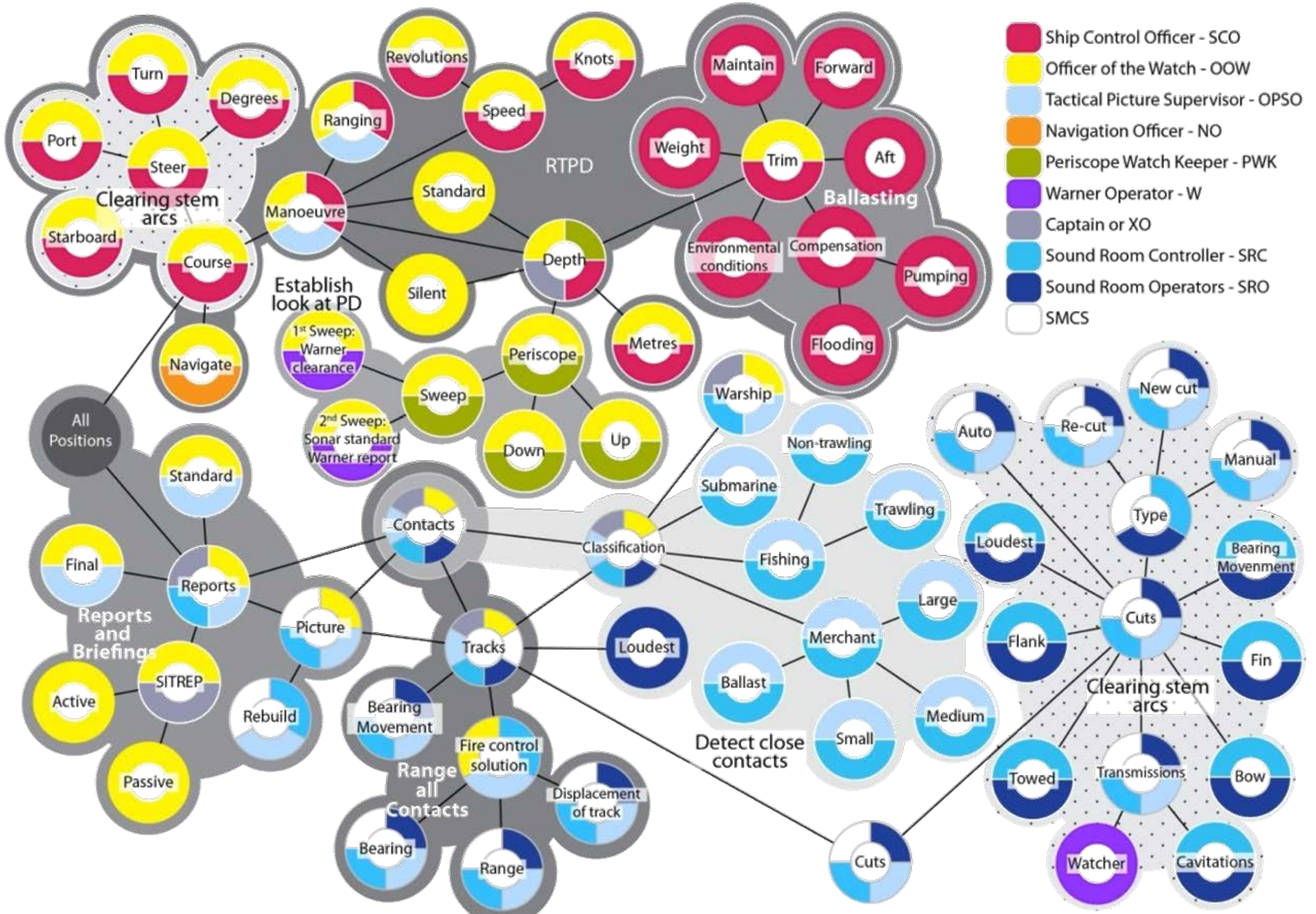
Multi-modal networks



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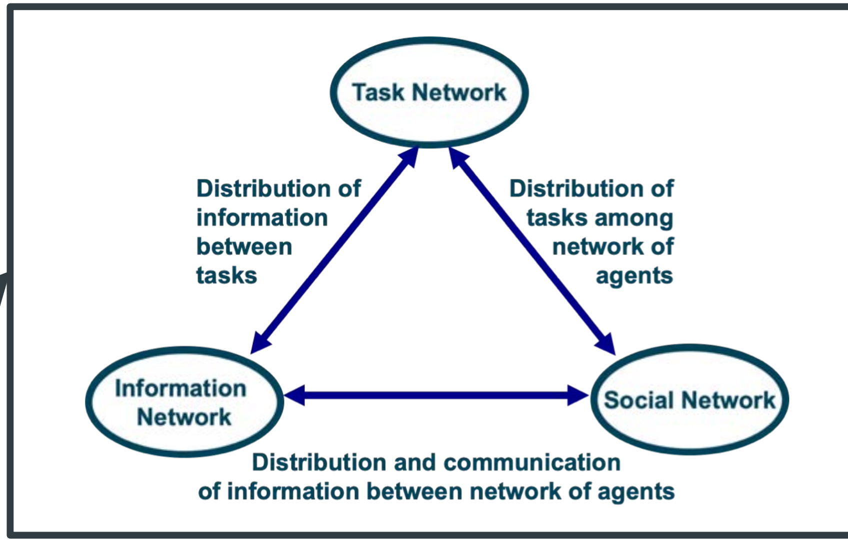
EAST-BN



Looking back
Investigating accidents by identify which nodes were broken: Uber collision case study

EAST-BN

Looking forward
Predicting sociotechnical systems safety: Hawk-frigate case study

EAST-BL

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“Most, if not ***all, accidents and near misses are caused****, at least in part,* ***by the failure to communicate information between agents and tasks****.”*

Stanton, N. A. and Harvey, C. (2017) Beyond human error taxonomies in assessment of risk in sociotechnical systems: a new paradigm with the EAST 'broken-links' approach. Ergonomics, 60 (2) 221-233.

EAST-BN for collision analysis

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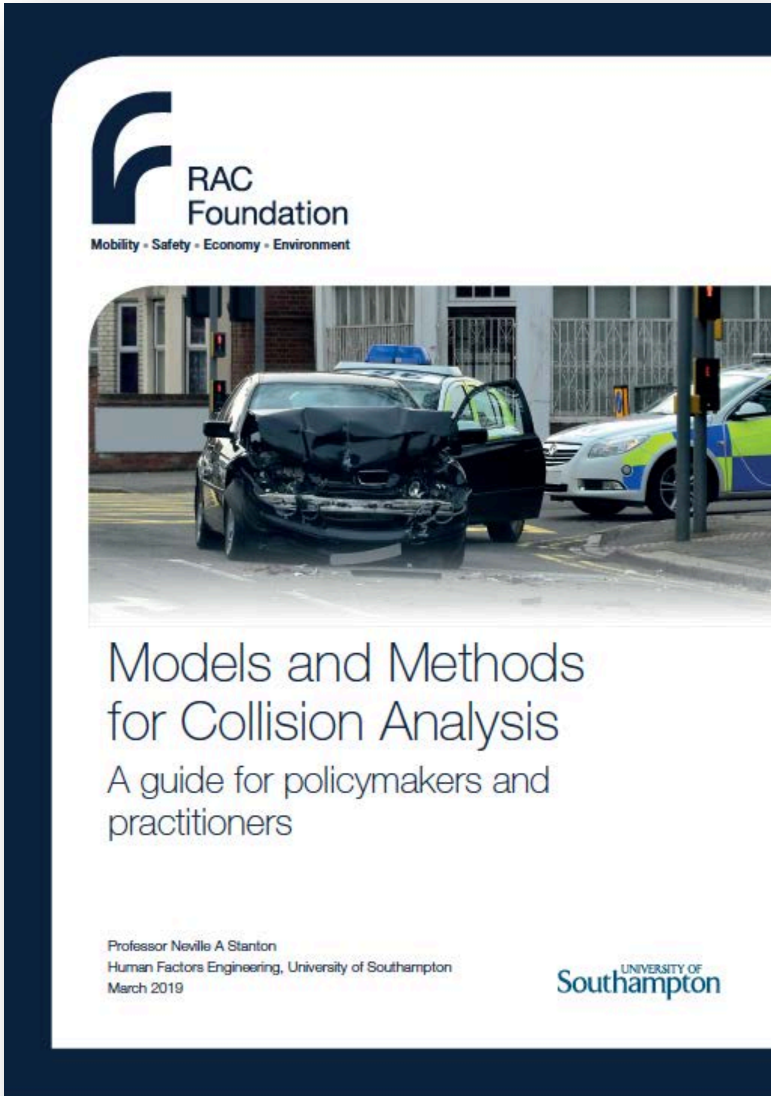
RAC Foundation
Mobility • Safety • Economy • Environment

Models and Methods for Collision Analysis

A guide for policymakers and practitioners

Professor Neville A Stanton
Human Factors Engineering, University of Southampton
March 2019

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https://www.racfoundation.org/research/safety/models-and-methods-for-collision-analysis

Timeline 18th March 2018

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- **6:30 p.m.**: 44-year-old Rafaela Vasquez arrives for work at the Uber facilities in Tempe, Arizona.
- **9:14 p.m**.: Vasquez leaves the Tempe facilities in a self-driving 2017 Volvo XC90 operated by Uber to run an established test route through downtown Tempe.
- **9:39 p.m**.: The vehicle is switched to autonomous mode.
- A report from Tempe police states Vasquez begins streaming "The Voice" on the Hulu app on a cellphone. During this time, the Tempe police state that Vasquez can be seen frequently looking down at the lower center console area near her knee and frequently smirking and laughing. Her hands are not visible in the frame of the surveillance footage. Police determine she looks down 204 times over the course of 11.8 miles. Her eyes were off of the road for 6 minutes and 47 seconds during this period (i.e., over 25% of time)**.** ***This report is not yet substantiated by NTSB.***
- **9:58 p.m.**: Vasquez looks up while driving northbound on Mill Avenue toward Curry Road, approximately 0.5 seconds before the crash. She attempts to swerve left before striking 49-year-old Elaine Herzberg at 39 mph (speed zone posted at 45 mph) as she crosses the street mid-block. Hulu's records also show the streaming of the show ended at this time.
- Vasquez calls 911 and is released later that night after speaking to police. She stated she was monitoring the self-driving system interface and neither her business or personal phones were in use.

NTSB interim report

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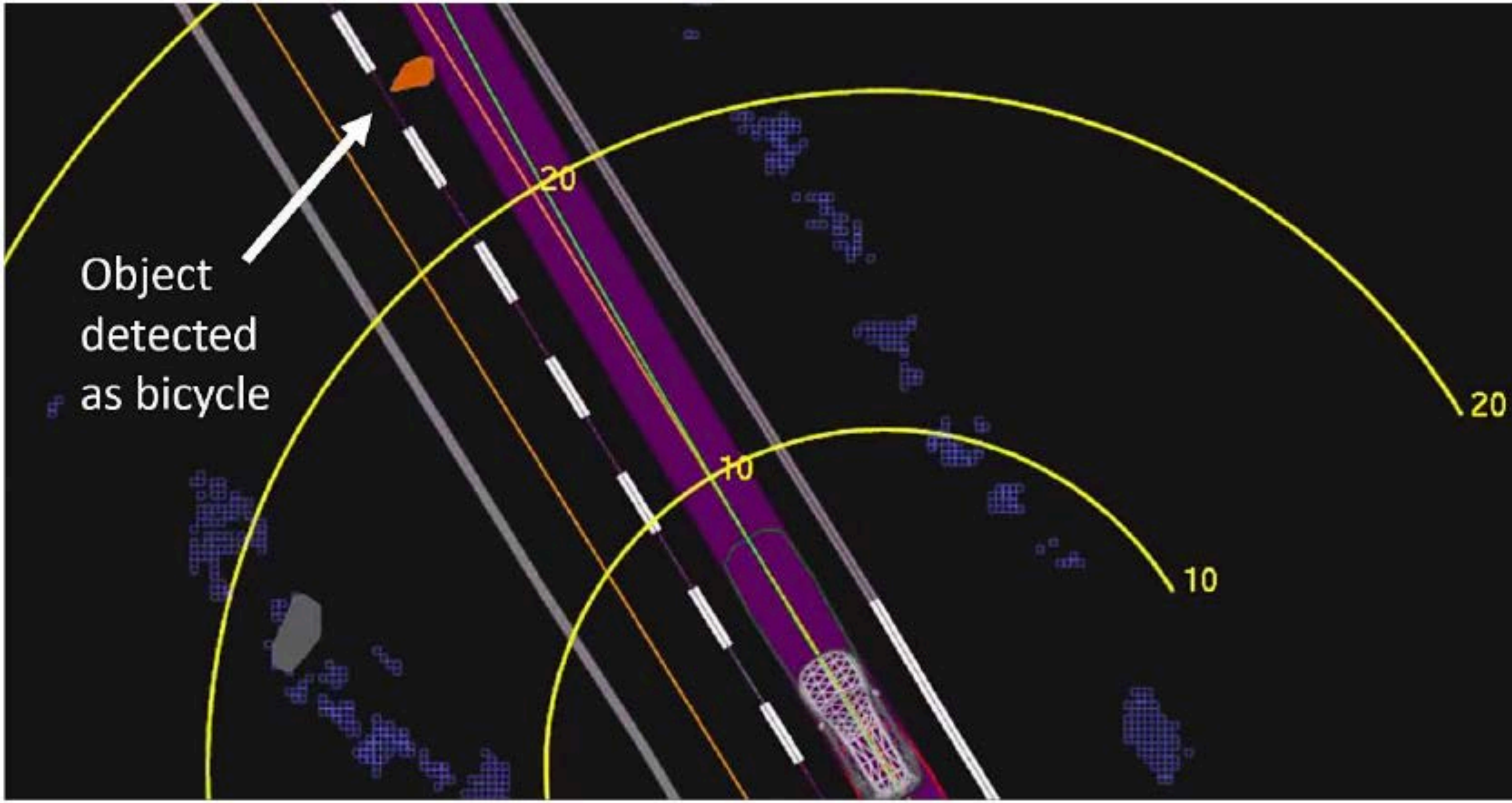

Figure 2. View of the self-driving system data playback at about 1.3 seconds before impact, when the system determined an emergency braking maneuver would be needed to mitigate a collision. Yellow bands are shown in meters ahead. Orange lines show the center of mapped travel lanes. The purple shaded area shows the path the vehicle traveled, with the green line showing the center of that path.

Paths of cyclist and vehicle

Junction approach (daytime)

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Paved median (no crossing sign)

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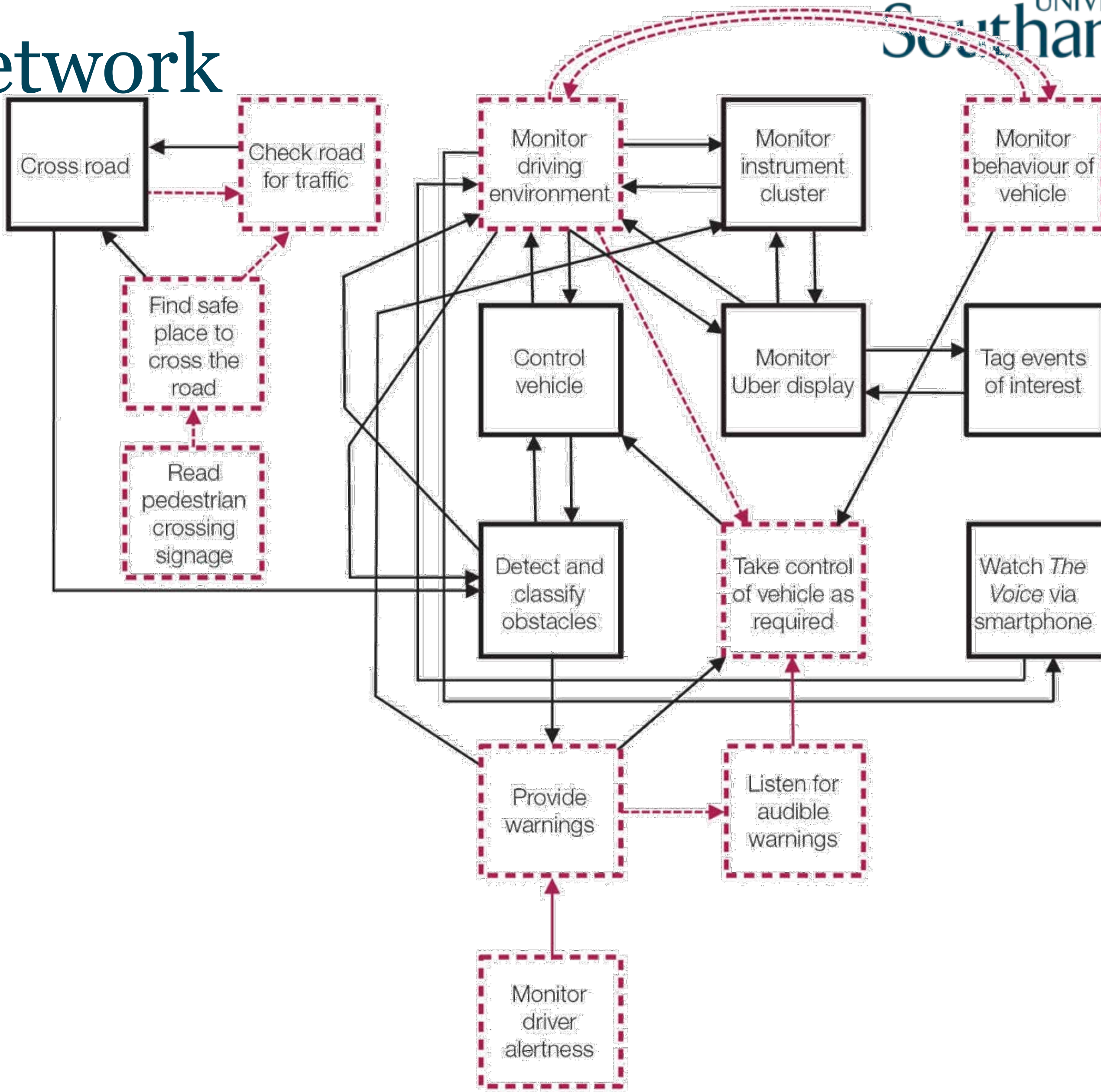
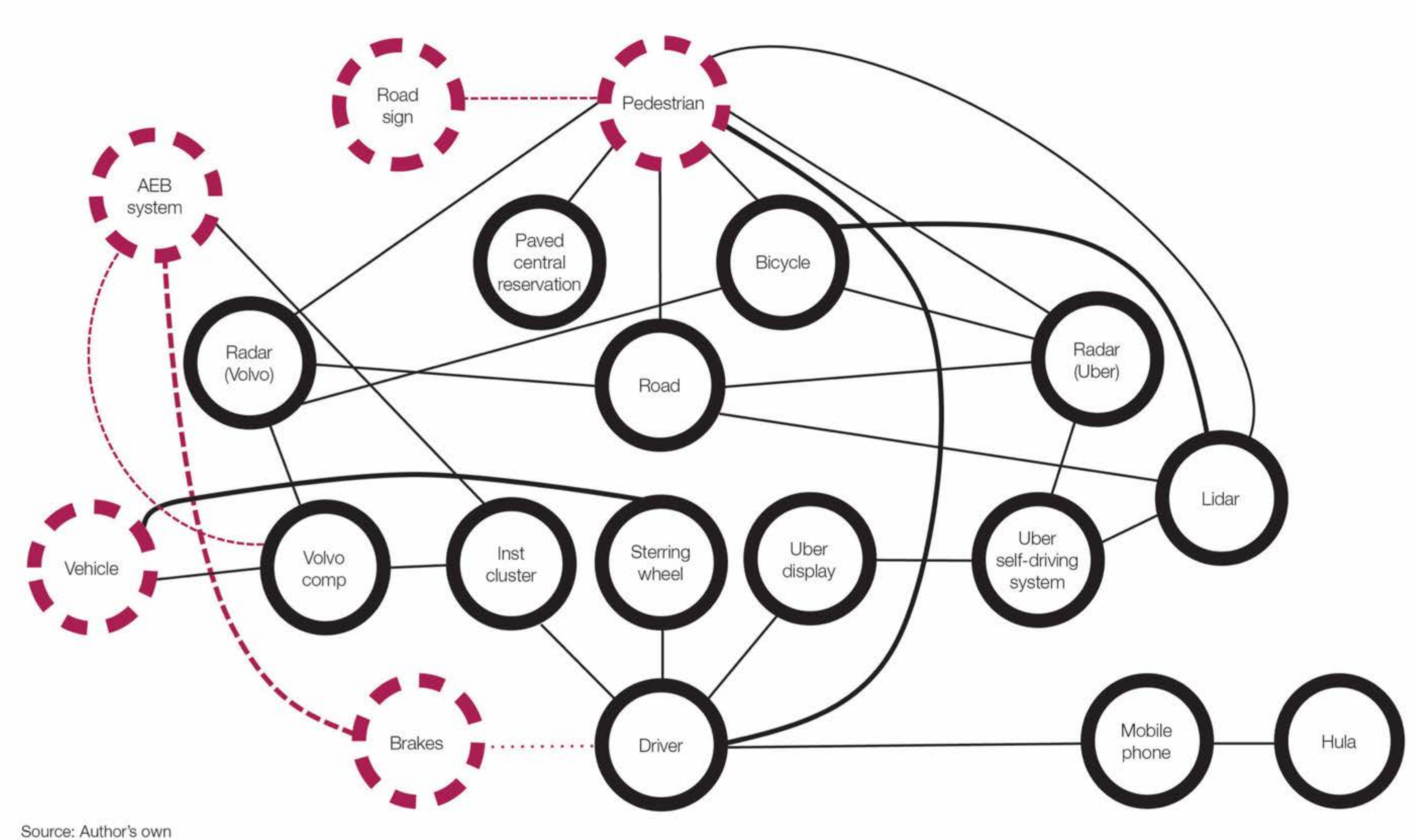
Task network



Stanton, N. A., Salmon, P. M., Walker, G. H and Stanton, M. (2019). Models and Methods for Collision Analysis: A Comparison Study based on the Uber collision with a pedestrian. Safety Science, 120, 117-128.

Social network



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Information network

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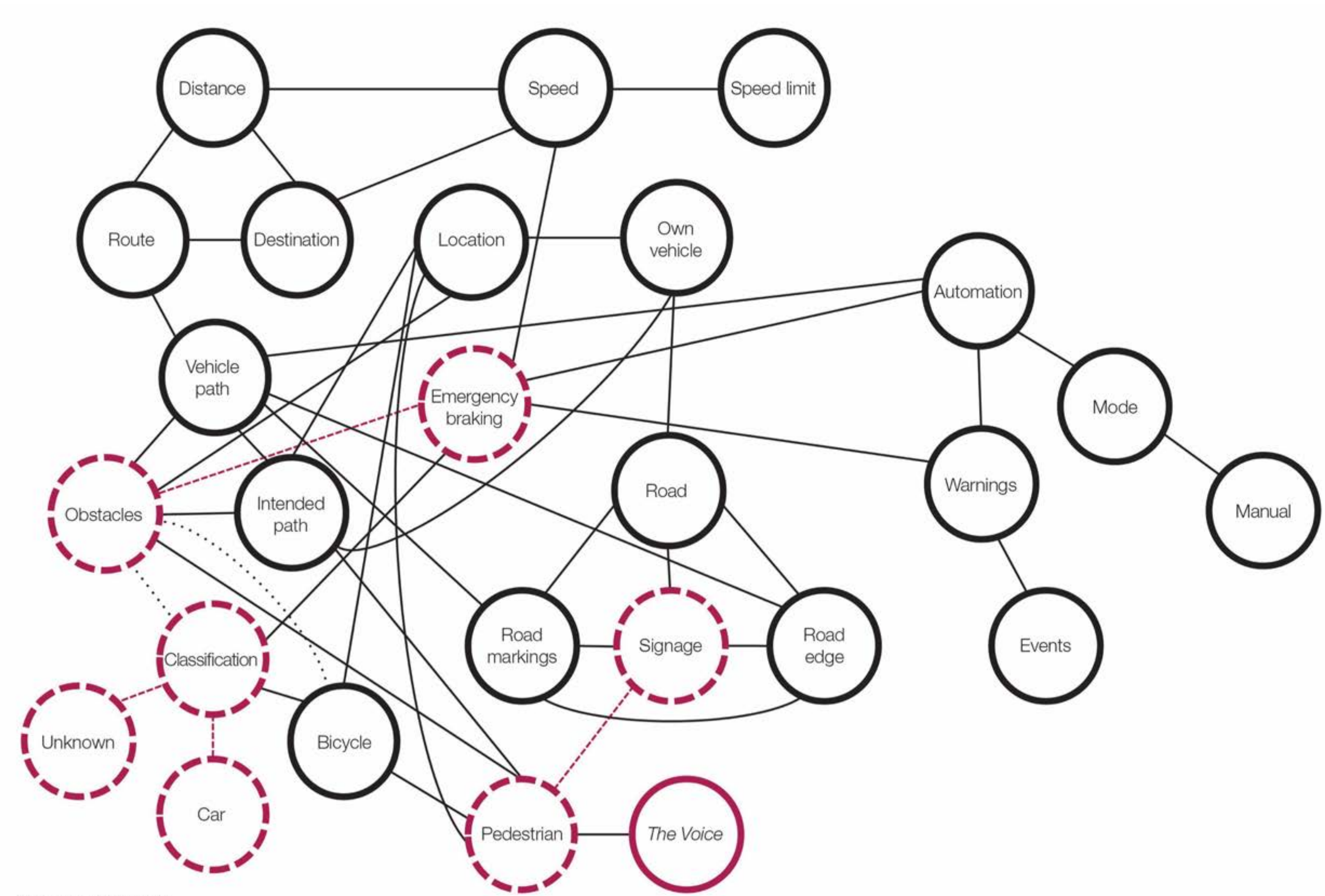

Source: Author's own

Stanton, N. A., Salmon, P. M., Walker, G. H and Stanton, M. (2019). Models and Methods for Collision Analysis: A Comparison Study based on the Uber collision with a pedestrian. Safety Science, 120, 117-128.

EAST-BN Insights

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- There were 9/16 broken nodes in the task network, and 5/19 broken nodes in the social network and 8/26 broken nodes in the information network.
- **Task network:** the pedestrian did not read the sign and find a safe place to cross, nor check the road for traffic. The vehicle did not monitor the driver's alertness, nor provide them with warnings when the need to take manual control arose. Similarly, the driver did not monitor the driving environment or behaviour of the vehicle adequately, nor did they take over manual control before the collision was unavoidable
- **Social network:** the pedestrian did not obey the no-crossing sign, but the no-crossing sign was small and unlit. Similarly, the vehicle did not brake for the pedestrian, but the AEB system had been disabled

EAST-BN Insights (continued)

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- **Information network:** the pedestrian did not use the information from the signage to cross further up the road. The Uber vehicle automation system had problems in classifying the pedestrian, first classifying it as unknown, then as a car and finally as a bicycle. With the obstacle detected, it could not evoke the AEB as it had been disabled. Finally, it has been alleged that the driver was attending to The Voice rather than the road environment, which led to a very late detection of the pedestrian in the path of the vehicle.

EAST-BL

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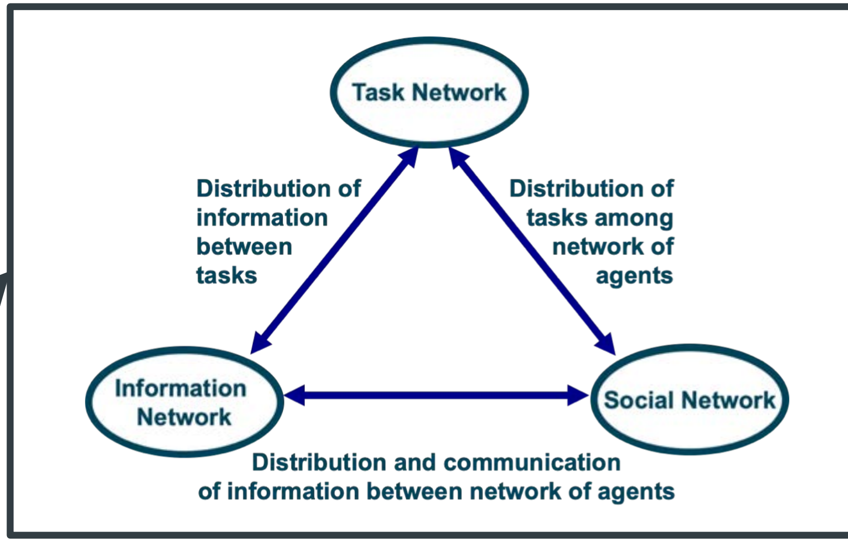

Looking back
Investigating accidents by identify which nodes were broken: Uber collision case study

EAST-BN

Looking forward
Predicting sociotechnical systems safety: Hawk-frigate case study

EAST-BL

EAST-BL

HMS Sheffield

- 4^{th} May 1982
- Struck by an Exocet air-launched missile
- Missile detection too late for crew to react
- 20 crew died
- Report severely criticised training and procedures

Type 23 Frigate
(training in detecting missile approach)

RAF Hawk (simulation of missile approach – without RADALT!)

EAST

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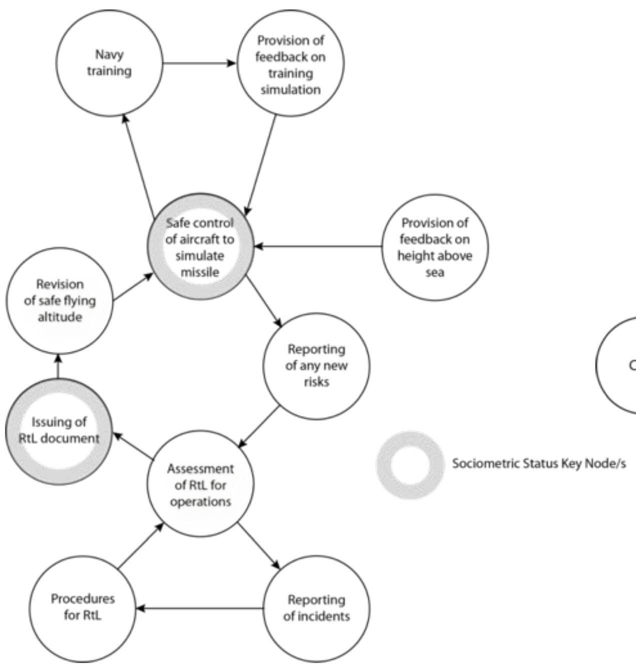
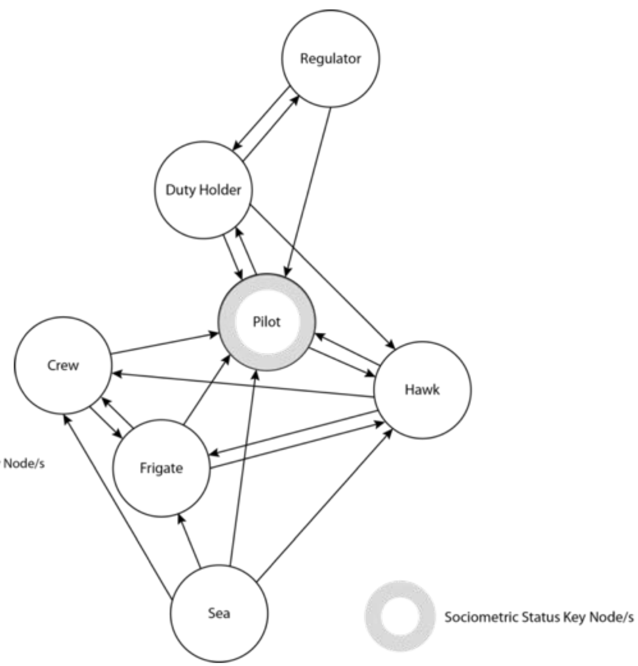
- EAST was applied to the Hawk case study to map the networks between **tasks, social**, and **information**.

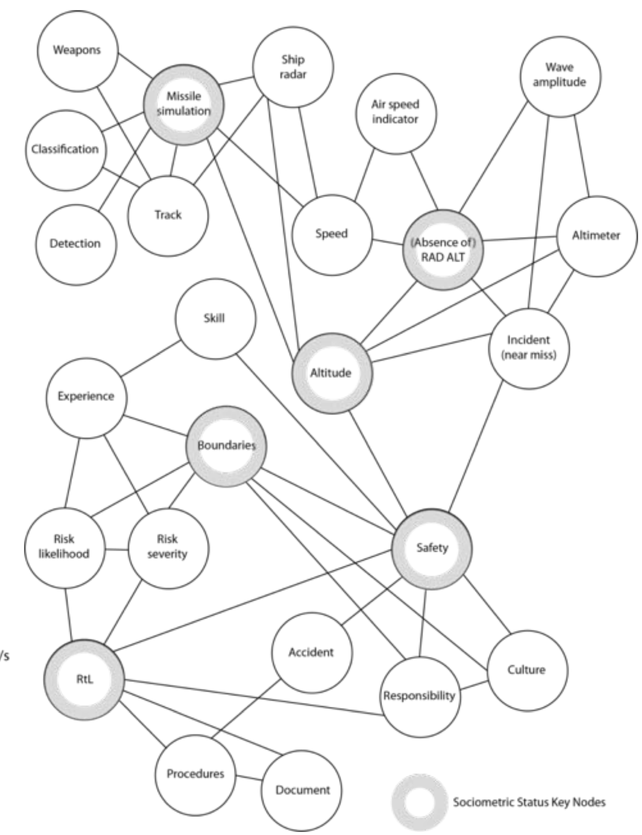
Task:



Social:



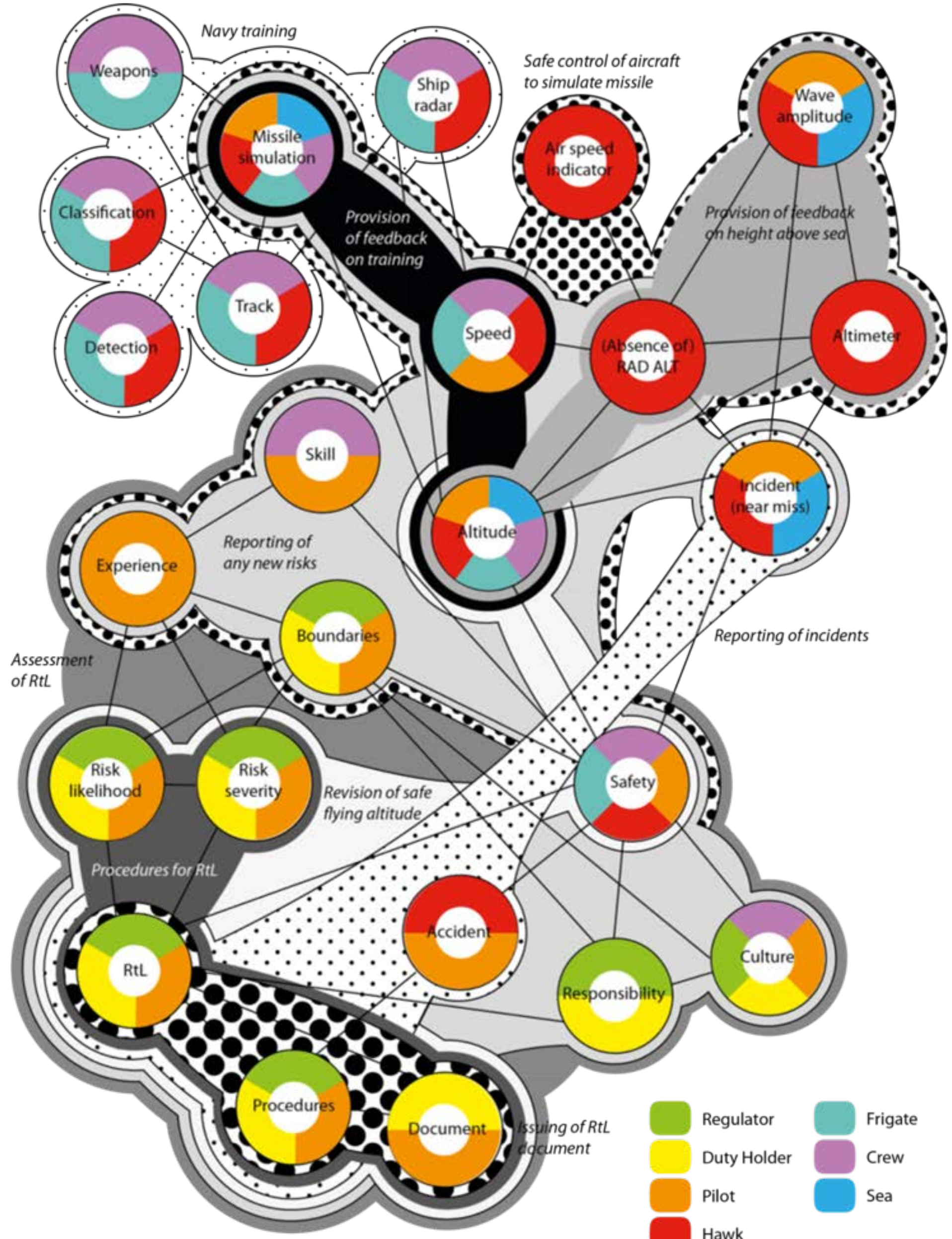
Information:



Stanton, N. A. and Harvey, C. (2017) Beyond human error taxonomies in assessment of risk in sociotechnical systems: a new paradigm with the EAST 'broken-links' approach. Ergonomics, 60 (2) 221-233.

EAST

Combined task, information, and social network



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EAST: Extension to method

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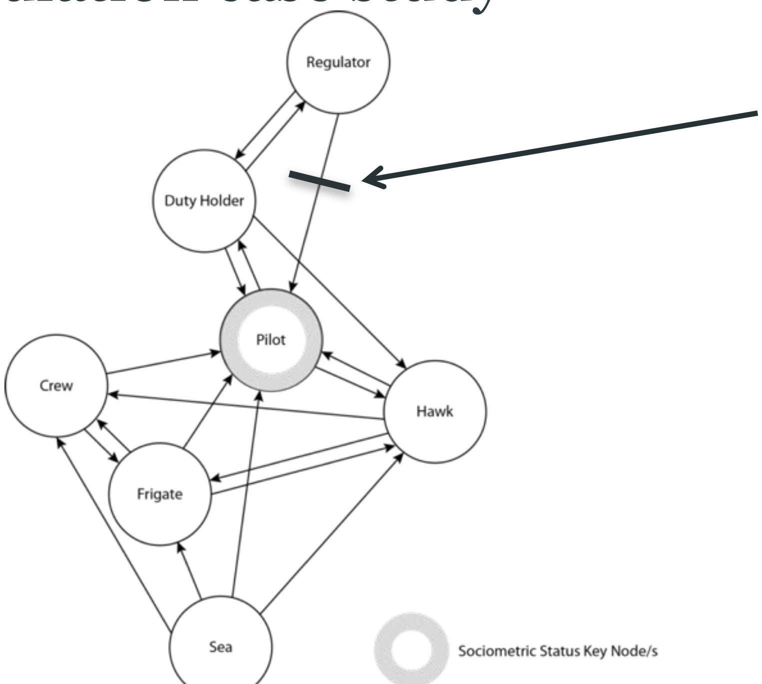
An additional stage was developed for EAST: **Broken links analysis**

This was used to identify **137 risks** for the Hawk missile simulation case study



1. Break the link between each pair of nodes
2. For every piece of **information (from the information network)** which is shared between those nodes, explore the impact on the network if the information is **not communicated.** These are the **risks**
3. Do this for all node pairs in the **Social network** and in the **Task network**

Stanton, N. A. and Harvey, C. (2017) Beyond human error taxonomies in assessment of risk in sociotechnical systems: a new paradigm with the EAST 'broken-links' approach. Ergonomics, 60 (2) 221-233.

Broken-social-links analysis

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From (agent)	To (agent)	Information not communicated	Resulting risk	Mitigation strategy
Duty Holder	Pilot	*Boundaries*	Pilots are not aware of the boundaries for flight operations and for the identification and reporting of risks within this	Boundaries for risk reporting must be made clear to pilots as part of the RtL process
Duty Holder	Pilot	*RtL*	Pilots are not made aware of the results and consequences of the RtL assessment process after it is conducted at DH level	Results and consequences of the RtL assessment process must be effectively communicated to pilots
Duty Holder	Pilot	*Risk likelihood*	Pilots are not made aware of risks assessed that their likelihood of occurrence	Risks identified as having a high likelihood of occurrence must be reported to pilots
Duty Holder	Pilot	*Risk severity*	Pilots are not made aware of risks assessed and their severity of impact	Risks deemed as having a high severity of impact must be reported to pilots
Duty Holder	Pilot	*Procedures*	Pilots are not aware of how the RtL process is conducted at DH level and of procedures for reporting incidents to the DH	Pilots must be provided with clear procedures describing the assessment of RtL at DH level and the reporting of risks to DH
Duty Holder	Pilot	*Document*	Pilots are not provided with documentation covering the RtL process and its results	Pilots must be provided with documentation covering the RtL process and its results
Duty Holder	Pilot	*Responsibility*	Pilots are not aware of the DH's nor their own responsibilities for safety	The responsibilities of both the pilot and DH for safety must be clearly defined and understood by pilots
Duty Holder	Pilot	*Safety*	Pilots do not receive information about the safety of operations, based on the RtL assessment process	The safety of operations, as assessed during the RtL process, must be reported to the pilots

Broken-task-links analysis

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From (task)	To (task)	Information not communicated	Resulting risk	Mitigation strategy
Issuing of RtL document	Revision of safe flying altitude	*Document*	The information contained in the RtL document does not trigger a revision of safe flying altitude	The RtL document must be used by regulators to inform changes to regulations and safety guidance where appropriate
Issuing of RtL document	Revision of safe flying altitude	*RtL*	The outcome of the RtL process outlined in the RtL document does not trigger a revision of safe flying altitude	The outcomes of RtL assessment must be used by regulators to inform changes to regulations and safety guidelines where appropriate
Issuing of RtL document	Revision of safe flying altitude	*Risk likelihood*	The outcome of the Risk likelihood assessment, conducted as part of the RtL process and outlined in the RtL document, does not trigger a revision of safe flying altitude	The outcome of the Risk likelihood assessment, conducted as part of the RtL process and outlined in the RtL document, must be used to inform changes to regulations and safety guidelines where appropriate
Issuing of RtL document	Revision of safe flying altitude	*Risk severity*	The outcome of the Risk severity assessment, conducted as part of the RtL process and outlined in the RtL document, does not trigger a revision of safe flying altitude	The outcome of the Risk severity assessment, conducted as part of the RtL process and outlined in the RtL document, must be used to inform changes to regulations and safety guidelines where appropriate
Issuing of RtL document	Revision of safe flying altitude	*Safety*	The safety implications of the RtL process outlined in the Rtl document do not trigger a revision of safe flying altitude	The safety implications of RtL assessment must be used by regulators to inform changes to regulations and safety guidelines where appropriate
Issuing of RtL document	Revision of safe flying altitude	*Responsibility*	Responsibility for the revision of safe flying altitude is not outlined in the RtL document	Responsibility for changes to regulations and safety guidelines based on RtL assessment must be clearly assigned and accepted

EAST-BL Insights

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- By breaking 19 social links and 12 task links, 137 potential risks in the system were identified
- There is variability in what individual pilots will report back to the duty holder, as they have different interpretations of what they consider to be a risk
- Crew on Frigate need to train against sea-skimming missiles which appear late on radar and require a short response time (higher Hawk = more risk)
- Pilot of Hawk flying at low altitude by eye using wave height as a cue (lower Hawk = more risk)
- Most, if not all, accidents and near misses are caused, at least in part, by the failure to communicate information (or the communication of wrong information) between agents and tasks.

Future Developments?

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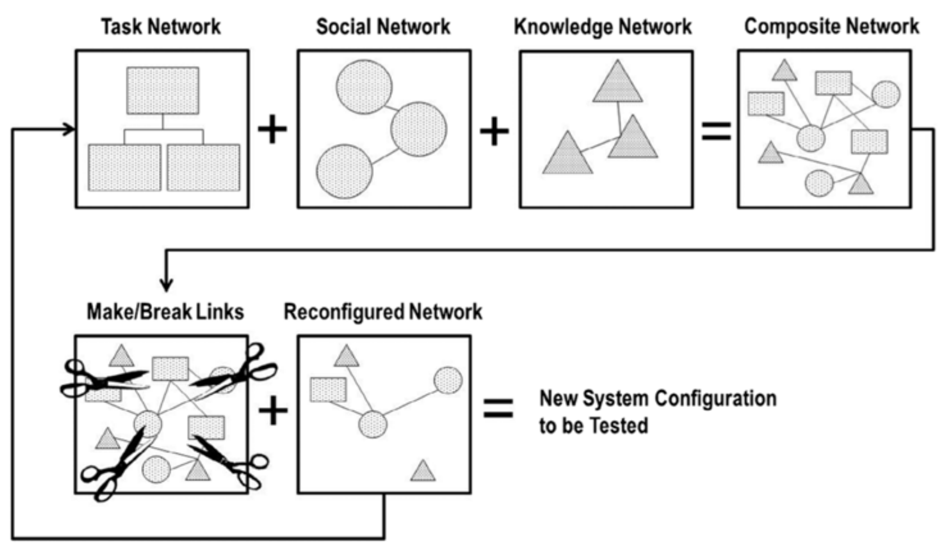
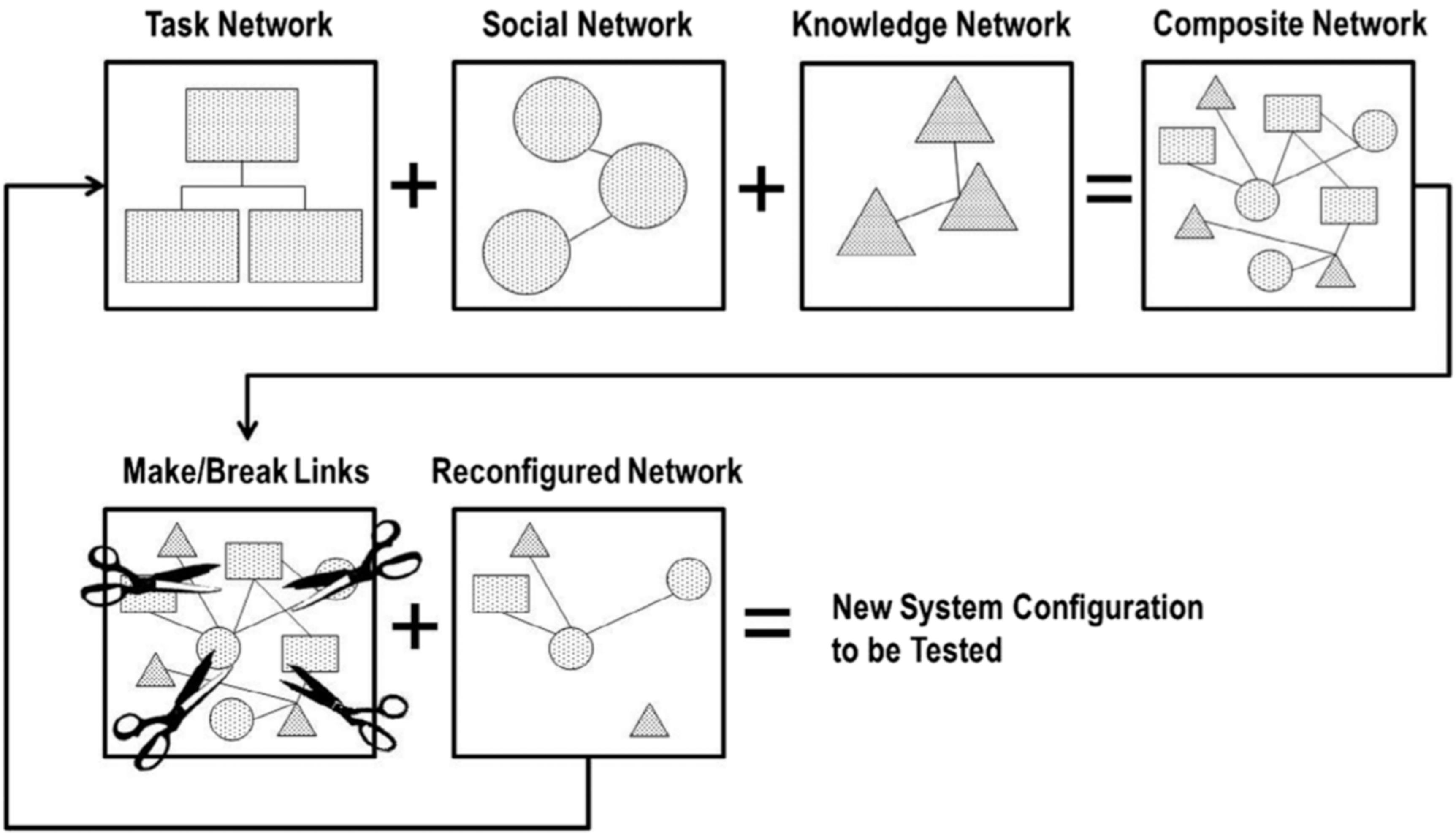
- ‘Wrong’ information as well as failure to transfer information?
- Dynamic models to replace static models?
- Concatenation of multiple failures (in parallel and series) from both human and technical sub-systems?
- Model-break-model approach?



Model-break-model approach



Salmon, P. M., Walker, G. H., Read, G. J., Goode, N., Stanton, N. A. (2017) Fitting methods to paradigms: are ergonomics methods fit for systems thinking? Ergonomics, 60 (2) 194-205.

Niels Henrik David Bohr
(7 October 1885 – 18 November 1962)

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“Prediction is very difficult….”

Niels Henrik David Bohr
(7 October 1885 – 18 November 1962)

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*“Prediction is very difficult, **especially about the future**”*

EAST books

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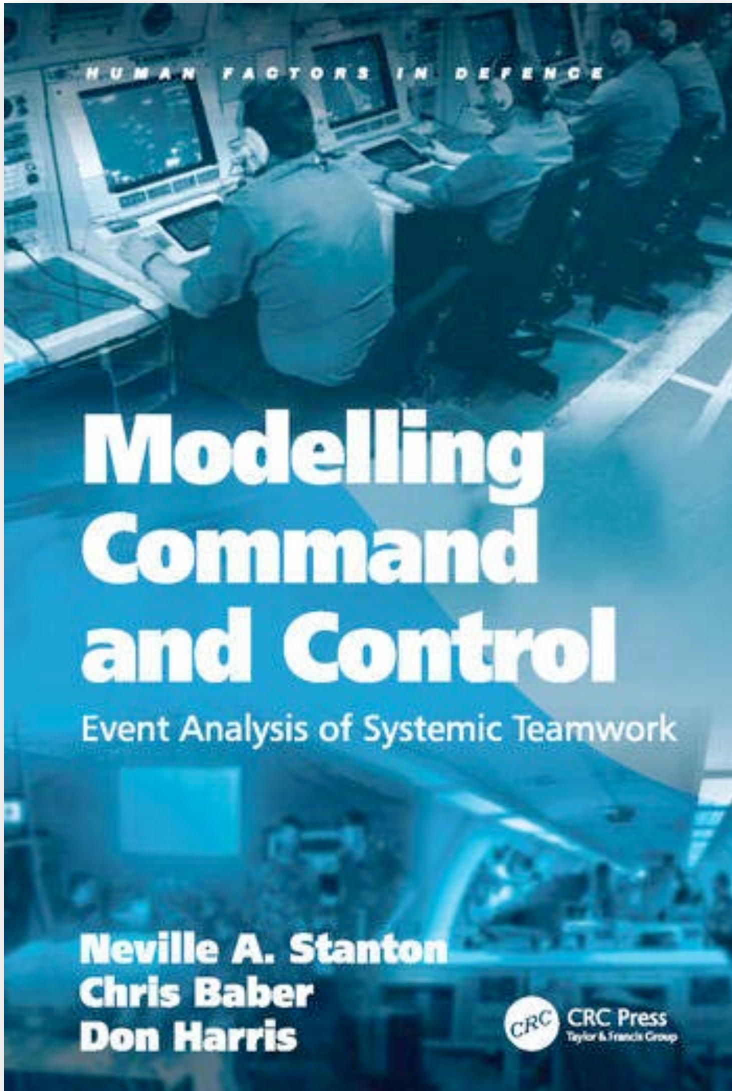

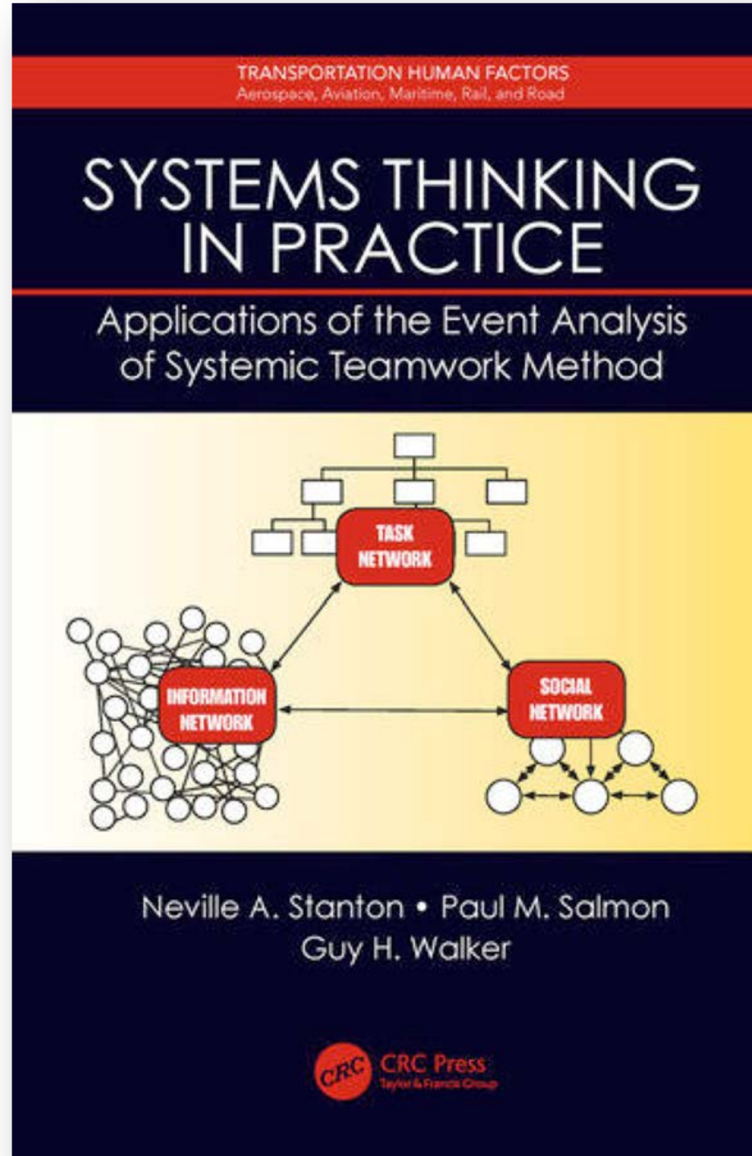

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Thank you for your attention

If you have any further questions please contact me at:

n.stanton@soton.ac.uk

www.hfesoton.com