2014 STAMP Conference
MIT Partnership for a Systems Approach to Safety

“Using STAMP Principles in Risk Management of Large Scale Pipeline Projects”

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Using STAMP Principles in Risk Management of Large Scale Pipeline Projects

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Using STAMP Principles in Risk Management of Large Scale Pipeline Projects
Background (1/3)

**ILF Group**

- **Oil & Gas**
  - Upstream facilities
  - Pipeline systems
  - Underground storage facilities
  - Tank farms & terminals
  - Refineries & petrochemical plants

- **Water & Environment**
  - Hydropower plants
  - Water transmission systems
  - Water & wastewater networks
  - Water & wastewater treatment plants

- **Energy & Climate Protection**
  - Thermal power plants
  - Desalination plants
  - Renewable energy
  - Climate protection
  - Power transmission & distribution systems

- **Transport & Structures**
  - Airports
  - Roads
  - Railways
  - Urban transport systems
  - Tunnels & caverns
  - Buildings & structures
  - Alpine resorts
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Background (2/3)

- Oil & Gas

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Motivation

Previous Master Thesis > Evaluating Project Safety (System Engineering and Safety Management) in an Organization for implementation of STAMP principles

Parallelism Hazard Analysis ↔ Project Risk Analysis

- Resource intensive, benefits questioned
- Impact on actual Project execution?

Transferring techniques might aid in improving established Project Risk Management practice

- e.g. PMI (Project Management Institute)
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Context of Large Scale Pipeline Projects (1/6)

- **Long Distance (Trans-National) Pipeline Systems (1/2)**

- Several 1,000 km length; Throughputs up to 60 bcma (gas) or 100 MTA (oil)

- Pipe Diameters 32”, 48”, 56”; Pressures typically in class ANSI 600 (up to 100 bar)

- Typical large Pump Stations up to 50 MW / Compressor Stations up to 200 MW / Metering Stations / Pressure Reduction and Offtake Stations

- Interconnecting to other systems/ facilities
  - Upstream/ Downstream Pipeline Systems
  - Loading Terminals/ Ports
  - Production facilities
  - Storage and Refining facilities
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Context of Large Scale Pipeline Projects (2/6)

- **Long Distance (Trans-National) Pipeline Systems (2/2)**

![Image of pipeline projects]
Context of Large Scale Pipeline Projects (3/6)

- **General Context**

- **Geopolitical aspects**

- ** Developed by Joint Ventures**
  - Pre-mature Project specific organizations
  - Different business & safety cultures

- **Driven by aggressive Schedules due to commitments with**
  - Interconnecting facilities/ projects along the value chain (supply/ demand)
  - Shareholders and Lenders (ROI greatly dependent on timely pipeline operation)
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Context of Large Scale Pipeline Projects (4/6)

Stakeholders and Agreements Landscape

- **Producers / Shippers**
- **Investors / Operators / Owners**
- **Government / Regulators**
- **Markets / Offtakers / Buyers**
- **Engineers / Procurement / Suppliers**
- **Landuse / Owners**

**Finance Institution(s)**

- Compliance with IFC Standards
- Intergovernmental / Host Governmental Agreements
- Taxes, Royalties Agreements
- Direct Contracts / Guarantees
- Indirect Guarantees

**FEED**

- Project Management
- Throughput Guarantees
- Tariff Agreement

**Contracts**

- Completion Guarantees

**Compliance with IFC Standards**

- Agreements
- Taxes, Royalties Agreements

**Intergovernmental / Host Governmental Agreements**

- Agreements
- Taxes, Royalties Agreements

**Compliance with IFC Standards**

- Agreements
- Taxes, Royalties Agreements

**Direct Contracts / Guarantees**

- Agreements
- Taxes, Royalties Agreements

**Indirect Guarantees**

- Agreements
- Taxes, Royalties Agreements
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Context of Large Scale Pipeline Projects (5/6)

- **Complex Project Execution Structures**
- **Multiple contractors involved**
- **Cascading requirements difficult**
Context of Large Scale Pipeline Projects (6/6)

Owner
IOC (International Oil Companies) & other Shareholders

Regulator
Policy Permits
Reporting Applications

Project Policy
Project Reporting

Public
International & National NGOs

Land Owners

Local Communities

Lenders

Interconnecting Systems and Facilities

International Managers
EPCM Contractor
PMC Contractor

-LInstructions -Specifications Plans & Procedures

Deliverables Reporting

Local Executors
EPC Contractors
Construction Contractors
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Risk Management in Large Scale Pipeline Projects (1/5)

- **Top-Down Risk Management driven by Project Owner**

  - Limited resources available for comprehensive and participative approaches (workshops perceived by managers as inefficient)

  - Based on Lessons Learned, Checklists, SWOT

  - A lot of the effort used in identifying Causes of Risks as Risks

  - Project Risk Probabilities effectively assessed by considering
    - Previous experience of involved individuals
    - Risk Proximity
    - Risk Manageability
Bottom-Up Risk Management after Project Sanctioning

- Transition between Define and Execute
- Instead of cascading Risk Control Requirements and so keeping the top-down structure, contractors start from scratch
Project Risk Analysis established practice appears superficial

- Risk Mitigation Strategies derived often seem just common sense,
  - e.g. „ensure proper…“

- Formulations used tend to be vague for those who have not been involved in an analysis > Records highly vulnerable to interpretation
  - Also influenced by concerns about who will read the reports

- Results are perceived as highly dependent on who is involved in the analysis

- Analysis efforts stop on a rather high-level, unless later it is identified that Risk Mitigation Strategies do not work
## Typical Risk Register Content

<table>
<thead>
<tr>
<th>Risk Identification</th>
<th>Risk Analysis</th>
<th>Risk Mitigation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Land Acquisition process delayed</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Causes: Land requirements data not delivered by engineering</td>
<td>Consequences: Delay in start of construction</td>
<td>Owner</td>
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<td></td>
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</tr>
<tr>
<td><strong>Construction Contractors do not comply with ESIA Plans</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Causes: Poor HSE culture</td>
<td>Consequences: Breach in environmental regulations. Stop of Project activities. Fines</td>
<td>Contractor</td>
</tr>
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<tr>
<td></td>
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<td></td>
</tr>
</tbody>
</table>
Small impact on Contracts Development

- Contracts built from "standard" templates and project management requirements
- Communication of Project Risks sometimes deliberately avoided
- Focus is on liabilities
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Development of a Risk Mitigation Framework with STAMP (1/11)

**Scope**

Operating Asset Life Cycle

- **Appraise**
  - Opportunity value identification
  - Feasibility Package preparation
  - Project framing

- **Select**
  - Opportunity framing
  - Conceptual Design Package preparation
  - Project strategy planning

- **Define**
  - Opportunity & venture definition
  - Permit engineering
  - Environmental, Social Impact Assessment
  - Basic Design Package preparation
  - Tendering
  - Project execution planning

- **Execute**
  - Opportunity realization
  - Procurement & contracting
  - Detail, construction & vendor design
  - Construction
  - Commissioning & trial operation
  - Project execution management

- **Operate**
  - Business control
  - Operation
  - Optimization
  - Maintenance
  - Project contracts close out
  - Business closure
  - Dismantling
  - Rehabilitation
  - Modification
Typical Pipeline Project Goals

- in STAMP terminology: defining Goals

Project Design Goals

- Deliver the Project to ensure target annual throughput
- Deliver the Project to enable safe pipeline operation

Project Execution Goals

- Deliver the Project in compliance with HSE regulations, norms and standards
- Deliver the Project without overrunning sanctioned Project Budget
  - Achieve Ready For Operation Target Date
Typical Unacceptable Project Losses (to be prevented)

- in STAMP terminology: defining Accidents or Unacceptable Losses

(Project) Operation Losses

- Pipeline system does not deliver target annual throughput
- Major fire and/or explosion during operations

Project Execution Losses

- Breach of HSE regulations, norms and standards
- Project Budget overrun
- Ready For Operation Target Date not achieved
Main Pipeline Project Risks (Limited Control by Project)

- in STAMP terminology: Identifying High-Level Hazards

- Geohazards along the pipeline route
- Weather conditions
- Archaeological finds along the pipeline route
- Steel and fuel price development
- Security threats
- Political and economic developments
Main Pipeline Project Risks (Control by Project)

- **Construction contractors** do not perform as required during Project construction activities
- **Damage to adjacent local infrastructure** during Project construction activities
- **Land acquisition** is not completed when required to be handed over to construction contractors for start of related Project construction activities
- **Authorities do not award permits** to the Project when required for start of related Project construction activities (*partially controllable*)
- **Public opposition** to the Project and its activities (*partially controllable*)
- **Line pipe and/or other LLIs are not available** when required to be used by construction contractors in the Project construction activities
- **Major fire and/or explosion** during Project commissioning activities
Risk Mitigation Strategy

- in STAMP terminology: deriving High-Level Safety Constraints

Project Risk: Major fire and/or explosion during Project commissioning activities

- Risk Mitigation Strategy: Major fire and/or explosion during Project commissioning activities must be prevented
Risk Mitigation Action Plan

- in STAMP terminology: Generating High-Level Safety Requirements, Risk Control Actions

Risk Mitigation Strategy: Major fire and/or explosion during Project commissioning activities must be prevented

- Plan sufficient time for Project Commissioning activities
- Early involvement of Operations in the development of Project Commissioning plans and procedures
  - SPA > Owner – Operations Manager
- Early and sufficient training of Contractors and Operations personnel in Project Commissioning plans and procedures
- Close supervision of Project Commissioning activities
Potential Threats to Project Risk Mitigation Action Plan

- in STAMP terminology: STPA 1 Inadequate Control Actions

Risk Mitigation Action: Early involvement of Operations in the development of Project Commissioning plans and procedures

- Operations is not involved in the development of Project Commissioning plans and procedures.
- Operations is timely involved in the development of Project Commissioning plans and procedures, but their recommendations are incorrect.
- Operations is timely involved in the development of Project Commissioning plans and procedures, but their recommendations are ignored.
- Operations is involved in the development of Project Commissioning plans and procedures too late.
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Development of a Risk Mitigation Framework with STAMP (9/11)

- Detail Partial Project Execution Structure
- Risk Mitigation Action: Early involvement of Operations in the development of Project Commissioning plans and procedures
- SPA Owner – Operations Manager
- Roles & Responsibilities
- Multiple controllers
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Development of a Risk Mitigation Framework with STAMP (10/11)

Potential Causes of Threats to Project Risk Mitigation Action Plan

- in STAMP terminology: STPA 2 Causes of Inadequate Control Actions

RMA.ACCIDENT.2
Early involvement of Operations in the development of Project Commissioning plans and procedures

ICA.ACCIDENT.2.1 - Operations is not involved in the development of Project Commissioning plans and procedures.

ICA.ACCIDENT.2.2 - Operations is timely involved in the development of Project Commissioning plans and procedures, but their recommendations are ignored.

ICA.ACCIDENT.2.3 - Operations is timely involved in the development of Project Commissioning plans and procedures, but their recommendations are incorrect.

ICA.ACCIDENT.2.4 - Operations is involved in the development of Project Commissioning plans and procedures too late.

1. Control input or external information wrong or missing
2. Inadequate control algorithm (flaws in creation, process changes, incorrect modification or adaption) and/ or Process Model inconsistent, incomplete or incorrect
3. Inappropriate, ineffective or missing control action and/ or Operation delays
4. Component failures, changes over time
5. Conflicting control actions
6. Unidentified or out-of-range disturbance
7. Process output contributes to system hazard
8. Incorrect or no feedback information provided and/ or Feedback delays
Potential Causes of Threats to Project Risk Mitigation Action Plan

1.1 Allocation of resources for start of involvement of Owner's Operations personnel is not provided by Owner's management

1.2 Incorrectly scheduled involvement of Owner's Operations personnel in Project Schedule

2.1 Incorrect understanding of scope and extent of development of Project Commissioning plans and procedures

2.2 Too optimistic estimation of Operations Engineer manhours required in development of Project Commissioning plans and procedures

2.3 Incorrect definition of required competence for Operations Engineers involvement in development of Project Commissioning plans and procedures

3.1 Late provision of instruction for Operations Engineers to start alignment with Engineering Contractor's Commissioning Engineers

3.2 Late provision of instruction to Engineering Contractor's Commissioning Manager for start of alignment between Owner's Operations Engineers and Engineering Contractor's Commissioning Engineers

4.1 Operations Engineers are not available when required start of alignment with Engineering Contractor's Commissioning Engineers

4.2 Operations Engineers are replaced during initial development of Project Commissioning plans and procedures

5.1 Operations Director requires support of Operations Engineers in another task in the same time frame

7.1 Incorrect advise is provided to Engineering Contractor's Commissioning Engineers

7.2 Correct advise provided to Engineering Contractor's Commissioning Engineers is not considered

8.1 Operations Engineers report start of alignment with Engineering Contractor's Commissioning Engineers, but effectively it has not started

8.2 Operations Engineers report start of alignment with Engineering Contractor's Commissioning Engineers too late
Comparison development of Risk Mitigation Strategies

Risk Management Planning phase similar

- Defining Goals, Risk Matrix approach vs. Defining Unacceptable Losses, Roles and Responsibilities

STAMP framework more structured

- Appears to be less dependent on who is involved in the Project Risk Analysis
- Traceability straightforward, rationale readily available

Identified ICAs and causes of ICAs in the example are credible

More detailed and precise Risk Mitigation Strategies (requirements) can be derived with STPA
Integration of STAMP into regular Project Risk Management (1/2)

Introducing different levels of Project Risks/ Risk Mitigation Reqs

- Similarly System Hazards/ Sys reqs ↔ Lower Level Hazards/ Lower Level reqs

STPA can be used in development of Risk Mitigation Strategies

- Short term > In ongoing projects
  - Use in Risk Monitoring and Risk Review

- Long Term > Development/ Improvement of
  - Project Management standards (e.g. requirements, but also as checklists)
  - Contracts

STPA can be used independently by an analyst with knowledge of techniques and Project context
Integration of STAMP into regular Project Risk Management (2/2)

Regular Risk Management
- Risk Management Planning
- Risk Identification and Analysis
- Risk Mitigation Strategy
- Risk Mitigation Action Plans
- Risk Tracking and Review

STAMP-based Risk Management
- Goals, Unacceptable Losses, Safety Control Structure
- High-Level Hazards
- High-Level Safety Constraints
- High-Level Safety Requirements, Control Actions
- STPA Step 1 Unsafe Control Actions
- STPA Step 2 Causes of UCAs
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More Information

- **MIT Partnership for a Systems Approach to Safety**
  - Papers, Masters Theses and Ph.D. Dissertations
  - References: Helferich, Samedi

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- **2nd European STAMP Conference (22-23 Sept 2014 @ Uni Stuttgart)**