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Vysus Group

ESRA Webinar
Enablers for Safe Autonomous Design and Implementation

Dr. Nalini Suparamaniam-Kallerdahl

Technical and Business Leader, Human Factors, Organizational Management and Autonomous Initiatives

+47 4685 1895

Agenda

- Introductions
- Vysus Group
- Technical Presentation: Enablers for Autonomous Design
- Questions and Answers

Vysus

Our legacy and global scale

We are a leading, independent provider of digitally enabled, engineering and technical consultancy expertise, supporting owners and developers of energy, power and complex industrial assets and infrastructure.

Established in November 2020 from the sale of the Lloyd's Register Energy division, we have amassed a wealth of deep technical and regulatory expertise.

At Vysus, we understand that risk straddles every element of your operation and that managing and reducing risk is crucial to developing safe and sustainable design and maintaining safe and reliable operations.

80+ years

Heritage

650+

Employees worldwide

1930 – Lloyd's Register Energy

2005
- Capstone
- ODS

2008
- Human Engineering
- Celerity3
- ModuSpec

2010
- Scandpower

2012
- West Engineering

2013
- Senergy

2020 – Vysus Group

2021
- Promaps Technology

Our services

Asset Management Consulting

Improve reliability, maintaining production, reducing cost and increasing profitability.

Drilling Rig Integrity & Assurance

ModuSpec ensures the integrity, reliability and optimization of your drilling, completions and intervention equipment, and campaigns.

Survey and GeoEngineering

From land development, infrastructure improvements and construction, to offshore construction and decommissioning, our land, seabed and shallow subsurface and data management services help you avoid hazards, map routes, evade delays and ensure project success.

Risk Management

Manage risks throughout the asset lifecycle, whether related to life and environment, asset performance, market, or for contractual or regulatory requirements.

Engineering, Operations and Project management

Enhance the planning and performance of well operations, from initial conceptual well design through to well construction and ultimate suspension or abandonment.

Energy Transition

Power the transition to clean energy by reducing project risk and optimise asset performance of your renewable assets.

Grid Connection

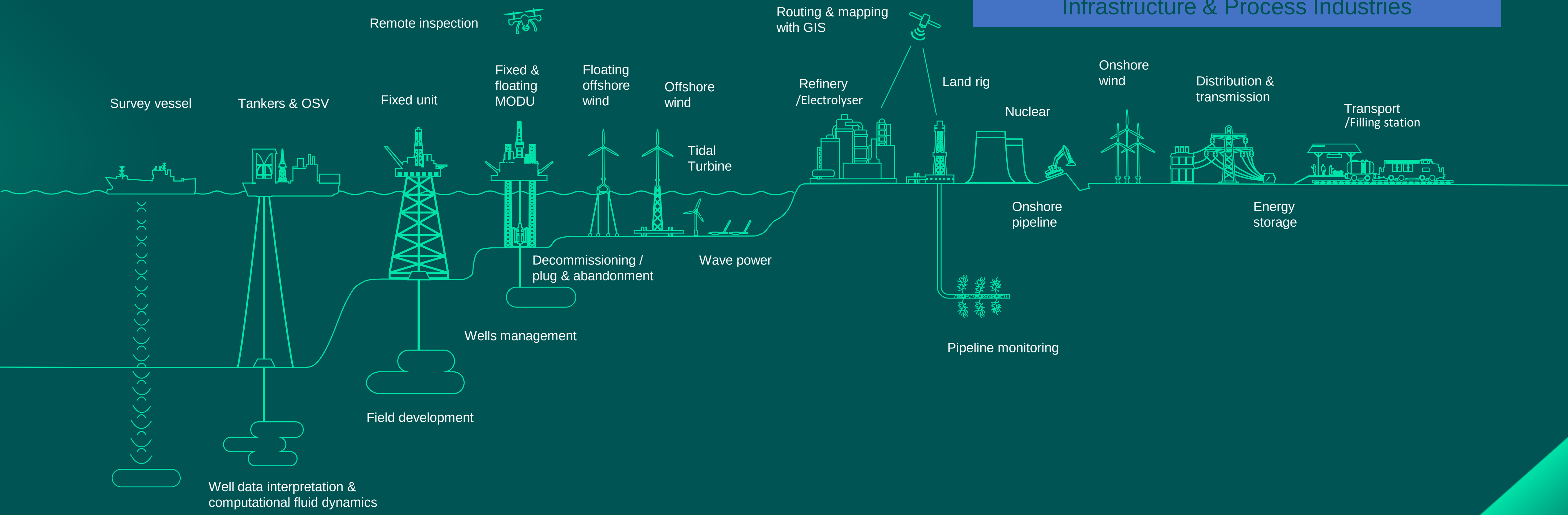
Improve the management of complex power systems and negotiate new technologies to maximise production in an increasingly constrained grid environment.

Sector expertise

Upstream Oil & Gas

Power, Renewables & Transition

Infrastructure & Process Industries



A short list ..

- Position/Role
  - 20+ experience in OG, Maritime, Military, Aviation
  - Principal Consultant
  - Technical and Business Leader with Vysus Group – Norway, Asia Middle East
  - Head of Human Factors/Autonomous Initiatives
- Academics
  - Ph.D. in Human-Systems Engineering (Sweden), Construction and Production Development
  - M.Sc. in Organizational Management (USA);
  - B. Sc.in Engineering Psychology (USA)
- Associate Professor, in a consortium of universities in Norway
- Experience
  - Design Projects - Concept – Decommissioning Phases; Plant/New Buildings, Control rooms, Modifications
  - Operational Projects – Process Safety, Safety Culture, Leadership, New technology, Audits
  - World-wide, based in Norway, works with global projects
  - Lived in USA, Scandinavia, North-East Asia, South-East Asia, and working with the Middle East

Enablers for Autonomous Design

What we will share with you

Why did we want to do project?

What did we want to explore?

How did we do it?

What did we find out?

What are the main issues and potential mitigation?

What work do we have to do further?

The basis

- A time of great change for how complex industries operate

- Profound technological advances disrupting old ways of working

- Key basis for drive toward autonomous design
  - convergence of low-cost
  - highly capable computing/sensor/digital communications systems
  - precise position, navigation, and timing;
  - open-source hardware/software

- The push towards higher levels of autonomy is challenging how society should
  - safely design,
  - operate,
  - interact,
  - approve, and
  - accept such systems

Significant benefits expected

Expectations that such systems will return significant benefits in,

safety

reliability

availability

efficiency

affordability,

Security

and/or previously unattainable operational capabilities

Step changes in productivity

Required for safe performance

Why is it important to you?

1. Jobs, including knowledge work are being replaced by automation on a large scale
2. Disruptive environment
3. Data generation continues to grow exponentially
4. Advanced analytics and machine learning to manage data
5. Opportunities to fundamentally reimagine how and where work gets done
6. Requires increased human machine interaction

Recognizing mismatches across project experience

Recurring challenging themes

Serious unanswered questions about how to safely integrate revolutionary technological advances into a well-established, safe, and efficiently functioning system

Operating rules that can only be changed after extensive deliberation and consensus across systems

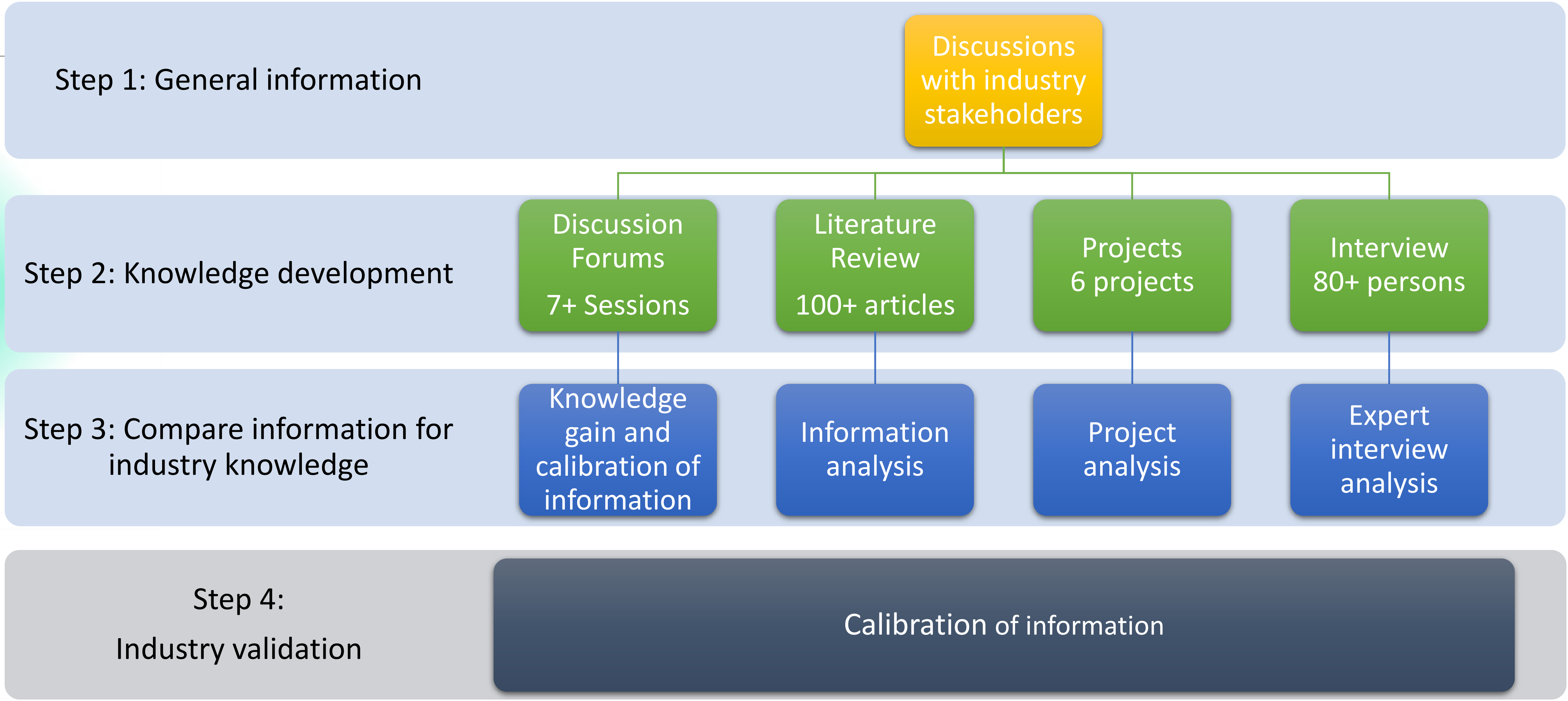
Emerging risks are imminent and present all along the value chain

Impact on the holistic environment of the technical, organizational and human related processes

Goals and aims

1. To discuss thoughts, current trends and practice, compiling patterns in design, implementation and sustainability to support development
2. To identify main issues impacting process, what are the barriers and enablers for good and resilient design process for implementation
3. To provide base insight and key current enabling concepts
4. To describe some of the main findings in the assessment, rather than serve to provide answers to challenges
5. To point to information to be further explored, whilst providing an evidence base that contributes to the safe design and implementation
6. To lead, facilitate and be a reference point for interaction and bridge between the various stakeholders in the exploration and development of safe design practices

Mixed methods approach

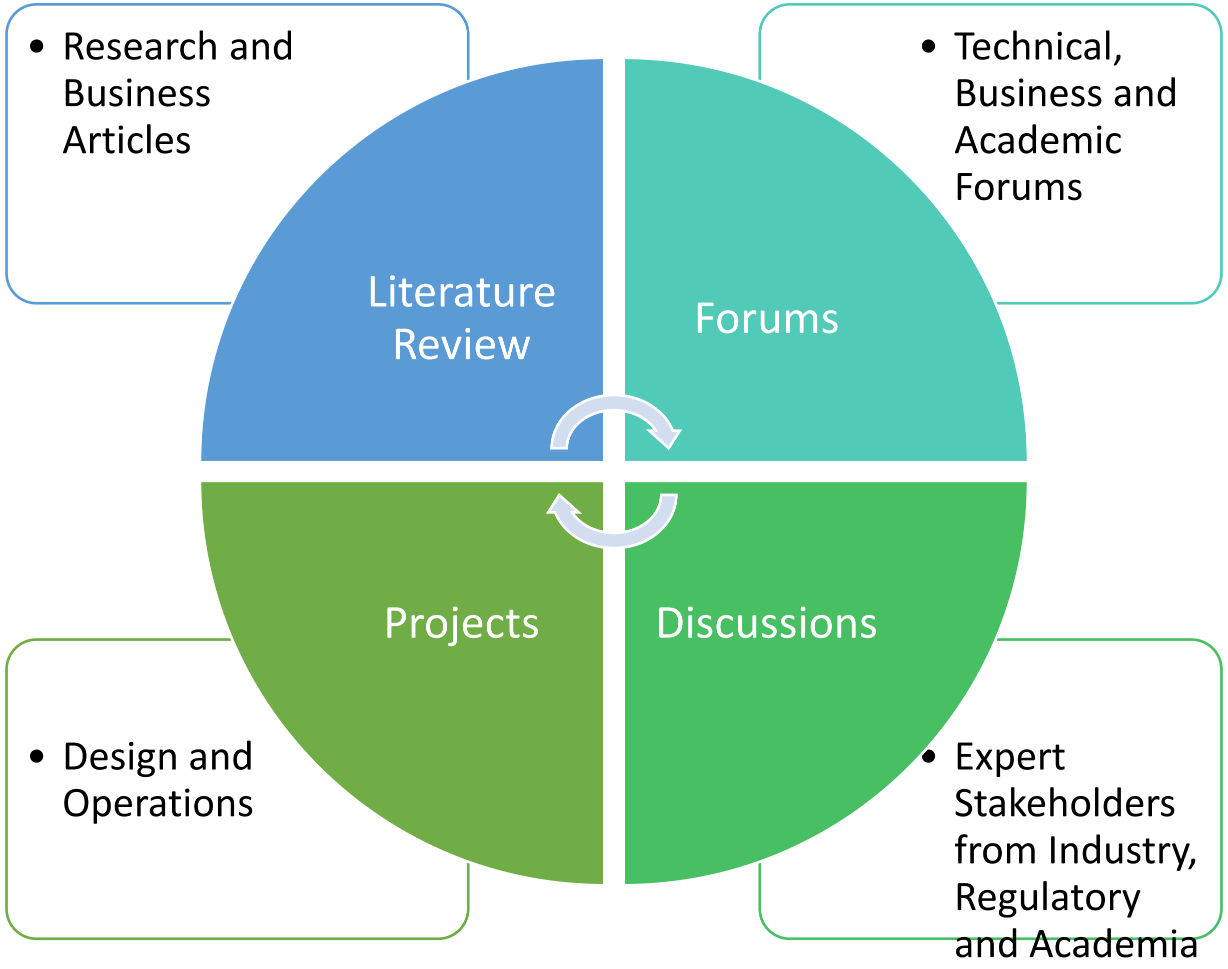


Information integrity

Projects explored
- Oil and Gas
- Transportation
- Military
- Production optimization
- Operations and maintenance

Method
- Data collection: Qualitative information from discussion forums, interviews
- Data analysis: Quantitative validation from discussion and article data

Patterns
- Tends and practices
- Barriers
- Enablers



Common themes identification

Reviewing for context information

Cross validating in discussions, forums and articles

Key barriers and enablers

Element	Barriers	Enablers
1. Definitions 2. Authority Negotiations in Autonomous System	Confusion in definitions, autonomous capabilities	Definition Taxanomy, clarification in adapatations
3 Integration Framework	Multiple Vendors, Multiple Developers, Multiple Levels of Users, Limited Integration Process	Integration Framework
4 Regulatory Framework	Loose regulations	Regulatory Framework
5 Contractual Framework	Contractual Limitations	Contractual Framework
6 Assessment integration	Distributed Technology Assessment	Holistic, Systematic Assessments (HTOE)
7 Assurance Framework	Assurance limitations	Assurance framework

#1
Need for taxonomy

Definition confusion and need for taxonomy

Barrier

Definition Confusion

- Continuing confusion exists in the reviewed projects on "automation" and AI based "autonomy", and could lead to
  - inappropriate expectations,
  - incorrect/missed design-attributes,
  - misapplication of technology and
  - non-conducive work-planning.

Enabler

Common Taxonomy

- Manner to distinguish between "automated" and "autonomous"; is by assessing the amount of
  - adaptation
  - learning and
  - decision-making that is integrated into the system
  - early to operation phase framework

Challenges related to definition of automation and autonomy

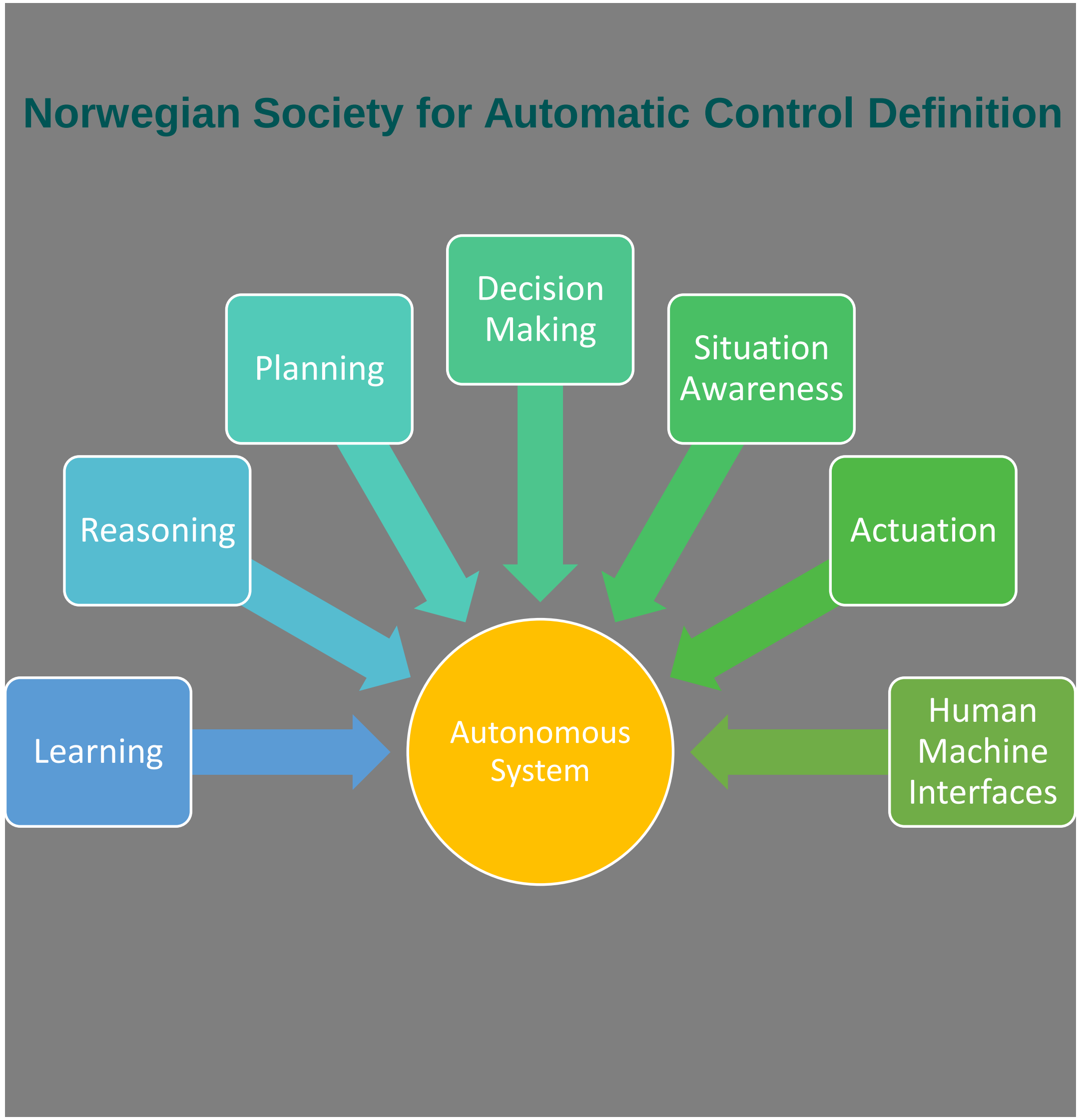
- Differences in the different sectors
- Developers who support different sectors
- Degree of automation and autonomy in design and expected in operations
- Degree the system will be used in its full function

Automated and Autonomous Systems

Automated Systems	Autonomous Systems
• typically run within a well-defined framework • are highly constrained in what tasks they can perform • decisions made or actions taken are based on predefined heuristics • perform well-defined tasks • produce deterministic results • relying on a fixed set of rules, parameters and algorithms • are without AI technologies • are embedded in autonomous systems	• learns and adapts to dynamic environments • independent from what was originally integrated or anticipated • evolves as the environment around it changes • (can) conduct a series of operations where the sequence is determined by the result of the prior operations, peripheral conditions that are monitored/measured • the results may not be deterministic • shapes its adaptive performance in accordance with the settings that it may find itself in; smart, intelligent • (can) handle unforeseen situations by performing problem solving operations • independent from human intervention

Autonomous system capabilities:

- Learning: Improvement through practice, experience, or by teaching
- Reasoning: Generate conclusions from available knowledge
- Planning: Construct a sequence of actions to achieve a goal
- Decision making: Select a course of action among several alternative scenarios – includes a notion of expected action outcome
- Situation awareness: Knowing and understanding what is going on;
- Actuation: The ability to physically interact with its environment;
- Human-machine interfaces: How the autonomous systems interact with humans.



#2
Need for renegotiation of authority

Goal confusion and need for taxanomy

Barrier

Goal Confusion

- Continuing confusion exists in the reviewed projects on “self sufficiency” and “self directedness” and could lead to
  - inappropriate expectations,
  - incorrect/missed design-attributes,
  - misapplication of technology and
  - non-conducive work-planning.

Enabler

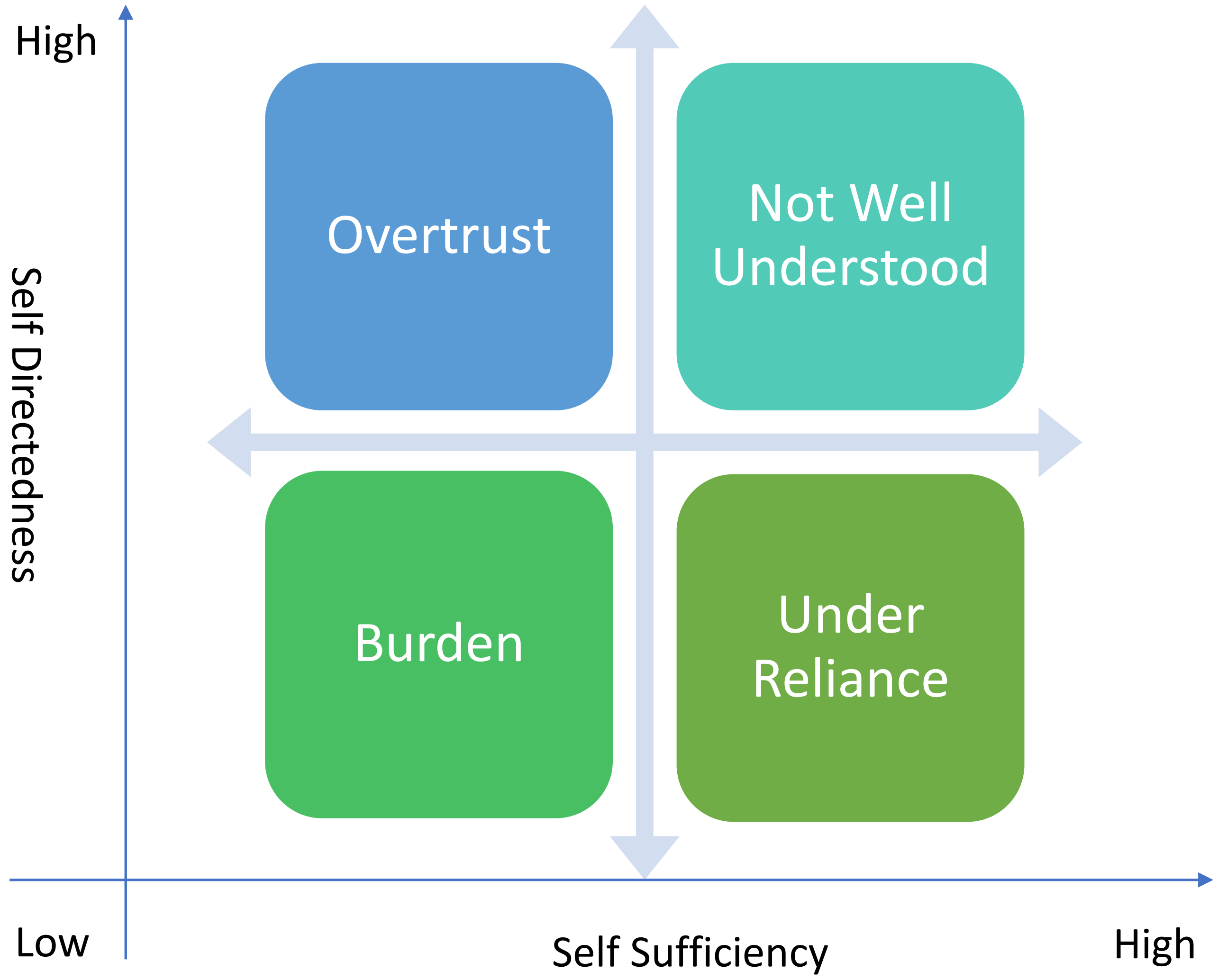
Common Taxanomy

- Manner to distinguish between “self sufficiency” and “self directedness” is by assessing the amount of
  - adaptation
  - learning and
  - decision-making that is integrated into the system
  - early to operation phase framework

Challenges in renegotiation of authority

- Designing for increasing automation and autonomous capabilities, while maintaining the dynamic balance between self-directedness and self-sufficiency
- Typical to limit self-directedness of the machine, where consequences of error may be disastrous
- Even when self-directedness and self-sufficiency of autonomous capabilities can be balanced for situational demands, the human-machine interaction may contain insufficient mental models
- Inadequate observability/understandability as a problem in operational interaction (creating a situation for renegotiating uncertain authority during operations.
- “Strong silent automation” where the system may fail to communicate information that allow humans to work interdependently with it e.g. mental-models and signals that allow operators to predict, control, understand and anticipate actions in different modes.

Renegotiation of authority between man and machine



Self Sufficient and Self Directed

- Despite the need for requiring a clear definition of project framework on automation and autonomy, there is another dichotomy that prevails designers. Self Sufficient and Self Directedness.
- An important realization is that independence from outside control does not entail the self-sufficiency of an autonomous machine; nor do a machine's autonomous capabilities guarantee that it will be allowed to operate in a self-directed manner.

Low Self Sufficiency, Low Self Directedness

- it cannot work as independently, nor can it determine its own goals.
- requires a lot of supervision
- considered a burden in some instances, as it needs a lot of direction from human team member

High Self Sufficiency, Low Self Directedness

- can work independently, but cannot it determine its own goals.
- requires direction but can function on its own
- considered an over trust in some instances, as it may cause complacency in supervision

High Self Directedness, Low Sufficiency

- self generates its own goals, problem solves
- independent from original integration, evolves, adaptive, non-deterministic
- requires a lot of supervision as system is not trusted for behaviour
- considered to be under reliance, as the system performance uncertainty requires close management

High Self Directedness, High Self Sufficiency

- self generates, works independently
- independent from human intervention
- unclear actions, challenge in intervention if system chooses to determine its own goals
- considered to be not well understood, as the system performance is not clear in its choices

#3
Integration framework

Unclear design mental model and need for integration framework

Barrier

Multiple developers, missing overall mental model

- Continuing confusion exists in the reviewed projects on mental model and could lead to
  - inappropriate design decisions and expectations,
  - incorrect/missed design-attributes,
  - misapplication of technology and
  - non-conducive work-planning

Enabler

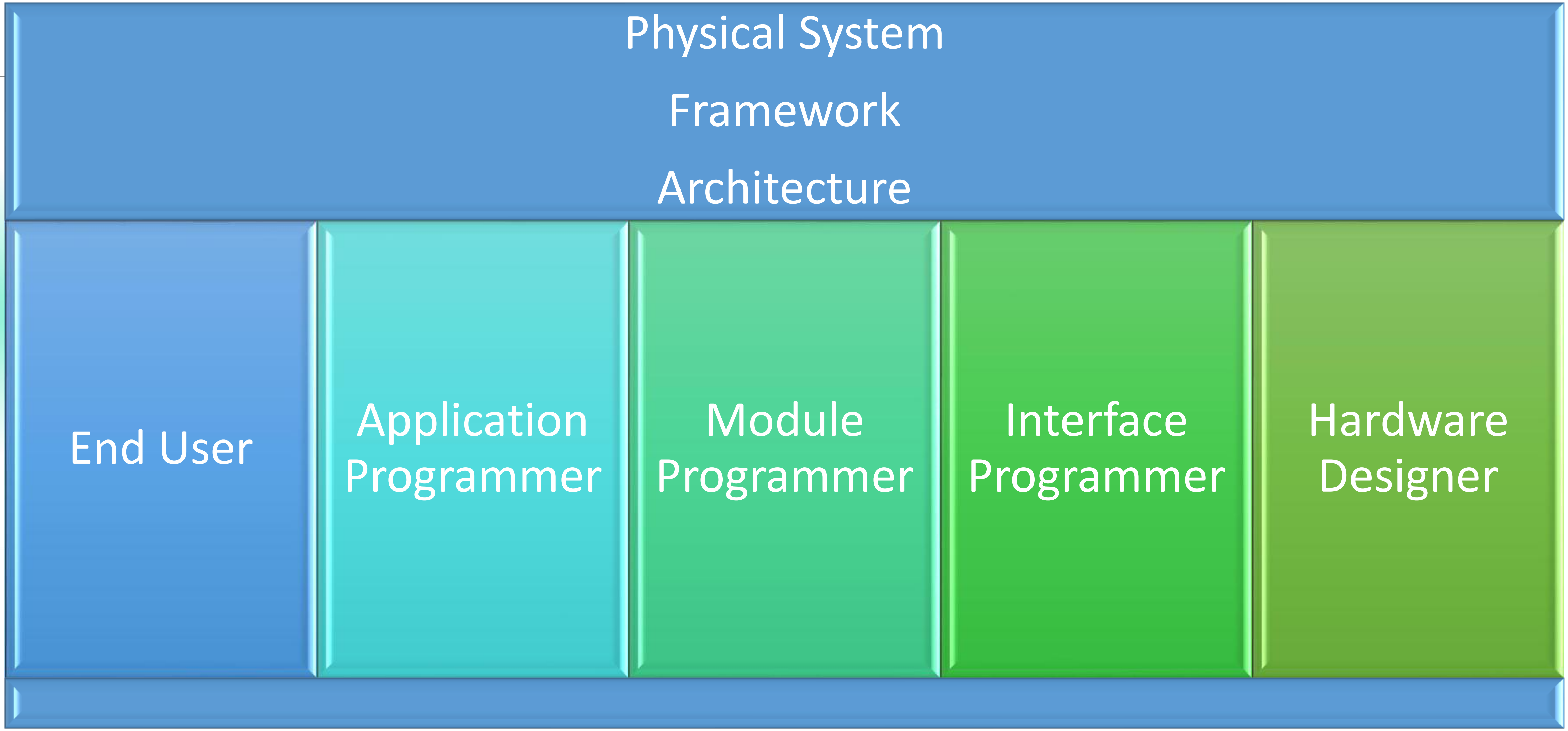
Mental model integration Framework

- Manner to distinguish mental model could be by
  - applying a triple loop system in design process where the mental model of the designer and the autonomous system is taken into account
  - acknowledging the different users with diverse demands and diverse skills
  - functionality and information for each user, not one more important than the other

Challenges in integrated mental model

- Autonomous systems are complex
- Need for developers with differentiated skills and knowledge to integrate the necessary functionality
- Designers work independently and exclusively
- Developers may be limited in operational knowledge e.g. on necessary data, parameters to define, and multiple scenarios to envision
- Typical to define and set parameters early in the single-unit designs prior to addressing cohesion needed with other units in same system;
- New systems may need to be integrated with other automation systems using machine-to-machine (M2M) communication systems

Integration framework - user model



User model interface

- Important to acknowledge the existence of different users of the software framework
- The physical system requires that each developer (also the user) provides a functionality to achieve its goal
- The system then needs to be functionally available for each developer, with proper information on parameters, limits, capabilities.

End User

- HMI
- Safety Features
- Maintenance Support
- User Manual

Application Programmer

- Modelling Paradigm
- Tools for system design, simulation, monitoring
- Software Maintenance
- Module Programming Manual

Module Programmer

- Tools – templates, test environment, documentation
- Portable libraries
- Standardized Interfaces
- Programming Languages
- Software Maintenance
- Documentation

Interface Programmer

- Specifications
- Standardizes OS Services
- Software maintenance

Hardware Designer

- Mechanical Components
- Electrical Circuits

#4
Regulatory framework

Fragemented guidelines and need for adaptive regulatory framework

Barrier

Uncoordinated regulations and standards

- Continuing confusion exists in the reviewed projects on regulatory expectations leading to
  - fragmented application in design e.g. technical and academic forums
  - subjective inputs, validation uncertainty
  - inappropriate design decisions and expectations,
  - incorrect/missed design criteria,
  - misapplication of technology and
  - non-conducive responsibility and work-planning

Enabler

Regulatory Framework

- Manner to establish a regulatory framework could be based on
  - motivation
  - balance
  - utilization
  - relevance
  - development and Implementation

Challenges to regulatory framework

Novel	Obsolete	Specific	Uncertainty
• Constantly changing envelope, makes it difficult to set criteria for e.g. design, testing, operations	• May not apply any longer since it is a machine who is a user, not a human operator	• Over inclusion • Under inclusion • Currently inappropriately applied or missed in which they should be applied	• Automated vs. autonomous • Difficult to classify, causing lack of clarity about the application of existing regulations
Example	**Example**	**Example**	**Example**
• Massive use of data for diagnosis or as decision aid, new coorelations	• Autonomous system as new team player, what information is relevant may be different	• Not correctly used for situation	• Not understood, not certain when to step in as team player

Regulatory framework

- Importance of regulator engagement for testing, verification and validation (VV), and technical maturity assessment to safeguard interests through setting expectations, management of "see-to" responsibilities and providing an open discussion platform to build trust
- Dynamic strategy of trust and innovation, transparent, strike sensible balance, creating supportive space for innovation while maintaining robust framework

Motivation

- Common understanding
- Uniformity
- Reliability
- Trust

Balance

- Innovation
- Robust framework

Utilization

- Design
- Testing
- Verification and Validation in varied environment e.g. construction, operations site
- Application

Relevance

- Different users
- Single units and multiple unit system
- Varied environment
- Sector specific

Development and Implementation

- Participation in formulation
- Sanctions and rewards

#5
Contractual framework

Traditional contracts and need for flexible contractual framework

Barrier

Traditional contractual programs

- Inflexibilities in traditional contracts lead to
  - inappropriate design decisions and expectations,
  - incorrect/missed design criteria,
  - misapplication of technology and
  - non-conducive responsibility and work-planning
  - fragmented application in design
  - hold up problem
  - distorted investments and poor outcomes
  - "shading", cutbacks when one party feels it is getting the shorter stick of a deal

Enabler

Flexible Relational Contractual Framework

- Manner to establish a flexible contract framework to support could be through,
  - relational contracts based for longer term
  - adaptive learning elements during design
  - design framework for innovation, as autonomous decision-making functions cannot be fully specific ahead
  - room for adjustment across multiple developers within design framework
  - especially useful for highly complex relationships in which it is impossible to predict every what-if scenario.

Challenges in developing relational contractual models

- Managing risks in change handling across developers
  - Changing framework can mean changes in specific safety performance details, requiring another cycle of risk assessments and consequence understanding

- Managing communication in change handling in contracts
  - Changing developers within projects, bringing different mental models, and different levels of understanding based on skill set, and moving target in autonomous goals

- Driven by distrust
  - Traditionally used contracts as protection
  - Range of tactics to lock in so as to protect
  - “Shading” when outcome is not what is expected
    - Misalignment in mutual reward
    - Cutbacks in subtle ways,
    - May be unconscious to compensate

Contractual framework

- A relational contract that specifies mutual goals and establishes governance structures to keep the parties' expectations and interests aligned over the long term.
- Designed from the outset to foster trust and collaboration, this legally enforceable contract is especially useful for highly complex relationships in which it is impossible to predict every what-if scenario.
- Vested methodology. "What is in for we" –traditional contract but also contain relationship-building elements such as a shared vision, guiding principles, robust governance, desired outcomes,
- Benefits include cost savings, improved profitability, higher levels of service, and a better relationship.

Lay Foundation	• Establish partnership mentality, conscious effort to create trust, transparent about their high-level aspirations, specific goals, and concerns.
Co Create	• Explain vision and goals for the relationship, not just the one with greater power
Adopt	• Guiding Principles—reciprocity, autonomy, honesty, loyalty, equity, and integrity
Align	•Expectations - responsibilities, pricing, and metrics; joint instead of adverserial
Remain Aligned	• **Relationship Team** – relationship health • **Excellence Team**- quality control, transformational initiatives, continuous improvement, prioritization/ tracking of innovation ideas. • **Sustainability Team**- workload, scheduling, recruiting, retention • **Best Value Team** - finance, billing, workload optimization, operational efficiencies

#6
Systems approach
and holistic design and operational risk assessment

Non-systematic approach and need for systematic risk assessment

Barrier

Non-Systematic Assessment for New Technology Design and Implementation

- Non-systematic risk assessment lead to
  - inappropriate design decisions and expectations,
  - incorrect/missed design criteria,
  - misapplication of technology and
  - non-conducive responsibility and work-planning
  - fragmented application in design assessments

Enabler

Systematic Design and Implementation Assessments - HTOE

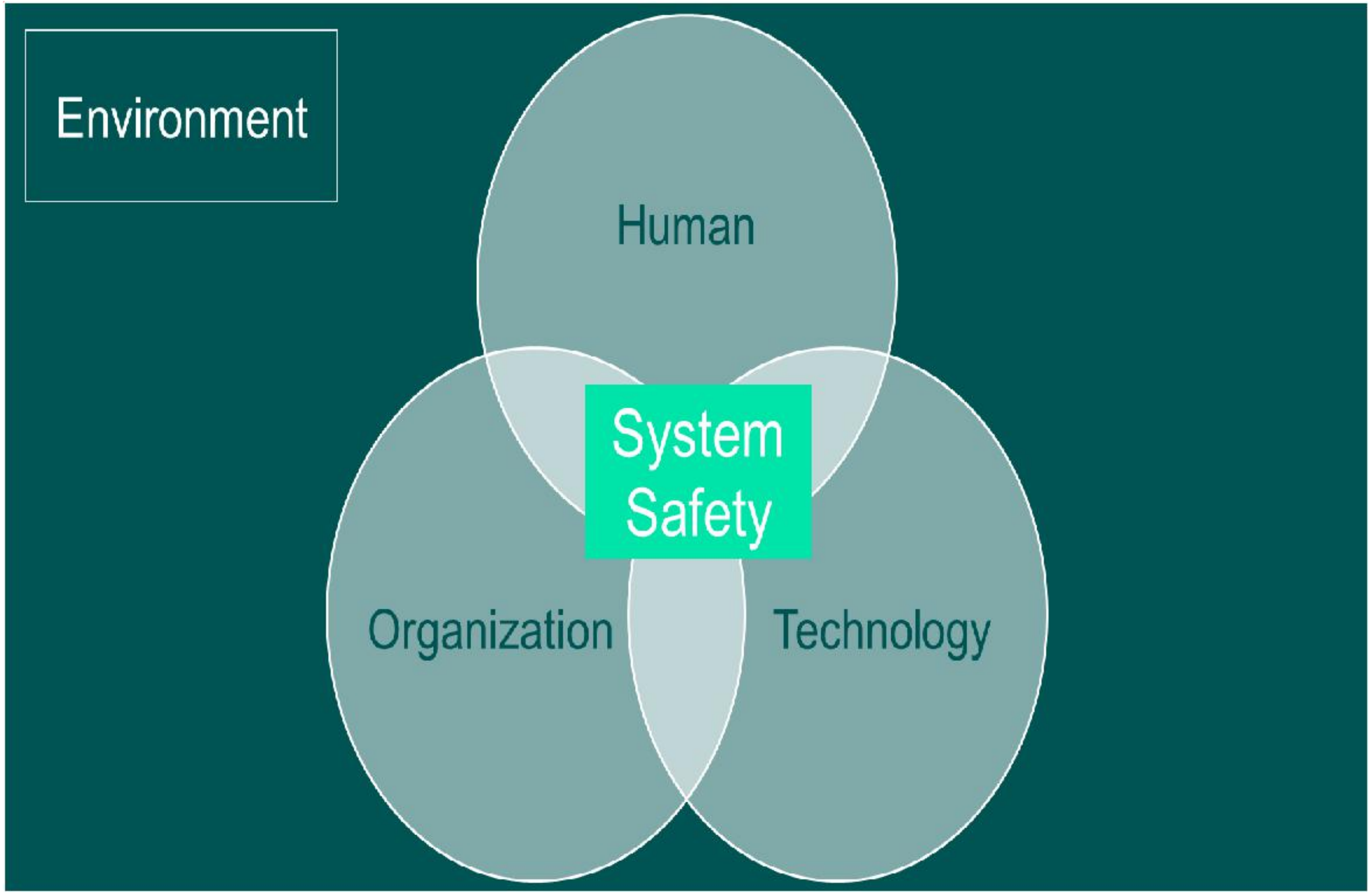
- Manner to establish sound design assessment is through
  - applying a human factors, systems engineering approach in risk assessments
  - applying a higher scale cyclical approach, with repeats on assessments when new information is updated into system
  - conducting holistic risk assessment for systematic understanding of risk, impact and consequences along the value chain in different modes e.g. design, operations, etc.

Challenges to systematic risk assessment

- Multiple vendors, multiple stakeholders, unclear authority on overall capabilities and limitations of system as it is being developed
- Adaptive and dynamic evolving development, each change may need a revisit to a prior tested condition, requiring time and attention to the adjustments in performance capabilities, limitations and pockets of unpredictability
- Novelty, complexity and consequences create challenges for a bullet proof safety assessment
- Responsibility for risk assessment, design errors can be an issue with multiple vendors/developers with different mental models
- Ticking the box exercise approach when it is not understood what, how much and when to assess
- Silo thinking in addressing technical, organizational, and environmental elements in new technology development and implementation

Holistic and systematic risk assessment

Expertise is in helping you manage these three dimensions of technology, organizational and human elements, all operating in a specific environment.



Systematic risk assessment

- The Human Factors discipline applies a systematic assessment process, where the discipline addresses system engineering to gain knowledge on new technical concepts that will require change in business and operational models; organizational framework and processes; human competence, skills and even attitude; functioning in a physical environment

Interdisciplinary Thinking
- Technology, organization, human in a physical environment

Design
- Single Unit
- Multiple Units
- Contextual Environment
- Dynamic Conditions

Operations
- Contextual Environment
- Dynamic Conditions
- Scalability
- Change Handling

Elements Specific
- Definition of operational domain
- Definition of autonomous levels
- AI capabilities and limitations
- Error behavior of team players non team players

Elements External
- Other elements capabilities and limitations

#7
Assurance for autonomous system development and implementation

Fragmented assurance practice and need for aligned assurance processes

Barrier

Traditional Assurance Practice e.g. Performance Standards

- Inflexibilities in traditional assurance practice lead to
  - inappropriate design decisions and expectations,
  - incorrect/missed design criteria,
  - misapplication of technology and
  - non-conducive responsibility and work-planning
  - fragmented assurance in design and operational assessments

Enabler

Alternative Assurance Process

- Manner to establish a design assessment could be through
  - applying a step by step, phased process for assurance activities
  - sector and context oriented
  - test environments, then controlled field
  - then in actual use with strict criteria on acceptable metrics

Challenges to adaptive assurance processes

- Current regulations are typically based on defined performance standards, based on well defined functions, stable contexts, and on standards
- Although components/modules can be subject to performance standards, autonomous systems pose a fundamental challenge, precisely because they go beyond the execution of a limited set of functions in well-defined context
- While for many engineered systems, testing either through real deployment or via simulation is regarded sufficient, the unique challenges of integrated systems communicating independently, their dependence on sophisticated software control and decision-making, and their increasing deployment in safety-critical scenarios require a stronger form of assurance
- It is difficult to formally verify and validate the predictability and reliability; and probability of failure
- The current practice is to develop in-house testing and VV, and it is not known if all critical elements are covered prior to deployment

Assurance for autonomous systems

- Step by step, phased process for assurance

Areas for Assurance

- the importance of understanding the physical environment it will function in;
- the single autonomous system itself;
- in relation to other systems;
- in relation to human interplay; and
- in relation with safety monitoring systems.

Assurance Approach 1

- apply current regulatory scope
- limit scope of autonomy, semi autonomous
- the human remains as a team player or constrain environment
- decreased vigilance, reduced situational awareness
- limits the benefit of autonomous design

Assurance Approach 2

- apply current regulatory scope
- testing regulatory and phased in different test contexts
- continuously updated with novel and unforeseen
- individuate context, select functions, confirm to operative norms

Assurance Approach 3

- trained users to monitor in the wild
- phased trials to progress as refined, addressed and reliability improved
- accepted effect metrics
- multiple assurance activities widening each time the elements pass a condition

Discussion

Vysus Group

Dr. Nalini Suparamaniam-Kallerdahl

Technical and Business Leadership Team

Head of Human Factors, Resilience in Operations/Principal Consultant

+47 4685 1895

nalini.sk@vysusgroup.com

Thank you