HFC

**HFC – forum for human factors in control**

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# RAPPORT

TITTEL

**Team dynamics in critical situations – Crew Resource Management (CRM) and other approaches;**
**Resultater fra HFC forum, 10. til 11.april 2013. (Møte nr 17)**

FORFATTER/REDAKTØR

Stig Ole Johnsen

OPPDRAGSGIVER(E)

HFC forum



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SAMMENDRAG


Denne rapporten inneholder agenda, deltakerliste, presentasjoner og relevante artikler fra HFC forum møtet den 10. til 11.april 2013 i Bergen. Det er møte nummer 17 i regi av HFC forum. Det vedlagte materialet er fra:

| | |
|---|---|
| M. Rosen | Managing team dynamics in routine and crisis situations: Evidence-based strategies |
| B. Sætrevik | Shared knowledge in second-line emergency handling teams |
| M. Ydalus | Evolution of CRM in aviation |
| A. Wahlstrøm | Å utvikle et CRM-kurs: Erfaringer fra et prosjekt med Kystverket |
| S.O. Johnsen | CRIOP med CRM fra 2004 – bakgrunn og erfaringer fra bruk |
| G. Christiansen | Crew communication in critical phases of flight |
| R. Pikaar | HF Case studies - On-shore supervision of off-shore gas production |
| S. Dahle | CRM brukt i skipshåndtering |
| L.B.Hviid | Bruk av CRM trening – praktiske erfaringer |
| L. R. Heemstra | Workshop – "Implementing a CRM Course in your area of Operations" |
| R. Valle | Developing CRM Training |




| STIKKORD | NORSK | ENGELSK |
|---|---|---|
| GRUPPE 1 | Menneskelige faktorer | Human factors |
| GRUPPE 2 | ISO 11064 | ISO 11064 |
| EGENVALGTE | Sikkerhet | Safety |

# INNHOLDSFORTEGNELSE

# 1 Evaluering av møtet og innspill fra møtedeltakerne

## 1.1 Innledning

I denne rapporten gis en oppsummering av HFC møtet den 10.-11.april i Bergen, *"Team dynamics in critical situations – Crew Resource Management (CRM) and other approaches"*, med presentasjoner, relevante fagartikler (”papers”), oppsummering av evaluering fra deltakerne og liste over alle deltakere.

I det nedenstående har vi oppsummert fra de skriftlige evalueringene som deltakerne leverte inn.

## 1.2 Hovedbudskap

Hovedbudskapet var at CRM trening burde innføres i olje og gass bransjen i Norge.
Aktørene bør systematisk måle effekten av CRM trening, ved å evaluere om brukerne er fornøyd med CRM treningen, om adferd endres, om teamet fungerer mer effektivt og om sikkerheten og robustheten forbedres.

## 1.3 Evalueringer

Vårmøtet i HFC forum samlet over 60 deltakere, både tema og foredragsholdere ble positivt mottatt. Det norske HFC forumet er en møteplass med mange forskjellige deltakere. Det er også en del som er relativt nye til forumet, så vi har en utfordring med å gi alle deltakerne noe av interesse. Vi får derfor mange forskjellige tilbakemeldinger, alle konstruktive og gode kommentarer som bidrar til å påvirke møteform og møteinnhold.

Det var mange forskjellige presentasjoner, fra forskjellige ståsteder som forskning, undervisning, drift osv. Presentasjonene ble generelt positivt mottatt. Balansen mellom presentasjoner, diskusjoner og pauser synes å være bra. Første dag ble avsluttet til tidsfristen satt av hotellet. Møterommene var litt trange til det store antallet av deltakere.

"Workshopen" som ble arrangert ble oppfattet som svært god, med en engasjert foreleser, L. R. Heemstra. Det ble ikke så god tid til å diskutere i grupper.

## 1.4 Formen på HFC møtene

Det virker som om formen på møtene, dvs. over to dager med hyppige pauser mellom forelesningene, fungerer bra. Forelesningene, paneldiskusjonen og muligheten for å diskutere i et fagnettverk ble trukket frem positivt. Studentene satte stor pris på å kunne delta. Det ble påpekt at det var viktig med tid til debatter og pauser slik at det blir tid til å utveksle erfaring med andre.

## 1.5 Samarbeid med HFN i Sverige

Det norske HFC forumet har et godt løpende samarbeid med human factors nettverket (HFN) i Sverige. Medlemmer fra HFN deltar aktivt på HFC møtene og de inviterer medlemmer i HFC til sine seminarer og møter. Aktuelle HFN samlinger kan være:

- "HFN-konferens, Människa-teknik-organisation i säkerhetskritiska verksamheter ", 20-21. november, 2013. Ytterligere informasjon: www.humanfactorsnetwork.se

**1.6 Tema og forelesere til de neste HFC møtene**

Av tema som ble trukket frem som spesielt interessante til neste møte, kan nevnes:

- "Lean production" – vil det bli framtiden på Norsk sokkel, med smalere marginer og økt krav til effektivisering – hvilke teknologiske løsninger, organisasjonsformer og opplæring trengs da? Hva er konsekvensen av lavbemannede installasjoner? Har vi noe å lære av andre industrier og andre områder?
- Erfaringer fra fjernstyring av bemannede og ubemannede plattformer. Bl.a. Human factors utfordringer knyttet til økt grad av ubemannede plattformer og fjernstyring – økt bruk av videokonferanser - bruk av CCTV.
- Hvordan håndtere avvik og kriser ved liten bemanning "Crisis management"
- "Threat and error management", Måling av Human Factor performance
- Beredskap og beredskapsorganisasjoner (hvordan dimensjoneres dette i forbindelse med lavbemannet drift?)
- Grensesnitt mellom automatikk og menneskelig intervensjon – ved økt grad av automatiseringer. Bruk av "Cognitive engineering" for å utforme løsninger, erfaringer fra automasjonsmiljøet - erfaringer fra styring av ubemannede droner - erfaring fra romfart og fjernstyring.
- Innovativt design fra andre bransjer eller egen bransje, andre designmetoder, andre organisasjonsmetoder og andre organisasjonsfaktorer
- Etikk, sikkerhet og risikokommunikasjon, hvordan kommuniseres risiko på en god og involverende måte?
- Oppfølging av bruk av CRM - "Hjelper treningsprogram – som for eksempel CRM" Hvor er bevisene?
- Omvisning romfartssenter (Trondheim/Ciris); Har vi noe å lære av andre industrier - Framtidige teknologiske muligheter og utfordringer (Teknologi push eller pull)
- Gjennomgang av metoder som oppgaveanalyse, kommunikasjonsanalyse og , arbeidsmiljøanalyser. Anvendelse av HF metoder i ulike faser av prosjektet - Konkret erfaring med hva som er kritisk for å få gjennomført gode analyser på rett tid som beslutningsgrunnlag og med effekt. Hva skal til?
- HRA - analyser - når benyttes de nå på nye områder? Metoder for Human Reliability Analyser, Human error identification, Presentasjon av PETRO HRA
- HF analysemetoder, praktiske eksempler på "situational analysis", "task analysis" og metodikk (Stavanger) – Gå gjennom et "case" - vis gjerne en film med en situasjon, bruk av "situational analysis" eller "task analysis".
- Sikkerhetskultur – hvordan kartlegge, og bygge sikkerhet
- HF i subsea operasjoner (f.eks vedlikeholdsaktiviteter som ROV operasjoenr etc..
- Standardisering av Human Factors (HF) innen olje og gass industrien
- Utvikling av verifikasjons og valideringsverktøy
- Diskusjon av endringstakt innen olje og gass - tar man i bruk ny teknologi raskt eller tar det lang tid - for eksempel bruk av CRM trening som har vært diskutert tidligere - hvorfor tar det lang tid å innføre det ?
- Gjennomgang av noen gode case - Hva skjedde på Scarabeo 8 høsten 2012 da den fikk slagside, var det en feiloperasjon i forbindelse med ballastering? I den sammenheng trekk inn erfarne operatører som har vært med på noen hendelser og som kan fortelle hva som gikk bra/dårlig – og hvordan/hvorfor operatørene tar feil valg/beslutninger i en kritisk situasjon. Det hadde vært veldig interessant perspektiv og ikke bare fått teori.
- Organisatoriske intervensjoner - samhandling mellom boreoperatør og Operatør - fungerer det greit og knirkefritt
- Proaktive data brukt i vedlikeholdsstyring og i andre barrierefunksjoner

- Hvordan ulike disipliner tilnærmer seg oppgaven å designe for sikkerhetskritiske miljø. Tema som går på tvers av disipliner– det blir ofte enten et rent teknisk perspektiv eller et psykologisk perspektiv.

Av nye forelesere ble følgende ønsket til neste møtet. (Listen inneholder navn som har vært trukket frem tidligere uten at de har fått plass):

- Noen med erfaring fra andre områder for eksempel transport, jernbane, noen med erfaring fra styring av ubemannede fly, droner
- Gjerne fra flere sektorer på samme tema; blanding av teoretikere og praktikere (som kan komme med konkrete eksempler)
- Fra andre forskningsmiljø vi ikke hører så mye fra: MiT – "user interface group", Google – erfaring ubemannede kjøretøyer eller fra miljøer som: Fraunhofer FKIE (Tyskland)
- Noen med erfaring fra organisatoriske intervensjoner
- Noen med praktisk kompetanse
- Noen som har gransket en ulykke
- Noen fra Petro HRA (Andreas Bye; Koen V. de Merwe.)
- Ron Westrum – resilience, K. Mearns, Sidney Dekker, Rhona Flin, M.Endsley (Situational awareness), E. Hollnagel, R. Woods, J. Reason, C. Weick, K. Haukelid, Cato Bjørkli, Frode Heldal eller Stig O. Johnsen. Fra Telenor eller DNV f.eks Nalini Suparamaniam-Kallerdahl fra DNV, Gary Klein, Gorry, (Decision Making), J.Frohm (f.eks. automasjon eller lean production), G.R. Hockey fra Univ of Leeds, Mark Young.
- Interessant å utvide HF mot community of practice og praksisfellesskap som J.S.Brown, P.Duguide - eks. hvordan mobiliserer man et praksisfellesskap?

### 1.7 Kurs og forelesninger innen human factors

Ved NTNU arrangeres et innføringskurs innen human factors i høstsemesteret 2013, se: videre.ntnu.no/link/nv13119

### 1.8 Kontakt opp mot Human Factors fagnettverket i Europa og USA

Human Factor nettverket i Europa og USA, se: *www.hfes-europe.org* – som er den europeiske Human Factors and Ergonomics Society. HFES er tilknyttet den internasjonale Human Factors and Ergonomics Society, Inc. Se *www.hfes.org*.

# 2 Agenda og deltakerliste

## 2.1 Agenda for HFC møtet

Vedlagt ligger agenda for HFC møtet.

| **Dag 1** | **Innlegg og diskusjon** | **Ansvar** |
|---|---|---|
| 11.00-12.00 | Lunsj. | |
| 12.00-12.30 | Velkommen til seminaret og runde rundt bordet (m/ Informasjon om OGP´s planer for CRM trening) | |
| 12.30-13.15 | **Managing team dynamics in routine and crisis situations: Evidence-based strategies** | M. Rosen/ JHMI |
| 13.15-13.30 | Diskusjon og pause | |
| 13.30-14.00 | **Shared knowledge in second-line emergency handling teams** | B. Sætrevik/ UiB |
| 14.00-14.30 | Diskusjon og pause | |
| 14.30-15.00 | **Evolution of CRM in aviation** | M. Ydalus/ Vision Monitor Aviation |
| 15.00-15.30 | Diskusjon og pause | |
| 15.30-16.00 | **Å utvikle et CRM-kurs: Erfaringer fra et prosjekt med Kystverket** | A. Wahlstrøm /DnV Kystverket |
| 16.00-16.15 | Diskusjon og pause | |
| 16.15-16.45 | **CRIOP med CRM fra 2004 – bakgrunn og erfaringer fra bruk (Case: boring, integrerte operasjoner)** | S.O. Johnsen/ SINTEF |
| 16.45-17.15 | Diskusjon og pause | |
| 17.15-17.45 | **Crew communication in critical phases of flight** | G. Christiansen/ CHC |
| 17.45-18.00 | Diskusjon og pause. | |
| 19.30- | **Middag -** | |

| **Dag 2** | **Innlegg og diskusjon** | **Ansvar** |
|---|---|---|
| 08.30-09.00 | Kaffe og noe å bite i | |
| 09.00-09.45 | **HF Case studies - On-shore supervision of off-shore gas production** | R. Pikaar/ ErgoS. |
| 09.45-10.00 | Diskusjon og pause | |
| 10.00-10.30 | **CRM brukt i skipshåndtering** | S. Dahle/ SMSC |
| 10.30-10.45 | Diskusjon og pause. | |
| 10.45-11.15 | **Bruk av CRM trening – praktiske erfaringer** | L.B.Hviid/Maersk Boring |
| 11.15-12.00 | Diskusjon og pause. | |
| 12.00-12.30 | **Introduksjon til Workshop – "Implementing a CRM Course in your area of Operations".** | L. R. Heemstra/ Emirates Airline |
| 12.30-13.15 | Lunsj | |
| 13.15-15.00 | **Workshop : Implementing a CRM Course in your area of Operations (Discussing threats, errors and CRM issues - leadership, communication, team dynamics, risk assessment, decision making, situational awareness, fatigue..)** | L. R. Heemstra/ Emirates Airline |

## 2.2 Påmeldte og deltakere

Nedenstående tabell lister opp påmeldte og deltakere i HFC møtet.

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**HFC**

# Managing team dynamics in routine and crisis situations: Evidence-based strategies

**M. Rosen, Assistant Professor Armstrong Institute for Patient Safety and Quality, and Department of Anesthesiology and Critical Care Medicine, The Johns Hopkins University School of Medicine**

**Mer informasjon:**
**Program to analyze complex data (used in slide 37), see web: circos.ca**

- **Rosen, M. A et al. "In Situ Simulation in Continuing Education for the Health Care Professions: A Systematic Review" Journal of continuing education in the health professions, 32(4):243–254, 2012**

**The article shows that a more positive patient safety culture is associated with fewer adverse events in hospitals:**

- **Mardon, R.E, et al.."Exploring Relationships Between Hospital Patient Safety Culture and Adverse Events"; J Patient Saf & Volume 6, Number 4, December 2010**

**Shows that the impact of new interventions is associated with culture:**

- **Haynes, A.B. et al "Changes in safety attitude and relationship to decreased postoperative morbidity and mortality following implementation of a checklist-based surgical safety intervention" BMJ Qual Saf 2011;20:102e107. doi:10.1136/bmjqs.2009.040022**

**The Weaver and Morello are recent reviews of interventions**

- **Weaver S.J. et al. "Promoting a Culture of Safety as a Patient Safety Strategy" 2013 Annals of Internal Medicine Volume 158 • Number 5 - (5 March 2013)**
- **Morello RT, et al. "Strategies for improving patient safety culture in hospitals:a systematic review" Quality and Safety in Health Care 2013;22:11–18. doi:10.1136/bmjqs-2011-000582**

JOHNS HOPKINS MEDICINE

# Managing team dynamics in routine and crisis situations: Evidence-based strategies

Michael A. Rosen, PhD
Assistant Professor
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The Johns Hopkins University School of Medicine



## Agenda

JOHNS HOPKINS MEDICINE

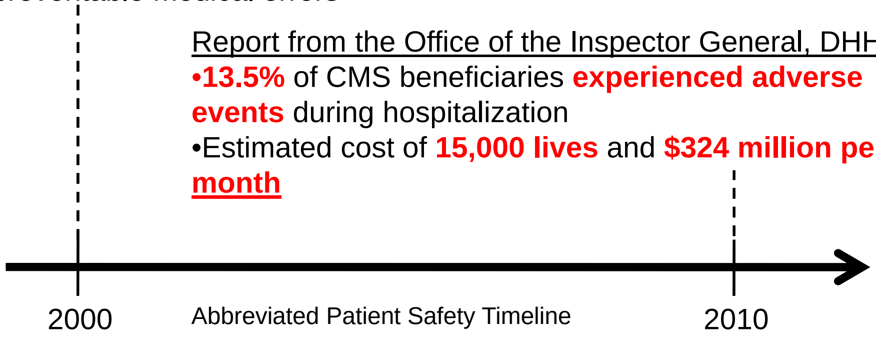
- Some context
  - Teamwork and the US healthcare system
- What determines team effectiveness?
- How do we get better teamwork?
- How do we encourage team self-regulation?
- How do teams manage non-routine events?

Armstrong Institute for Patient Safety and Quality 2

## The Patient Safety Journey

<u>Institute of Medicine report *To Err is Human*</u>
•**98,000 lives a year** lost due to preventable medical errors

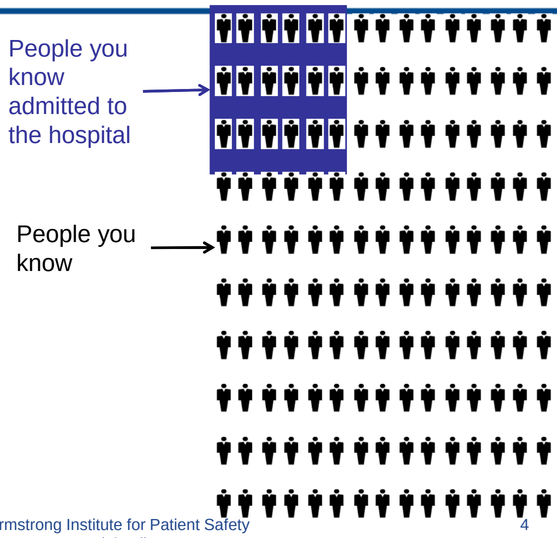
<u>Report from the Office of the Inspector General, DHHS</u>
•**13.5%** of CMS beneficiaries **experienced adverse events** during hospitalization
•Estimated cost of **15,000 lives** and **$324 million per <u>month</u>**




## Why teamwork in healthcare?

Dunbar's Number:
We have a maximum of ~150 meaningful personal relationships

~18 people you know well will be admitted to the hospital each year



## Why teamwork in healthcare?

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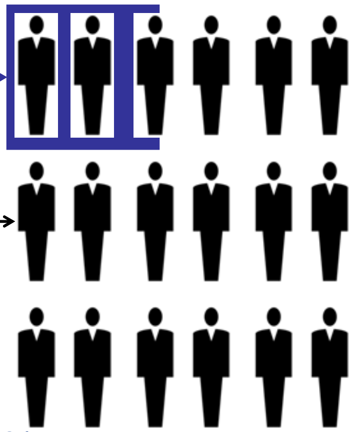
Between 2 and 3 people you know will be harmed by medical error each year

Over the course of four years, someone you know will die from medical error

People you know harmed by their care

People you know admitted to the hospital



Armstrong Institute for Patient Safety and Quality

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## Why teamwork in healthcare?

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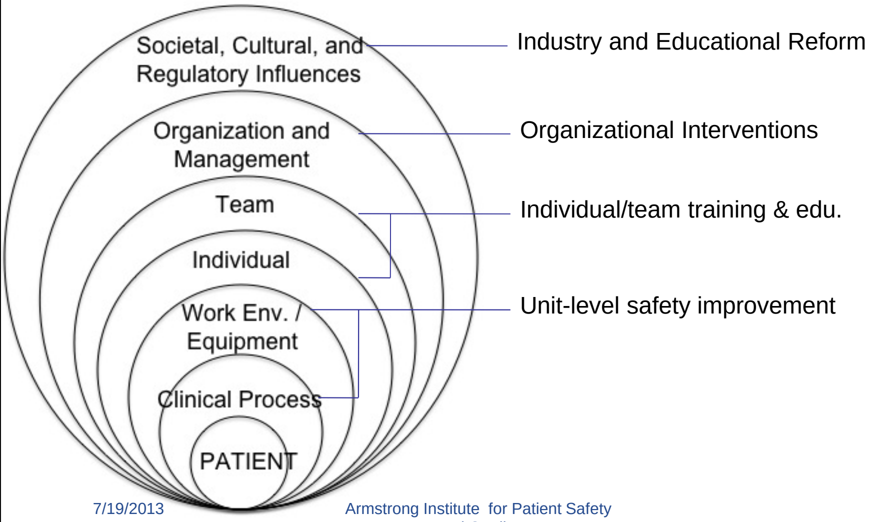
- **70-80% of sentinel events**[1]
- **Twice as many preventable deaths** as issues of technical competency[2]
- **~30% of all communication events in the OR were failures** [3]
- **~37% of error reports in the ICU included some type of communication failure** between nurses and physicians[4]
- **Lack of communication** was the most frequently occurring ‘behavioral failure’ in a review of **closed claims** against surgeons[6]

1Joint Commission, 2006, 2011
2Wilson et al., 1995
3Lingard et al., 2004)
4Donchin et al, 1995
5Gawande et al., 2003
6Griffen et al., 2008

## The Awkward Adolescence of $T^2$ in Healthcare






## WHAT DETERMINES TEAM EFFECTIVENESS?

## Frameworks for understanding communication and teamwork

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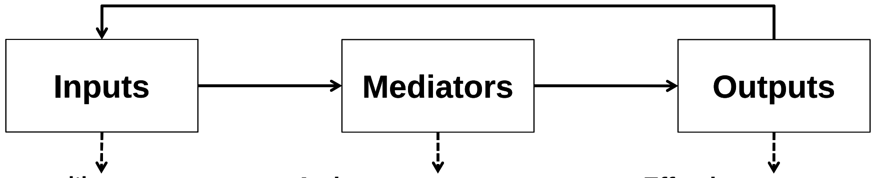


**Composition**
- Team member
  - Knowledge, Skill, Attitudes

**Team / task characteristics**
- Interdependence
- Standardization

Technology
- Synchronous / Asynch. Displays, etc.

**Org. context**
- Culture

**Action processes**
- Communication
- Leadership
- Performance Monitoring
- Back-up behavior
- Adaptation & learning

**Transition processes**
- Planning
- Goal specification

**Interpersonal processes**
- Conflict management
- Trust building

**Effectiveness**
- Task Outcomes
- Member Satisfaction
- Viability

**Team Learning Outcomes**
- Δ Knowledge
- Δ Skill
- Δ Attitudes

Salas et al., 2008

## Some Key Findings From Recent Meta-analytic Synthesis

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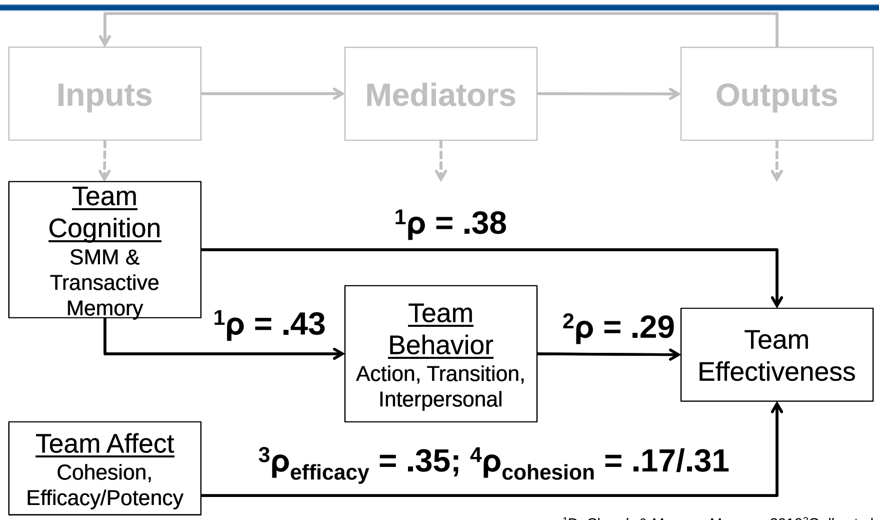


[1]DeChurch & Mesmer-Magnus, 2010 [3]Gully et al., 2002
[2]Lepine et al., 2008 [4]Beal et al., 2003

# Frameworks for improving communication and teamwork

JOHNS HOPKINS MEDICINE

Inputs → Mediators → Outputs

- **Organizational interventions:** *Work Redesign (tasks, tools, processes)*

- **Structured tools:** *Standardize critical interactions*
- **Training & Coaching interventions***: Improve teamwork interaction / processes*

Buljac-Samardzic et al., 2010

# Do teamwork interventions work in healthcare?

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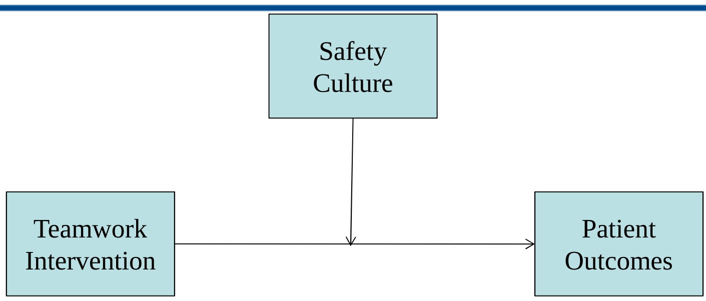
- Learner **reactions are positive** [1,2]
- **Learning occurs** [1,2]
- **Behavior change** in transfer environment **occurs.**[1,2]
- **Safety culture improves**[2]
- **Improved efficiency and effectiveness of clinical processes**[3-6]
- **Improved clinical outcomes**[7,8]

[1]Rabøl et al., 2010 [5]Capella et al., 2010
[2]Weaver et al., 2010 [6]Deering et al., 2011
[3]Siassakos et al., 2009 [7]Mann et al., 2006
[4]Wolf et al., 2010 [8]Neily et al., 2010

## But… It's a tough crowd / transfer environment




- Safety culture moderates the effectiveness of teamwork improvement efforts
  - Safety climate scores correlated with the degree of reduction in mortality and morbidity achieved in the implementation of a surgical team checklist ($r = .71$, $p < .05$)

Haynes et al., 2011



## HOW DO WE GET BETTER TEAMWORK?

## The Science of Teams & Team Training

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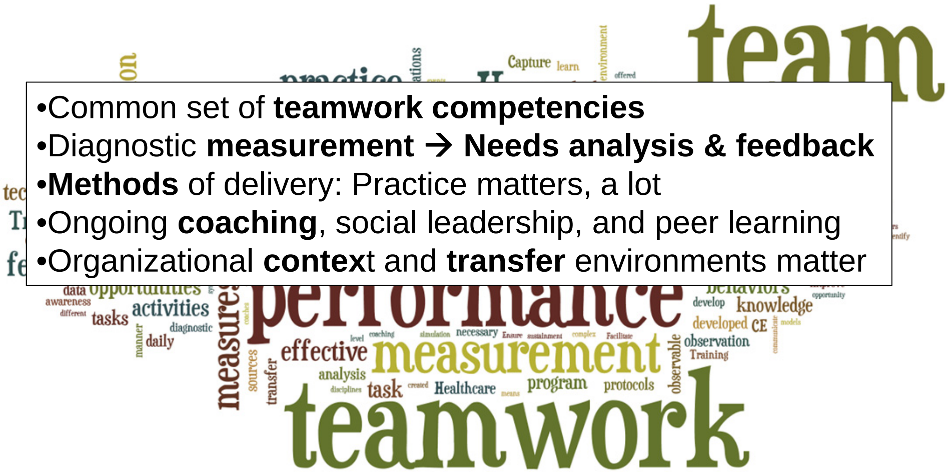


- Common set of **teamwork competencies**
- Diagnostic **measurement → Needs analysis & feedback**
- **Methods** of delivery: Practice matters, a lot
- Ongoing **coaching**, social leadership, and peer learning
- Organizational **context** and **transfer** environments matter

## Train & Coach Adaptive Team Behaviors

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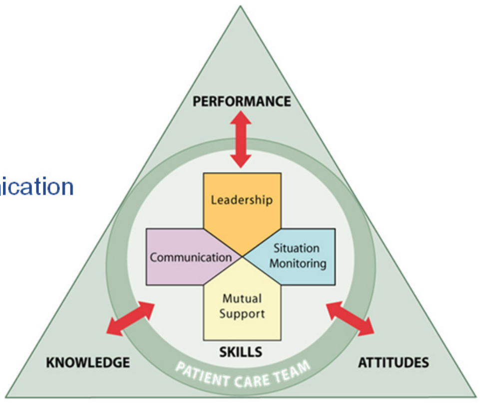
- **Leadership**
  - Delegation
  - Resource management
  - Modeling good teamwork skills
- **Communication**
  - Closed-loop communication
  - Using clear, structured communication
- **Mutual Support**
  - Task assistance
  - Conflict resolution
  - Feedback
- **Situation Monitoring**
  - Shared mental models
  - Cross-monitoring
- **Team Structure**
  - Role clarity




***TeamSTEPPS*®** Competency Framework
Teamstepps.ahrq.gov

## Improving Teamwork through Training & Education

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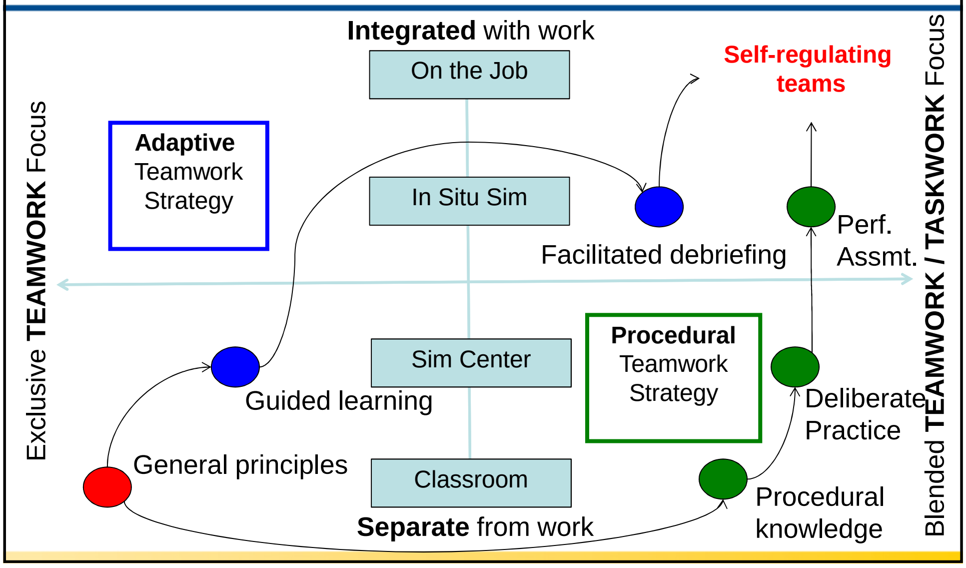


## The role of in situ simulation

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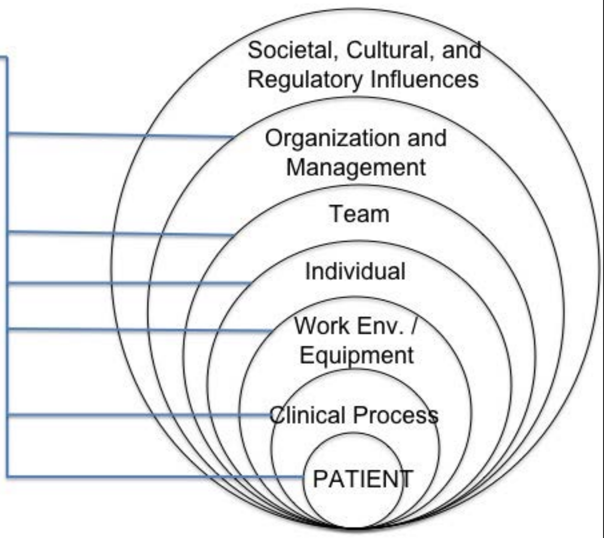
### Why Simulate?

- **Individual & Team Level:**
  - Learning / training
- **Unit Level:**
  - Prospective hazard identification and mitigation
- **System Level:**
  - Needs analysis & research



## An Example: Mobile Obstetric Emergencies Simulator (MOES)

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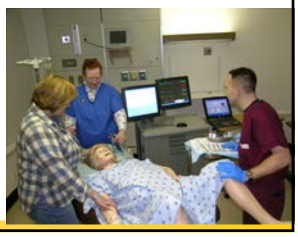
Mobile OBstetric Emergencies Simulator

- Standardized simulators, curriculum (teamwork & technical), and debrief process.
- Implemented in every L&D unit in the DoD (> 50 sites)
- 10 key obstetric emergencies
  - E.g., shoulder dystocia, postpartum hem., eclampsia, cord prolapse



Deering, S., Rosen, M. A., Salas, E., & King, H. B. (2009). Building team and technical competency for obstetric emergencies: The Mobile Obstetric Emergency Simulator (MOES) System. *Simulation in Healthcare, 4*(3), 166.

## An Example: Mobile Obstetric Emergencies Simulator (MOES)

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- Debrief and Measurement Tool
- Observers & Learners Ratings of:
  - Team performance
  - Technical performance
  - Systems issues
  - Training eval. items

## MOES Trends: Teamwork and System Performance

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- **2558** ratings of performance at **32** L&D wards on **3** continents using **10** scenario types, representing **260** learning activities.

| | *Location* | *Scenario Type* | *Location X Scenario Type* |
|---|---|---|---|
| **Overall Teamwork** $R^2$ = .64 | F(30, 1884) = 8.70 **partial $\eta^2$ = .247** | F(8, 1884) = 5.39 **partial $\eta^2$ = .051** | F(8, 1884) = 3.05 **partial $\eta^2$ = .202** |
| **Response Time** $R^2$ = .62 | F(30, 1870) = 7.76 **partial $\eta^2$ = .228** | F(8, 1870) = 3.31 **partial $\eta^2$ = .033** | F(65, 1870) = 2.74 **partial $\eta^2$ = .184** |

$p < .01$ for all

## Local context ≈ 25% of variance

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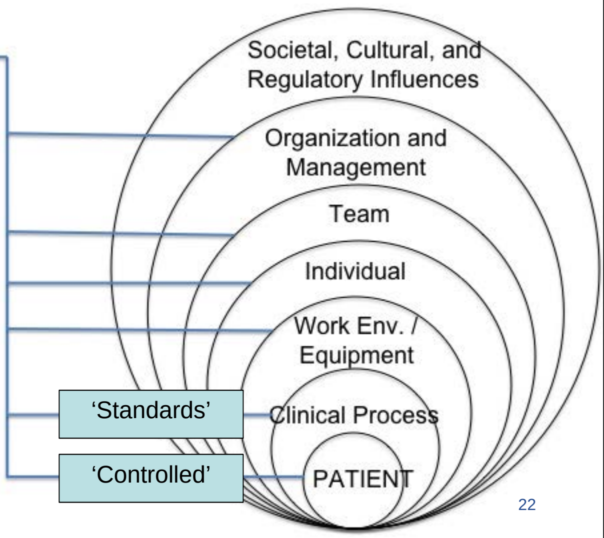
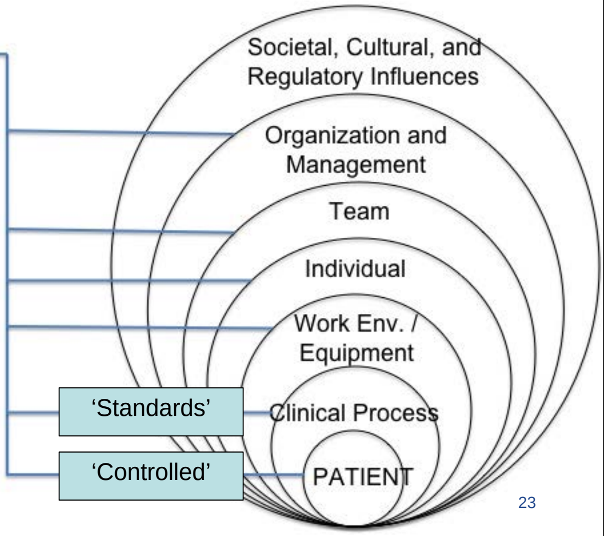
- **Where is that coming from?**
  - Culture?
  - Policies or management practices?
  - Physical design of facility?
  - Equipment availability and location?
  - Communication structures?



## Local context x Emergency Type ≈ 20% of variance

- **Where is that coming from?**
  - Unique teamwork, technical, and systems demands of dealing with different types of emergencies.






## HOW DO WE ENCOURAGE TEAM SELF-REGULATION?

# Team reflective practices

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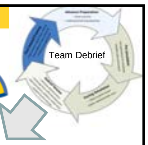
- Debriefing
- Learning from Communication Failures
- Team Interaction Mirror



# Debriefing performance as a team practice




| | |
|---|---|
| Introduce | **Introduce: Introduce debrief process**<br>• Set stage, describe process<br>• Expectations and goals of the debrief<br>• Recap major story line of scenario |
| Reflect and Critique | **Reflect and Critique: Encourage team reflection/discussion**<br>• Ask questions about key events and actions<br>• Have them reflect on what happened, should have happened, and why<br>• Draw out concerns and positives |
| Guide | **Guide: Add observations, guidance, reality check**<br>• Offer observations, suggestions, data<br>• Ensure group considers key areas<br>• Provide a reality check |
| Agree | **Agree: Establish lessons learned and agreements**<br>• Help team generate lessons learned<br>• Discuss how to correct deficiencies in future<br>• Agree how to apply in daily practice |

# Debriefing performance (and culture) as a unit practice

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- Data is data
  - Debriefing turns data into information
- Debriefing accelerates improvement

Units who used semi-structured debriefing of culture survey **10.2% Reduction in Infection Rates**

Units who did not debrief survey results **2.2% Reduction in Infection Rates**

Vigorito MC, McNicoll L, Adams L, Sexton B. Improving safety culture results in Rhode Island ICUs: lessons learned from the development of action-oriented plans. Jt Comm J Qual Patient Saf. 2011 Nov;37(11):509-14.



# The Armstrong Institute Model to Improve Care

JOHNS HOPKINS MEDICINE

| Translating Evidence Into Practice (TRiP) | Reducing Surgical Site Infections | Comprehensive Unit based Safety Program (CUSP) |
|---|---|---|
| 1. Summarize the evidence in a checklist<br>2. Identify local barriers to implementation<br>3. Measure performance<br>4. Ensure all patients get the evidence<br>• Engage<br>• Educate<br>• Execute | • Emerging Evidence<br>• Local Opportunities to Improve<br>• Collaborative learning | 1. Educate staff on science of safety<br>2. Identify defects<br>3. Assign executive to adopt unit<br>4. Learn from one defect per quarter<br>5. Implement teamwork tools |
| Technical Work | | Adaptive Work |

http://www.hopkinsmedicine.org/armstrong_institute

## CUSP & Teamwork

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- ***Teamwork tools:***
  - Handoffs
  - Briefings / Debriefings
  - Call list
  - Daily goals
  - AM briefing / huddle
  - Shadowing
  - Cross unit collaboration
  - *Learning from defects**

**Comprehensive Unit based Safety Program (CUSP)**

1. Educate staff on science of safety
2. Identify defects
3. Assign executive to adopt unit
4. Learn from one defect per quarter
5. Implement teamwork tools

7/19/2013 Armstrong Institute for Patient Safety and Quality

## Learning from Communication Failures

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1. ***Description***: What happened?
2. ***Diagnosis***: Why did it happen?
3. ***Intervention***: What is the best approach for addressing the underlying problems?
4. ***Evaluation***: How do you know the underlying problems were fixed?

# Descriptive Framework

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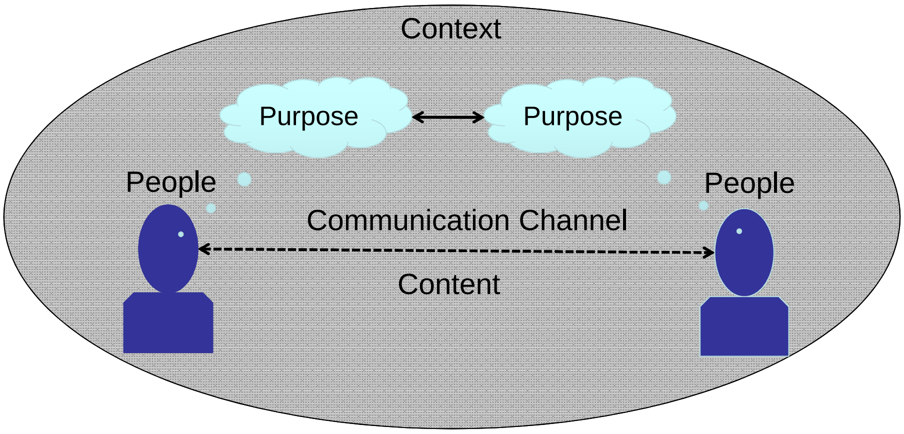
- The basic elements…




# Content: *What were people communicating about?*

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| **Descriptive Questions**<br>*What happened?* | **Diagnostic Questions**<br>*Why was it happening?* |
|---|---|
| • Was communication about the patient status, background, and basic clinical information?<br>• Was the communication about the plan of care?<br>• Was the communication about material resources or coordination with other units, services, or specialists?<br>• Was the communication about staff resources? | • Was information omitted, incomplete, incorrect, or untimely? (*communication slip or lapse*)<br>• Was information transferred, but misunderstood in terms of meaning or accountability for acting on the information? (*communication mistake*)<br>• Was information transferred and understood, but actively dismissed? (*communication violation*) |

## People: *Who was involved in the communication?*

JOHNS HOPKINS MEDICINE

| Descriptive Questions<br>*What happened?* | Diagnostic Questions<br>*Why was it happening?* |
|---|---|
| • How many people where involved?<br>• What were their…<br>o Roles (in general and in this situation)?<br>o Expertise types and levels?<br>o Status?<br>o Familiarity with others and the context?<br>o History and existing relationships with other participants? | • Did the size of the group or length of the communication 'chain' corrupt the message?<br>• Did unclear roles and responsibilities interfere with information transfer or understanding?<br>• Were the right parties involved? Or, was the right information going to the wrong people?<br>• Were there differences (or assumptions about differences) in expertise types or levels that led to misunderstandings?<br>• Were there differences in status or power?<br>• Was there interpersonal conflict between participants? |

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## Channel / Mode: *How were people communicating?*

JOHNS HOPKINS MEDICINE

| Descriptive Questions<br>*What happened?* | Diagnostic Questions<br>*Why was it happening?* |
|---|---|
| • Were people communicating…<br>o Face to face?<br>o Synchronously distributed?<br>▪ phone, chat<br>o Asynchronously distributed?<br>▪ Email, paging, electronic records, paper records, cognitive artifacts | • Were asynchronous modes of communication not updated quickly enough?<br>• Were there usability or accessibility issues with information systems contributing to the error (difficulty finding or reading information, inappropriate alerts)?<br>• Did environmental factors interfere with face to face communication?<br>• Did communication technology otherwise interfere with completeness of information or interpretation?<br>• Was the channel used appropriate for the type of communication? |

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## Context: *What was the situation and environment surrounding the communication?*

JOHNS HOPKINS MEDICINE

| **Descriptive Questions** *What happened?* | **Diagnostic Questions** *Why was it happening?* |
| --- | --- |
| • What was the environment like where communication was occurring?<br>• What was happening with the patient when the communication failure occurred?<br>• Were there other major events occurring at the time of the error?<br>• Were there workload or staffing issues? | • Did high workload, distractions, or other competing attentional demands interfere with effective communication?<br>• Did environmental issues such as noise levels or the physical design of the facility interfere with effective communication?<br>• Did patient flow issues such as direct admissions contribute to communication breakdowns?<br>• Did a shift change, location change, or transition of care interfere with communication? |

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## Purpose: *Why were people communicating?*

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| **Descriptive Questions** *What happened?* | **Diagnostic Questions** *Why was it happening?* |
| --- | --- |
| • What goals was each of the participants attempting to achieve with the communication?<br>• What were other critical goals being pursued? | • Did participants have different or conflicting goals for the interaction?<br>• Did participants have competing priorities that directly impacted communication? |

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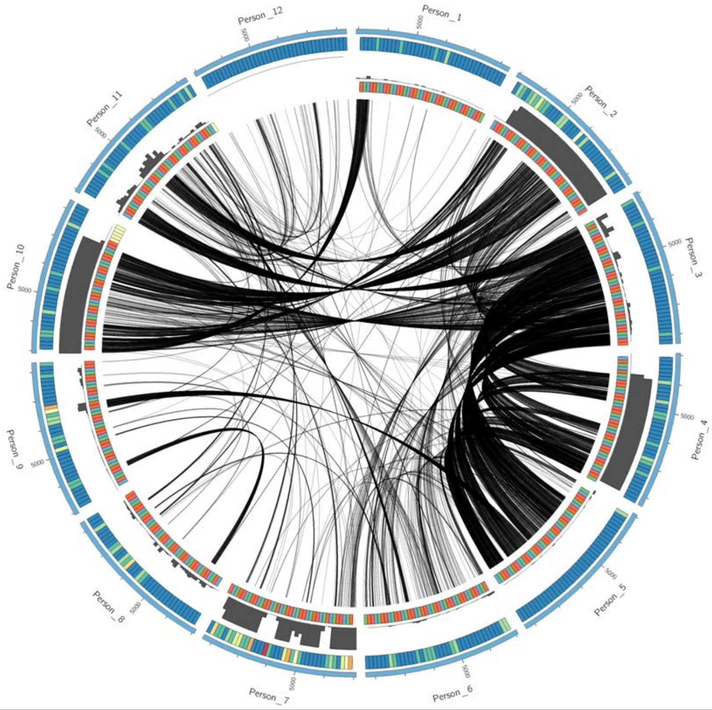
**Team Interaction Mirror.**
*A work in progress.*




# TEAMWORK IN NON-ROUTINE EVENTS

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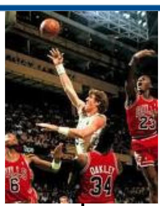
## Commonsense Understandings of Team Cognition



Winning is about having the whole team on the same page.

*-Bill Walton*

If everyone is thinking alike, then somebody isn't thinking.

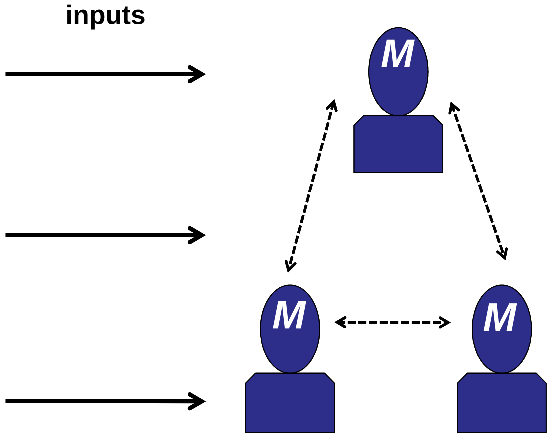
*-George Patton*

**Homogeneity** of Cognition ⟷ **Heterogeneity** of Cognition

## Rule-based Performance in Teams

**Stable / routine task inputs**

**Individual + Team cognition**
***M = Meaning-making***




**<u>Drivers of Effectiveness</u>**
- Shared (compatible) mental models
- *Information* exchange

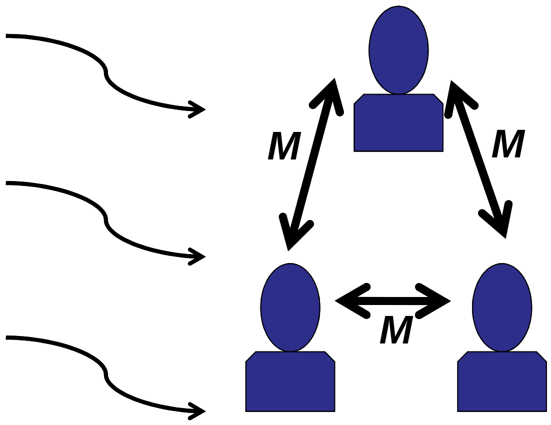
**<u>Adaptive Capacity</u>**
- Ability to detect and correct deviations from normal/optimal

**<u>Implications for Meas.</u>**
- Mental model quality
- Information exchange quality
  - Accuracy, timeliness, clarity, *structure*

## Knowledge-based Performance in Teams

**Unstable / novel task inputs**

**Individual + Team cognition**
***M = Meaning-making***




**Drivers of Effectiveness**
•Diverse expertise types / levels
•Explicit knowledge building at team level

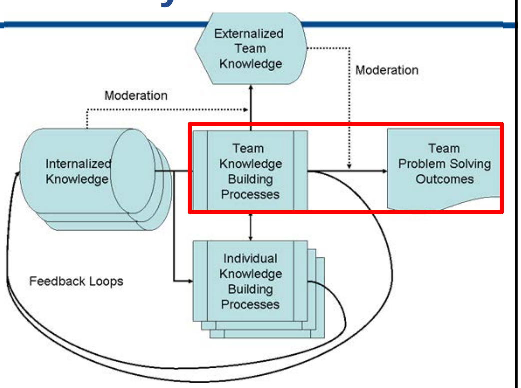
**Adaptive Capacity**
•Effectively combining diverse expertise types and levels to generate new knowledge

**Implications for Meas.**
•Distribution & congruence of knowledge structures
•More complex processes

## Knowledge-based performance in teams: A simulation study

### Team Knowledge Building Processes

– Information Exchange
– Knowledge Sharing
– Solution Option Generation
– Option Evaluation
– Process and Plan Regulation




**Information vs. Knowledge:**

- **Information** = basic task information, no context added
- **Knowledge** = integration of information, value judgments, context added

Fiore, Rosen, Salas, Smith-Jentsch, Letsky, & Warner, 2010

# Study Design / Methods

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- **Study design**
  - Single group correlational design (model building)
- **Task**
  - Strategic planning simulation
  - Diverse *individual* *level 'expertise'*
- **Participants**
  - 69 three person teams
- **Communication analysis**
  1. Transcription
  2. Unitization (≈ 30,000 conversational units)
  3. Coding (kappa = .7)

| Time - Min/Sec | Role | Utterance/Action | Codes |
|---|---|---|---|
| 14.00 | Air | Or B4f sorry not B4h. | IP |
| | | | INC/F/EX |
| | | | SU/R |
| | | | S |
| | | | SU/R |
| | | | SU/R |
| | | | OG-P |
| | | | IP |
| | | | OG-P |
| | | | KP |
| | | | Seval |
| | | | KP |
| | | | OG-P |
| | | | OG-P |
| | | | KR |
| | | | S |
| | | | KR |
| | | | S |
| 14.43 | LandSea | Are there- are there 3 medical patients there? | IR |

**Main Communication Coding Variables**
1. Information exchange
2. Knowledge sharing
3. Option generation
4. Option evaluation
5. Regulation
6. Acknowledgements

**Functional Analysis**

•*How much process did the team devote to each task function?*

•*Multiple regression analysis looking for unique effects of each process variable*

**Sequential Analysis**

•*What patterns of interaction characterize high and low performers?*

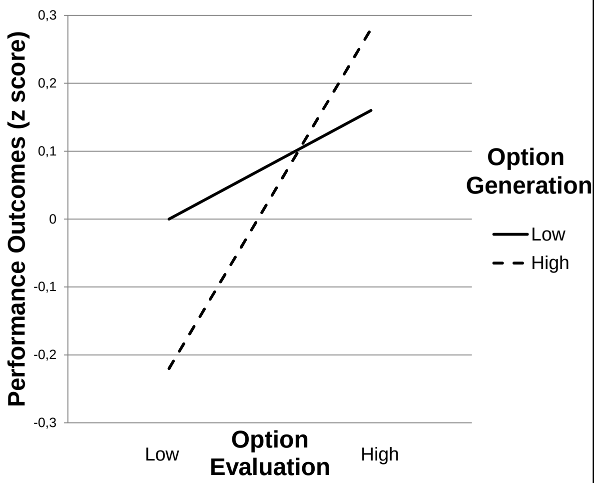
•*Multi-way frequency analysis looking at transition*

## Information Exchange and Knowledge Sharing

- **No significant overall relationship between the amount of information exchange and performance**
  - But, after controlling for acknowledgements…
- **High performing teams shared <u>LESS information</u>.**
  - Negative linear relationship after controlling for acknowledgements (β = -.323, $p < .05$)
    - $F(2,66) = 7.119$, $p < .01$, Adjusted $R^2 = .153$
- **High performing teams shared <u>MORE knowledge</u>.**
  - Positive linear relationship (β = .324, $p < .05$)
    - $F(3,65) = 5.215$, $p < .01$, Adjusted $R^2 = .195$

## Option Generation and Evaluation

- **Option generation was only useful if accompanied by Evaluation**
  - Significant interaction (β = -.368, $p < .05$)
    - $F(5,46) = 4.029$ $p < .01$, Adjusted $R^2 = .248$



## Regulation

- **Moderately performing teams engaged in MORE regulation than high or low performing teams.**
  - Negative curvilinear (inverted U) relationship ($\beta = -1.204$, $p < .05$)
    - $F(2,66) = 3.550$, $p < .05$, Adjusted $R^2 = .070$
  - Need future research to fully explain
    - Potentially moderated by goal / role clarity
  - Implications for measurement: Levels of process are not enough to determine effectiveness

## WHAT CAN WE LEARN FROM HEALTHCARE?

## The Science is there… team training works. Getting the science into practice is tough.

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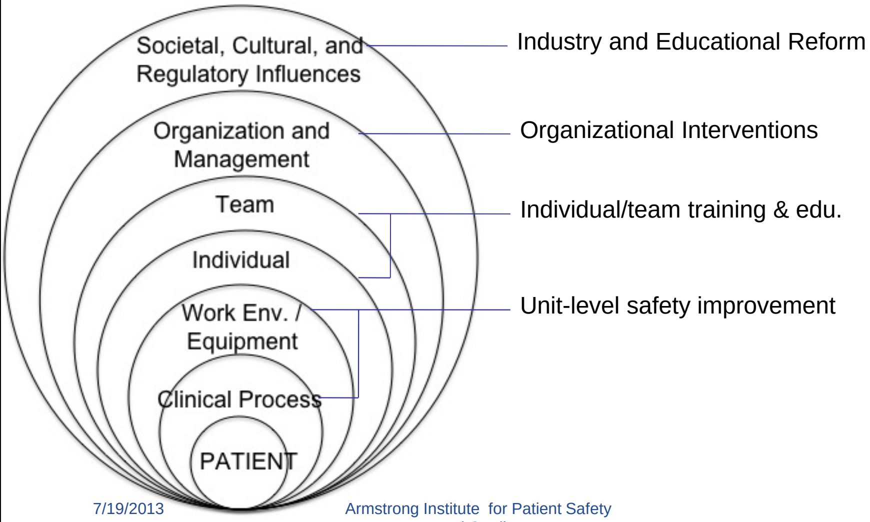




## To date, almost exclusive focus on training.

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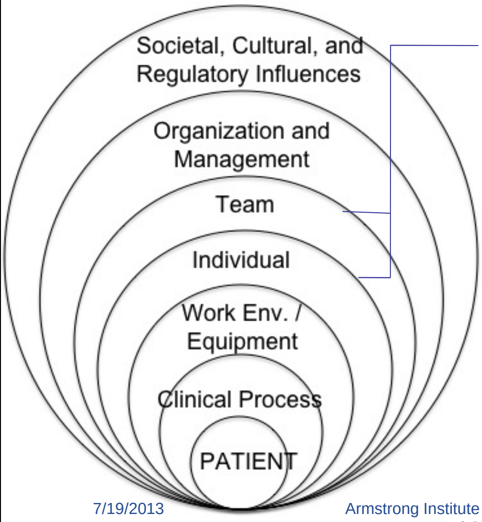


**Individual/team training & edu.**

- Good evidence of effectiveness
- A wealth of best practices
- *Need integration with existing training*
- *Need better fit with task demands:* Balance between general competencies, and situation specific competencies
- **Sustainment is a challenge**
- **Spread is a challenge**

## Top down barriers

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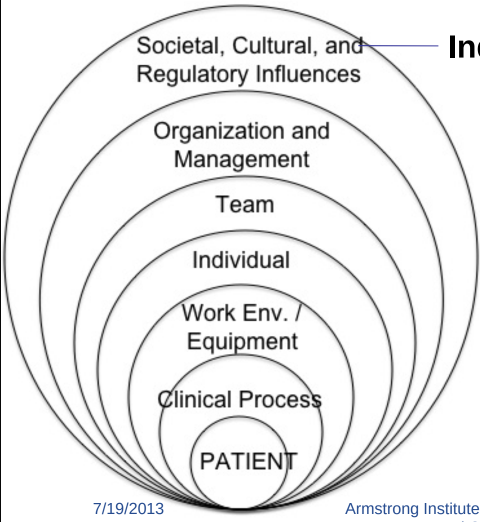


**Industry and Educational Reform**

- Some attention from regulators, no mandate
- Some attention from educational organizations; mostly lip service; movement is slow
- **Territoriality is a challenge**
- **Logistics are a challenge**
- **Mandates have downsides**



## Top down barriers

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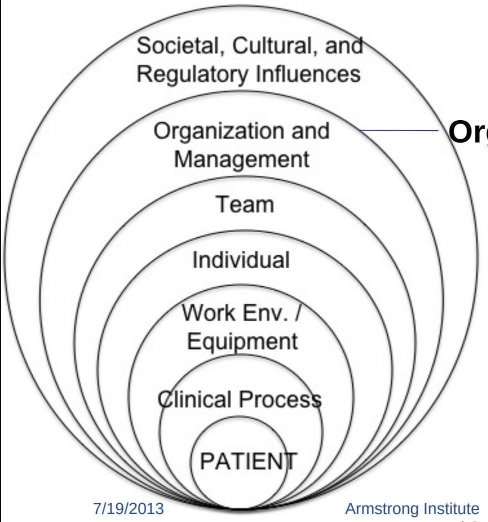


**Organizational Interventions**

- NO accountability
- NO systematic capacity building
- NO time and resources

## Bottom-up barriers

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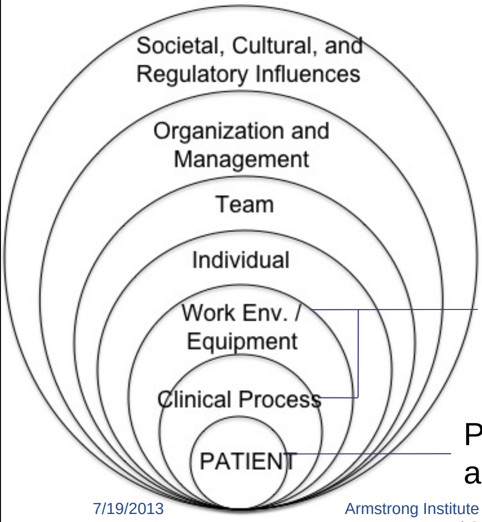


- (Unnecessarily) chaotic work practices
- Poor information tool design
- The physical environment
- Staffing models

**Unit-level safety improvement**

Poorly represented in models and practice of communication



## Thank you!

JOHNS HOPKINS MEDICINE

- Questions??
  - – mrosen44@jhmi.edu

HFC

# Shared knowledge in second-line emergency handling teams

**B. Sætrevik, University of Bergen, Operational psychology research group**

**Mer informasjon:**

B. Sætrevik "A controlled field study of situation awareness measures and heart rate variability in emergency handling teams"

# A controlled field study of situation awareness measures and heart rate variability in emergency handling teams

Bjørn Sætrevik
Operational psychology research group, University of Bergen, Norway

Five second line emergency handling teams within hydrocarbon energy industry were studied while they performed a scripted training scenario. To have the same knowledge as the team leader was used as an objective index of situation awareness (SA). Self-assessment of performance proved a poor indicator of objective SA. Objective SA varied according to team membership, but not according to roles in the team. Heart rate variability correlated with some objective SA measures, but not with self-report measures of SA.

## INTRODUCTION

It can be argued that in large scale incidents in the hydrocarbon energy sector, the necessary information to avoid the incident or to reduce its consequences is often present within the organization in the final moments, but the information is not made available to the right people at the right time (for a case study of the Deepwater Horizon incident, see Barstow, Rohde, & Saul, 2010). There is not necessarily a lack of information, but a failure of transferring the information within the organization. Thus research on emergency handling should focus on mechanisms of information transfer and to which extent the team members have the same knowledge. In the current research project, I have measured communication and knowledge about the external situation among members of operative teams. In particular, I wanted to examine whether the team members' situation awareness was associated with subjective ratings of performance, team membership, team role and psychophysiological measures of cognitive load. This paper presents preliminary results from this study.

*Situation awareness.* The situation awareness (SA) construct remains the leading paradigm within the field of human factors for studying individual and team knowledge states and the impact they have on the interaction with the environment. Despite disagreement on a definition of SA (see Hone, Martin, & Ayres, 2006; Patrick & Morgan, 2010), the dominant view has become that of Endsley's hierarchical model (1995b, 2004), which divides the concept into three levels: (1) Gathering information from the environment, (2) compiling that information into a coherent view of the situation, and (3) using that understanding to predict future events. A concept of this nature appears to have relevance for maintaining safety in a number of settings, and resonates with the policies of safety-critical organizations (for a review from the offshore hydrocarbon industry, see Sneddon, Mearns, & Flin, 2006).

*Measurement of situation awareness.* A number of measurement techniques for situation awareness have been suggested. In general, one can distinguish between subjective and objective measures (Rousseau, Tremblay, Banbury, Breton, & Guitouni, 2010; Salmon, Stanton, Walker, & Green, 2006). In subjective measures, the agents give their own assessment of the extent to which they have an overview of the situation. One of the most popular subjective SA measures, the situational awareness rating technique (SART; Taylor, 1989), asks the respondent to rate his or her SA on a scale with separate dimensions for demand for attention, attentional resources and situational understanding. For objective SA measures on the other hand, an external qualification of the agent's knowledge is used. The situation awareness global assessment technique (SAGAT; Endsley, 1995a) develops factual questions suited to the specific setting, to which the answers express having a correct understanding of the situation. For example, a soldier in a field exercise may be asked where the enemy units are, and giving the correct answer is scored as having accurate SA. To some extent, the choice between subjective and objective measures is an epistemological question; do we trust our responders to be the best judge of their own internal mental states and for these assessments to be relevant for the performance, or are we more interested in assessing the extent to which the respondents' beliefs correspond to an objectively true reality? Some authors (e.g. Endsley, 1994) have argued that subjective measures have limited value, as they merely measure the agent's confidence, rather than their actual awareness of the situation. On the other hand, in real-life situations an objective ground truth may be difficult to establish while in-situ, and in some cases it is also difficult to do in retrospect.

*Situation awareness in teams.* Team work is defined by specialization, in that different team members hold different skills and abilities, and handle different aspects of the situation. Yet in order for a team to resolve a problem efficiently, its efforts must be coordinated through a shared overall understanding of the situation and the team processes. In the context of information processing and SA, some information needs to be shared by all team members, while other information is only needed by some of the members. To account for the common understanding necessary for efficient team work, the term *shared mental models* is often used (Cannon-Bowers, Salas, & Converse, 1993). Having the same understanding of important factors in the environment, their interplay, as well as knowing the capabilities of your team members, have been shown to be a predictor of team performance (Espevik, Johnsen, Eid, & Thayer, 2006). Some of the aspects are captured in the concept of *shared situation awareness* (Saner, Bolstad, Gonzalez, & Cuevas, 2009), which focuses on the team having the same view of the situation, and the sharing of that view between team members.

A useful metric of SA in the absence of an available ground truth could be to compare the different team members' beliefs about the scenario. One would expect a high SA member of a well-functioning team to have the same understanding of the situation as other team members, and in particular when comparing him or her to the best informed member of the team. Additionally, a team where there is extensive overlap between the different team members' knowledge would be expected to have shared SA to a larger extent than in a team where the knowledge states are divergent.

*Heart rate variability.* Cognitive and emotional activation caused by task work will be reflected in psychophysiological activation of bodily systems outside the nervous system. The high stakes involved emergency handling may lead one to expect effects in the parasympathetic system, involved in adapting the body's responses to the external world. At the same time, second line emergency handling team members are stationary for most of the time, thus avoiding some of the artifacts that would be caused by more physically active respondents. Processes associated with cognition and emotion will dampen the parasympathetic modulation that the nervous systems has on peripheral systems such as heart rate. Thus, less high-frequency (HF) modulation of heart rate variability (HRV) can be used as an index of stress or cognitive load (Jorna, 1992; Thayer, Åhs, Fredrikson, Sollers III, & Wager, 2011).

*Hypotheses.* In this study, I wanted to examine whether team members' subjective estimates of SA corresponded to objective SA measured as knowledge agreement within the team. Further, I wanted to examine whether belonging to a given team (team membership) or holding a given specialized position in the team (team role) would predict objective SA. Finally, I wanted to see if HRV measures would correspond to subjectively or objectively measured SA.

## METHODS

*Research setting.* My current research project examined information flow and SA among team members in a second line emergency handling organization of a hydrocarbon production company. Whenever an offshore production installation or onshore refinery goes into an alarm state, nine onshore employees are mustered to a second line emergency handling team in a dedicated control room. The emergency handling team is tasked with communicating with first and third line of emergency handling, and through this get an overview of the situation and to advise and coordinate the emergency handling effort. Each member is trained for one of these specific roles: line leader, chief of staff, personnel coordinator, medical advisor, air transport officer, maritime resources officer, maritime communications, authority liaison and communications officer. The chief of staff has a key role in organizing the team's activities and directing the team's efforts in accordance with plans, orders and strategies. Pilot studies showed that most of the teams' internal communication was focused around the chief of staff. There are monthly full scale training exercises and real incidents are more frequent than that. The organization and its teams are verified to all relevant regulations, and all measures prior to the research project indicate a well-functioning and efficient organization.

*The exercise scenario.* The data collection took place during scripted exercise scenario on five non-consecutive dates within a four-week period. A different second line emergency handling team participated on each of the five dates. The team was positioned at their regular work stations using their regular equipment. In preparing for the current study, my industry partners identified some key facets of information that they considered critical for all members of the team to have knowledge of during an exercise or a real event. In the exercise scenario, an offshore production rig was threatened by a subsea gas leak under difficult weather conditions, which was further complicated by personnel injuries. The scenario was set to last for 160 minutes. The exercise was scripted according to a specific timeline, and used a group of actors to play all the external parties the emergency handling team would normally interact with (e.g. offshore installation manager, local hospital, authorities). The actors made different information available at given times, according to the scenario timeline.

*Freeze probes.* At nine times throughout the scenario, the scenario play was frozen, and all team members were probed for SA. As a subjective SA measure, team members were asked to assess their information access, their attention load and their understanding of their area of responsibility. These questions were inspired by the 3-D SART measure (Taylor, 1990), but were adapted to the current setting. The ratings were rescored to go from 0-100%, where 100% corresponds to high confidence in your own cognition. As an objective SA measure, team members were probed for what knowledge they had of five different aspects of the external situation. The probes asked where on the installation the incident was happening (e.g. "Is there now an on-going incident in the living quarter? Y/N"), what type of incident(s) it was (e.g. "Is there an on-going fire? Y/N"), personnel status (e.g. "How many people are currently missing?"), what likelihood different outcomes of the incident had (e.g. "How likely is a full evacuation? Rate from certain to very unlikely"), and which three main goals the team was expected have for the next 20 minutes. Thus the probes concerned both knowledge of operational details, evaluation of overall situation, knowledge of the team work and estimates about the future. These questions were intended to tap the three levels of SA in Endsley's model (1994). In evaluating the answers to the factual questions, it would be difficult to state what the objectively correct answer would be, and more difficult still to say what each team member should be expected to know at a given time. Rather, the assessment of objective SA built on the assumption that the chief of staff is the best informed member of the team, and compared the team members' answers on the factual questions with the chief of staff's answers. Each answer was scored between 0% and 100%, based on the degree of overlap, between the responder and his or her chief.

*Scoring of communication and expert rating.* Two observers registered the onset and duration of the communication the chief of staff had with each of the team members, while audio recordings were made of the conversations. The communication pattern and content has yet to be analysed at the time of writing. Further, the chief of staff, line leader and an external subject matter expert evaluated team performance at the end of the exercise. These ratings were overall high and showed little variation, which may reflect a ceiling effect, high confidence or insufficient access to examine the team work.

*Recording of heart rate variability*. In order to get objective measures of individual emotional stress and cognitive load throughout the scenario, all team members wore consumer grade equipment (Polar RS800CX) capable of registering interbeat intervals (Thuraisingham, 2006). The time series were imported to Kubios (Tarvainen, Niskanen, Lipponen, Ranta-aho, & Karjalainen, 2009), subjected to smoothing of priors and the amount of artefact correction algorithms deemed necessary for each individual. The HF (0.15 – 0.4 Hz) power for each section of the scenario (20 minutes before each freeze probe), was calculated using a fast fourier transform algorithm, and the ratio between HF power in the sample and HF power throughout the exercise was calculated. As HF modulation is typically taken to reflect parasympathetic activity, low HF power was taken to indicate a relative increase in cognitive load.

## RESULTS AND DISCUSSION

*Subjective situation awareness.* All five teams performed well in the scenario, and met the expected scenario milestones at the expected time. The subjective SA measures inspired by 3D-SART showed that team members in all five teams had high confidence in their SA (mean across measures and time = 74.1%, SD = 27.7%), as shown in Figure 1. Processing demands were seen as the most challenging aspect (mean = 47%, SD = 26.7%), while information availability (mean = 83.7%, SD = 21.2%) and understanding (mean = 85.2%, SD = 20.5%) were seen as more manageable aspects. Examining average subjective SA over time (see Figure 2) showed that while measurements were low at 5 and 20 minutes after scenario start, scores increased throughout the first hour and then remained stable.

*Objective situation awareness.* Objective SA was assessed by comparing the factual claims of each team member with the claims of their chief of staff. Across measures and time, objective SA was lower and showed more variation than subjective SA (mean = 62.6%, SD = 37.9%). The average degree of agreement regarding incident location was 61.2% (SD = 47%), agreement regarding the type of incident was 67.8% (SD = 37.5%), agreement regarding personnel status was 78.4% (SD = 32%), agreement on outcome likelihood was 74.1% (SD = 15.8%), and agreement on current team goals was lowest, at 26.1% (SD = 25.6%). The average score for each of the five team on these measures are shown in Figure 3. Examining objective SA over time (see Figure 4), did not show the gradual increase and then stable pattern that was seen for subjective SA (Figure 5), and in fact some teams decreased their objective SA towards to end of the scenario. This could reflect the chief of staff failing to make the team aware of changes to the external situation.

*Comparison of SA measures*. Did the team members' own assessment of their access to information, attentional load and understanding (subjective SA) at a given time in the scenario correspond to the overlap between the member's knowledge and the chief of staff's knowledge (objective SA)? A correlation matrix between the subjective and the objective SA measures showed that while a high rating of own understanding of situation correlated positively with knowing the location of the incident ($r = .14$), it correlated negatively with knowing the type of incident ($r = -.14$, both at $p < .05$), and did not significantly correlate to the other objective measures. The two other subjective measures did not show significant correlations to any of the objective measures. The lack of a coherent pattern supports the literature arguing that self-reports are unreliable measures of SA (Dekker, Hummerdal, & Smith, 2010; Endsley, 1995a; Hone, et al., 2006; Salmon, et al., 2006; Saner, et al., 2009).

*Inherent assumptions in team comparison approach.* The current analysis assumed that the chief of staff was the best informed member of the team, and that the team members' SA could be assessed by comparing their knowledge to the chief's knowledge. It should be noted that this assumption has some caveats. For example, if the chief of staff is misinformed on some subject while a team member has the correct information, the team member will nevertheless be scored as having low SA. However, we could argue that such a state nevertheless expresses a poor functioning team, as the

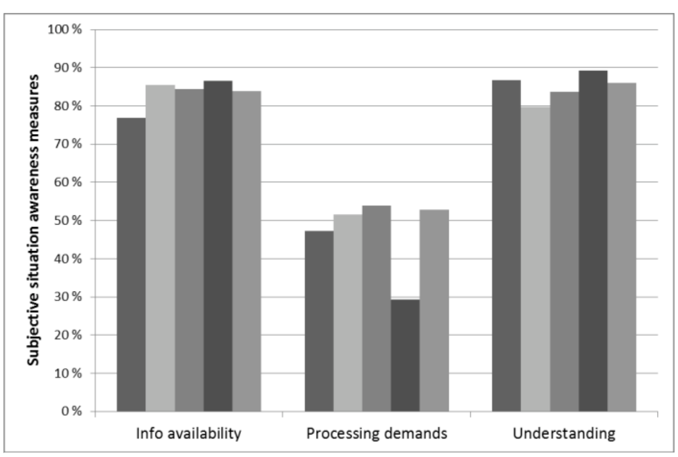


Figure 1: Average scores for the five teams on measures of subjective situation awareness.

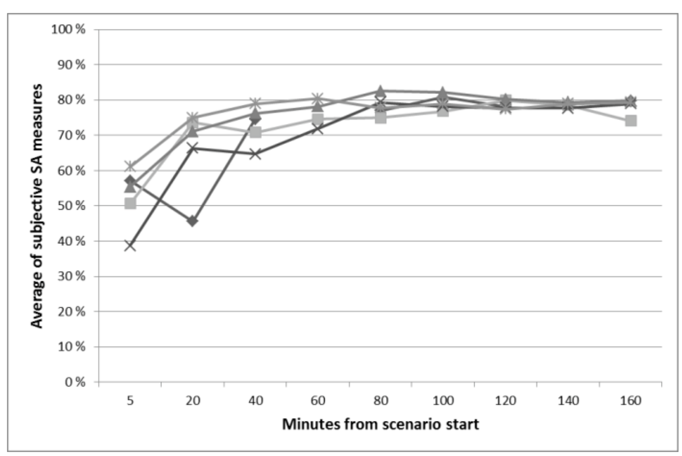


Figure 2: Average scores for the five teams on subjective measures of situation awareness throughout the scenario.

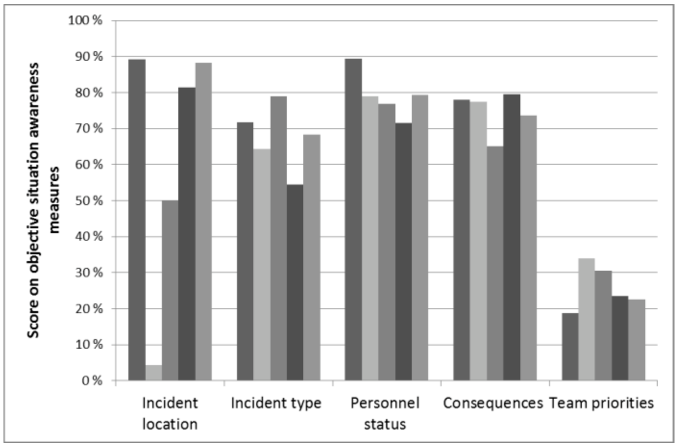


Figure 3: Average scores for the five teams on objective situation awareness.

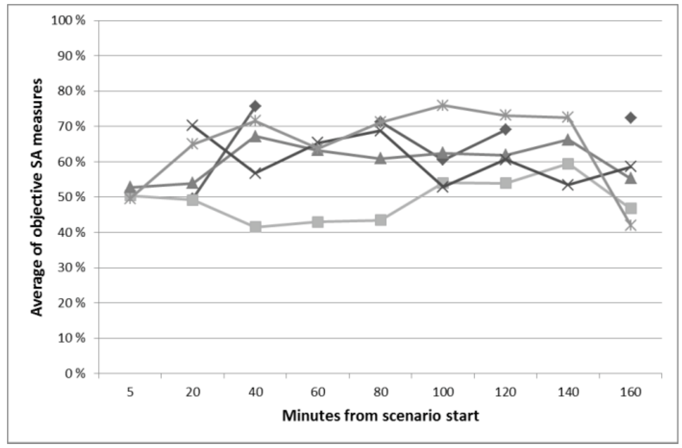


Figure 4: Average scores for the five teams on objective measures of situation awareness throughout the scenario.

chief has not been able to acquire the correct information from the team member. Another objection is that as team work is defined by specialization, one could argue that all the team's knowledge does not need to be shared by all team members. However, the probe questions used in the current study queried for information that subject matter experts in advance of the data collection had identified as being crucial for the whole team to possess.

*The effect of teams and team roles.* A factorial 5x9 ANOVA was performed for the effect of team membership and team role against an average of the three subjective SA measures at all nine probes. The test showed that belonging to a given team influenced subjective SA rating ($F (4, 311) = 3.52$, $p < .008$), as did having a given role in the team ($F (8, 311) = 10.82$, $p < .001$). Although which role rated highest varied between teams (interaction effect of $F (32, 311) = 3.93$, $p < .001$), the main effect showed that in particular the line leader, communications officer and chief of staff felt more confident in their overview of the situation, while the personnel coordinator, medical advisor and maritime resources officer were less confident.

A factorial 5x8 ANOVA was performed for the effect of team membership and team role against the average of the five objective SA measures at all nine probes. The test showed that belonging to a given team influenced the objective SA score ($F = (4, 285)\ 10.72$, $p < .001$), but having a given role in the team did not ($F (7, 285) = 1.47$, $p = .176$). In arranging the training exercises, we attempted to keep the scenario parameters as stable as possible across teams. Thus the effect of team membership on objective SA scores indicates that some team factor, e.g. leader behaviour, team familiarity or shared mental models may have had an effect on developing accurate SA for the team members. While there were too few data points to run the two ANOVAs as repeated measures with all factors, testing each main effect as repeated measure yielded the same significant effects.

*Heart rate variability.* The amount of HF power in each sample compared to the individual's average power is shown in Figure 5 (the final 40 minutes have been removed due to signal decay and many non-stationary participants). As low values indicate lower parasympathetic modulation, the figure indicates that each participant had highest cognitive load at the start, and decreased throughout the scenario. Overall HF power did not correlate with overall subjective SA measures, overall HF power correlated negatively with overall knowledge overlap for the location of the incident (-0.52) and personnel status (-0.24, both significant at $p < .05$). This correlation could indicate that high physiological activation prevented team members from collecting and keeping track of information, and thus impacted the SA scores. The opposite causality, that that poor SA was experienced as stressful and thus caused physiological activation is made less likely by the lack of correlation between HF power and subjective SA.

It should be noted that the current HRV analysis used long (20 minutes) samples that could be subject to effects of non-stationarity. Thus parts of the observed effects could be due to other factors than cognitive load, e.g. that team members moved around more towards the end of the exercise. A different analysis approach using shorter HRV samples, may bring different and more reliable results.

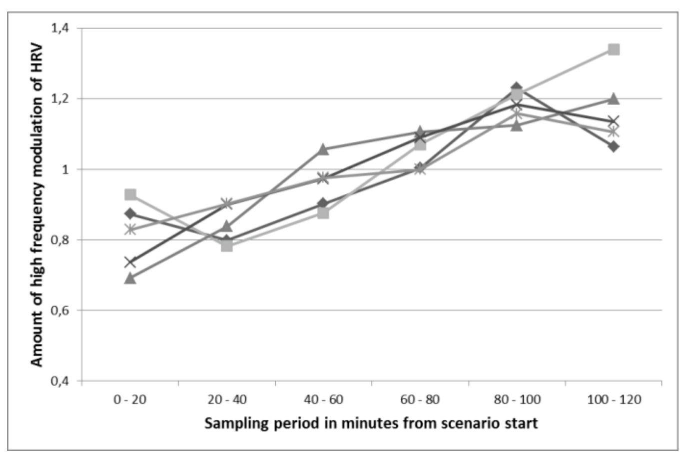


Figure 5: Amount of high-frequency modulation of HRV for the five team throughout the scenario.

## CONCLUSION

The current study has explored the possibility of using team knowledge overlap as an indicator of objective SA. Subjective SA ratings did not systematically correspond to objective SA measured in this way, which indicates that subjective SA may not be a reliable measure for knowledge states. In feedback meetings with my industry partners, the knowledge overlap was considered to be lower than expected for these well-trained and well-performing teams. In light of this, the subjective SA measures were seen as a less relevant measure. The current study, which is still in its preliminary analyses, thus appears to caution against relying on subjective measures of SA alone, and it suggests that comparing knowledge states within a team could be a useful approach to achieve measures of objective SA. Using HRV as a physiological measure of cognitive load to predict SA in a field setting shows promise, yet more sophisticated analysis approaches may be necessary.

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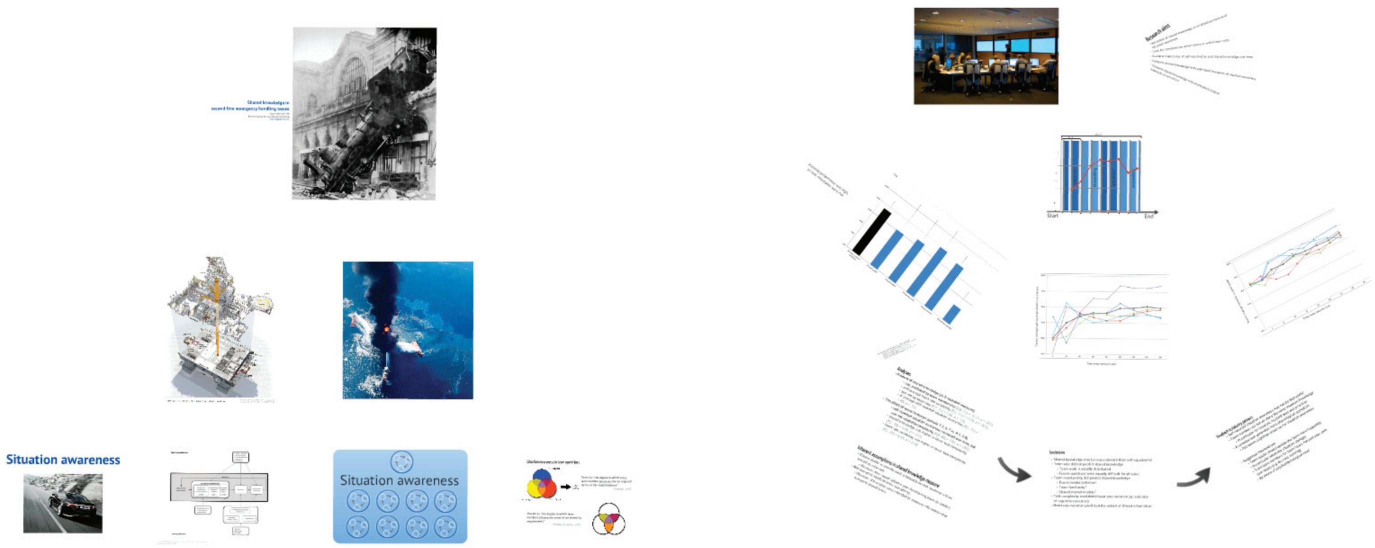


## Shared knowledge in second-line emergency handling teams

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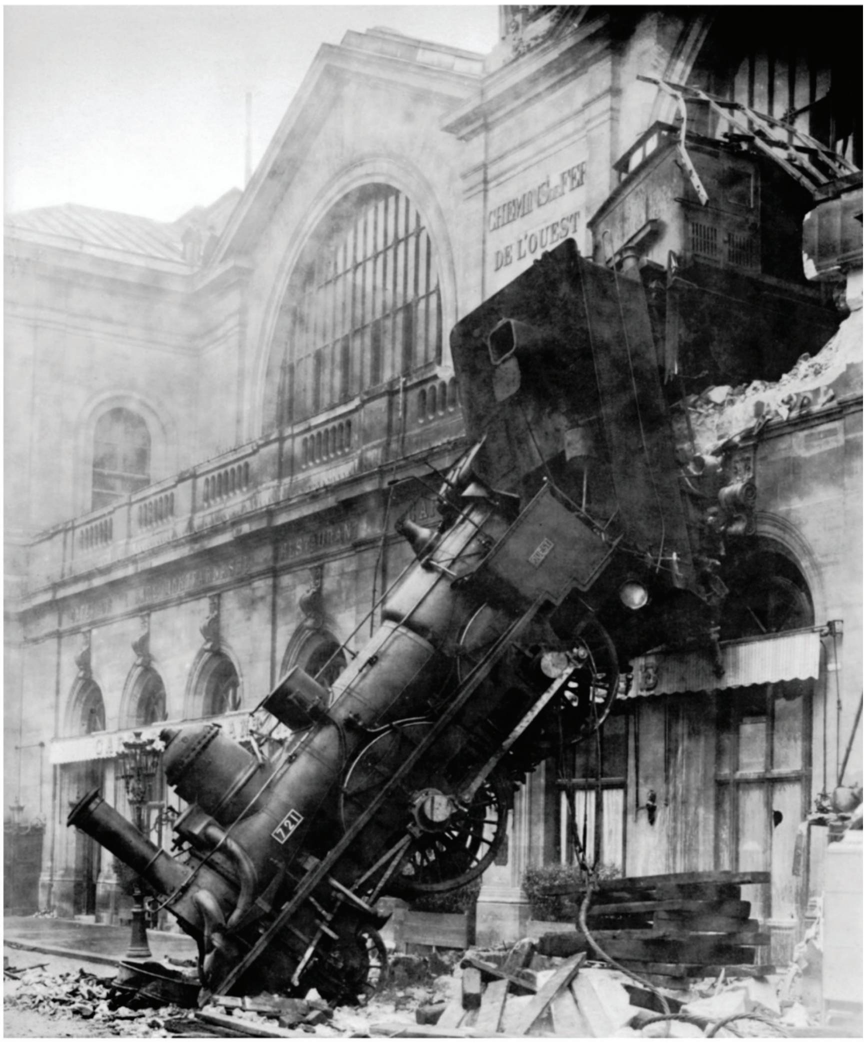
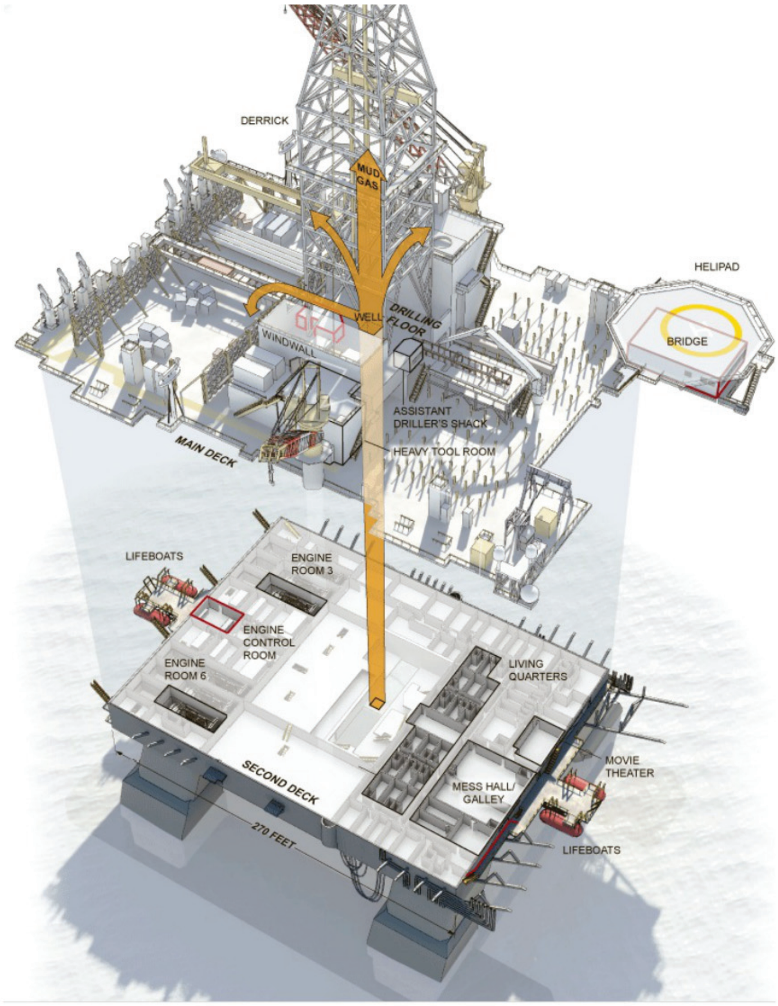
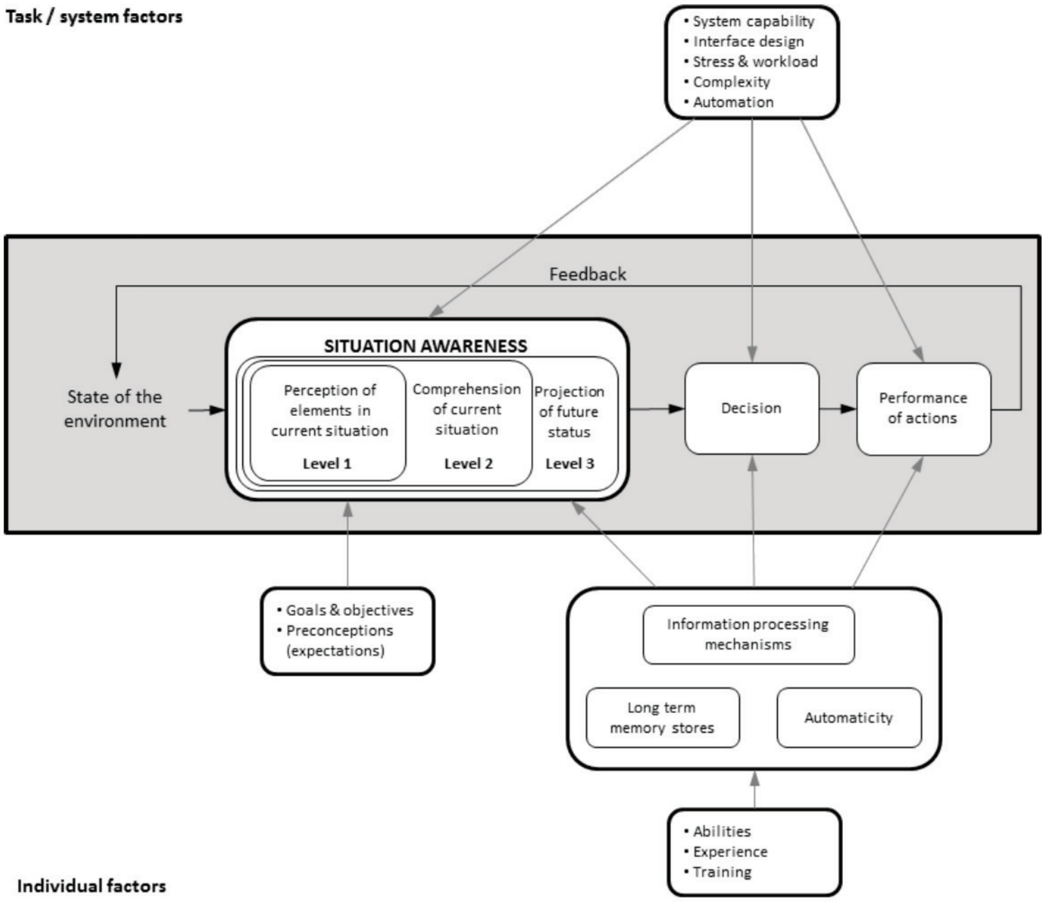





Graphic by Haeyoun Park, Graham Roberts and Archie Tse/The New York Times

Barstow, D., Rohde, D., & Saul, S. (2010, December 26). Deepwater Horizon's Final Hours, The New York Times.

# Situation awareness

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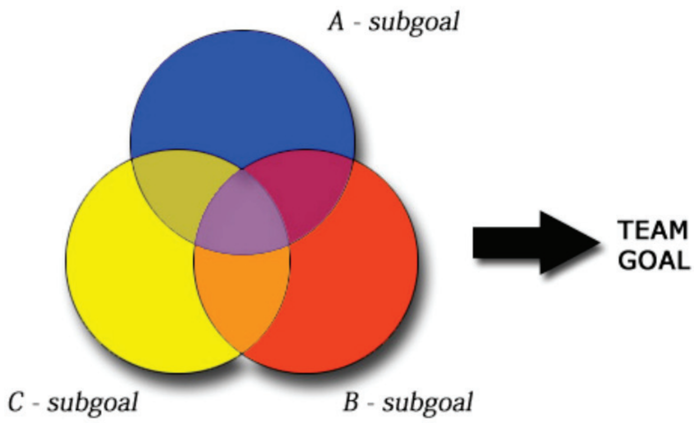
# Situation awareness in team operations

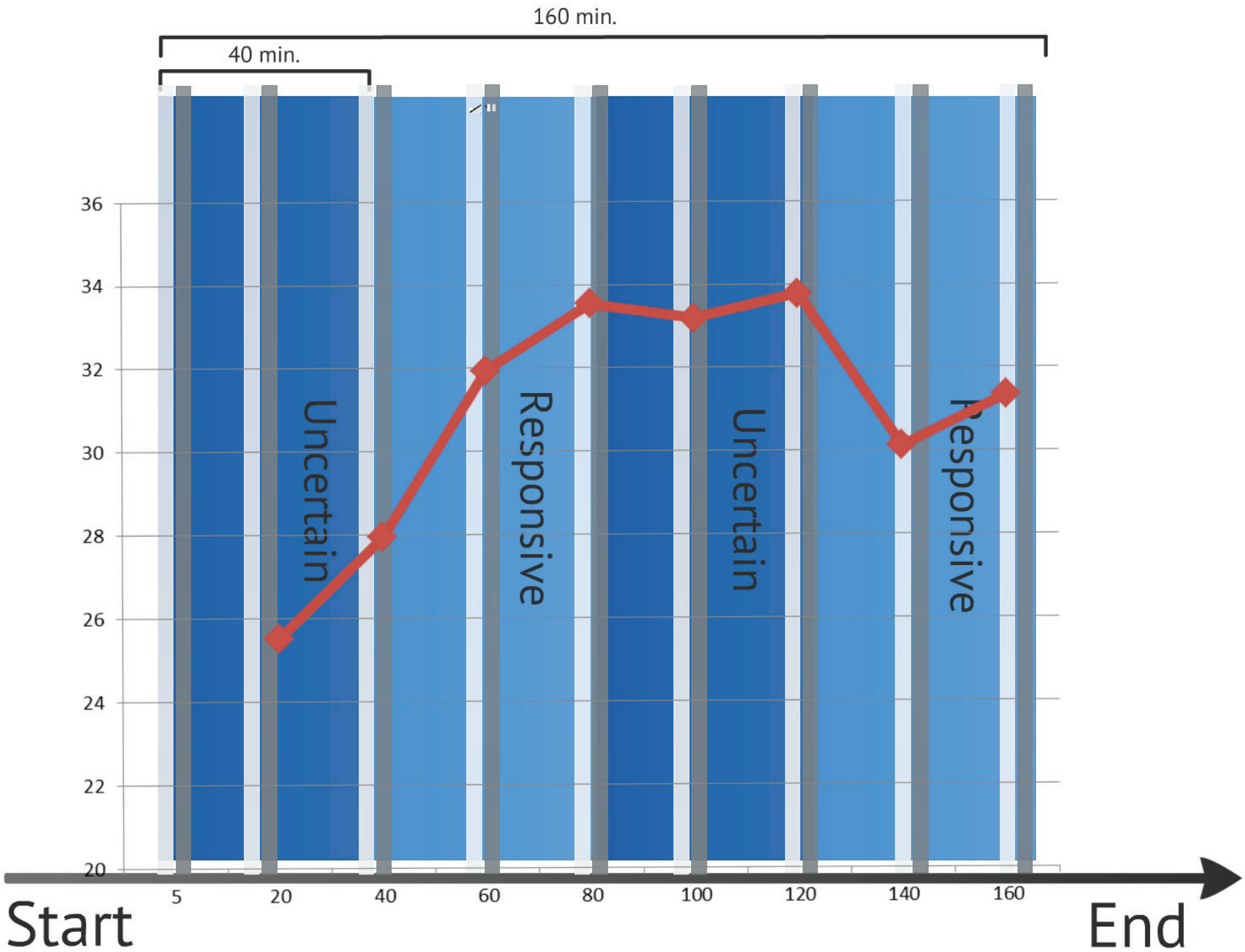


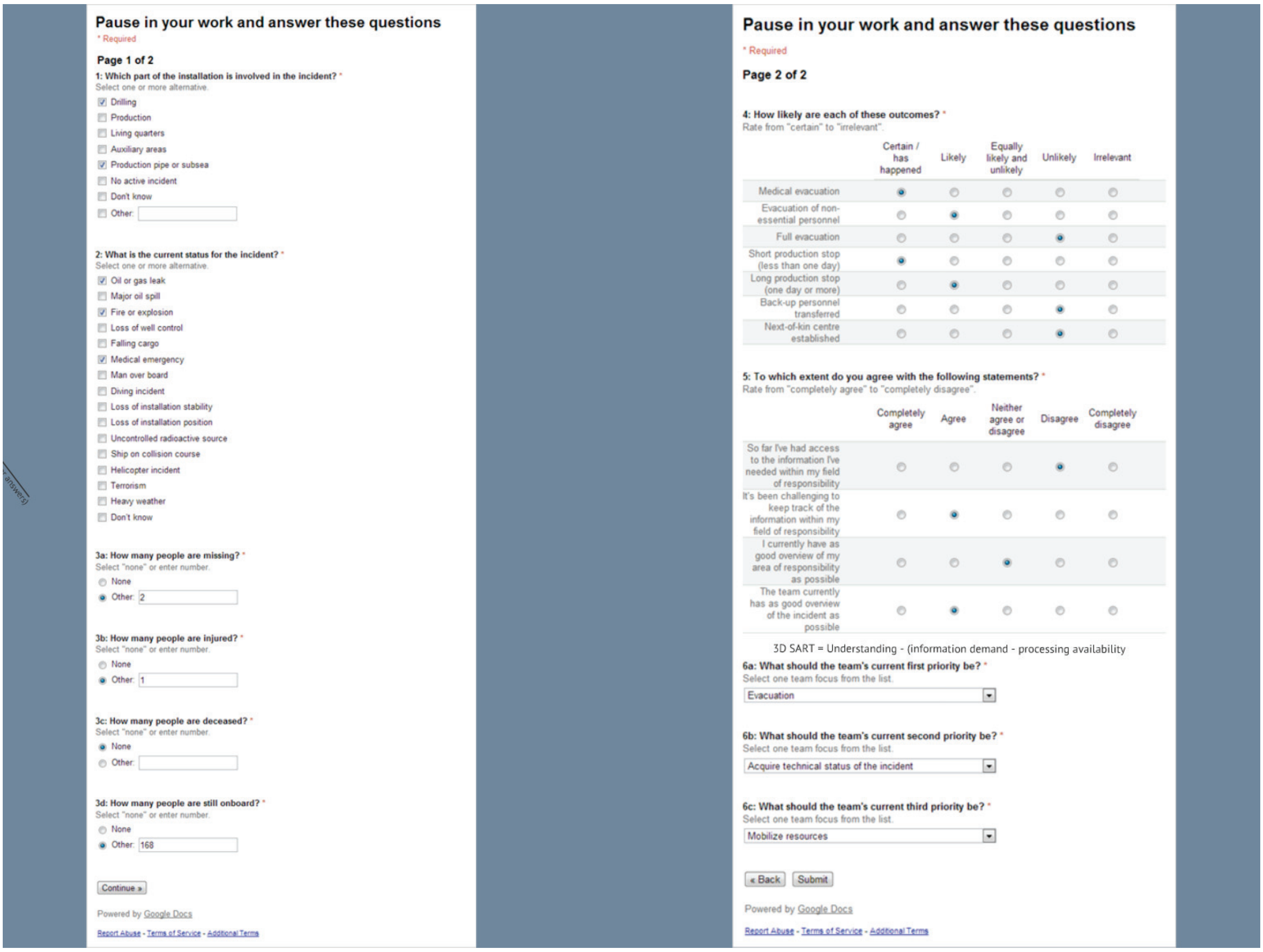

Team SA: "the degree to which every team member possesses the SA required for his or her responsibilities"
Endsley, 1995

Shared SA: "the degree to which team members possess the same SA on shared SA requirements"
Endsley & Jones, 1997

## Research aims

- Use extent of shared knowledge as an objective measure of situation awareness
- Look for consistencies within teams or within team roles
- Examine trajectories of self-reported SA and shared knowledge over time
- Compare shared knowledge with self-report measures of situation awareness
- Compare shared knowledge with psychophysiological measures of activation



**Pause in your work and answer these questions**

* Required

**Page 1 of 2**

**1: Which part of the installation is involved in the incident? ***
Select one or more alternative.

- [x] Drilling
- [ ] Production
- [ ] Living quarters
- [ ] Auxiliary areas
- [x] Production pipe or subsea
- [ ] No active incident
- [ ] Don't know
- [ ] Other:

**2: What is the current status for the incident? ***
Select one or more alternative.

- [x] Oil or gas leak
- [ ] Major oil spill
- [x] Fire or explosion
- [ ] Loss of well control
- [ ] Falling cargo
- [x] Medical emergency
- [ ] Man over board
- [ ] Diving incident
- [ ] Loss of installation stability
- [ ] Loss of installation position
- [ ] Uncontrolled radioactive source
- [ ] Ship on collision course
- [ ] Helicopter incident
- [ ] Terrorism
- [ ] Heavy weather
- [ ] Don't know

**3a: How many people are missing? ***
Select "none" or enter number.

- ( ) None
- (•) Other: 2

**3b: How many people are injured? ***
Select "none" or enter number.

- ( ) None
- (•) Other: 1

**3c: How many people are deceased? ***
Select "none" or enter number.

- (•) None
- ( ) Other:

**3d: How many people are still onboard? ***
Select "none" or enter number.

- ( ) None
- (•) Other: 168

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**Pause in your work and answer these questions**

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**Page 2 of 2**

**4: How likely are each of these outcomes? ***
Rate from "certain" to "irrelevant".

| | Certain / has happened | Likely | Equally likely and unlikely | Unlikely | Irrelevant |
|---|---|---|---|---|---|
| Medical evacuation | (•) | ( ) | ( ) | ( ) | ( ) |
| Evacuation of non-essential personnel | ( ) | (•) | ( ) | ( ) | ( ) |
| Full evacuation | ( ) | ( ) | ( ) | (•) | ( ) |
| Short production stop (less than one day) | (•) | ( ) | ( ) | ( ) | ( ) |
| Long production stop (one day or more) | ( ) | (•) | ( ) | ( ) | ( ) |
| Back-up personnel transferred | ( ) | ( ) | ( ) | (•) | ( ) |
| Next-of-kin centre established | ( ) | ( ) | ( ) | (•) | ( ) |

**5: To which extent do you agree with the following statements? ***
Rate from "completely agree" to "completely disagree".

| | Completely agree | Agree | Neither agree or disagree | Disagree | Completely disagree |
|---|---|---|---|---|---|
| So far I've had access to the information I've needed within my field of responsibility | ( ) | ( ) | ( ) | (•) | ( ) |
| It's been challenging to keep track of the information within my field of responsibility | ( ) | (•) | ( ) | ( ) | ( ) |
| I currently have as good overview of my area of responsibility as possible | ( ) | ( ) | (•) | ( ) | ( ) |
| The team currently has as good overview of the incident as possible | ( ) | (•) | ( ) | ( ) | ( ) |

3D SART = Understanding - (information demand - processing availability

**6a: What should the team's current first priority be? ***
Select one team focus from the list.

Evacuation

**6b: What should the team's current second priority be? ***
Select one team focus from the list.

Acquire technical status of the incident

**6c: What should the team's current third priority be? ***
Select one team focus from the list.

Mobilize resources

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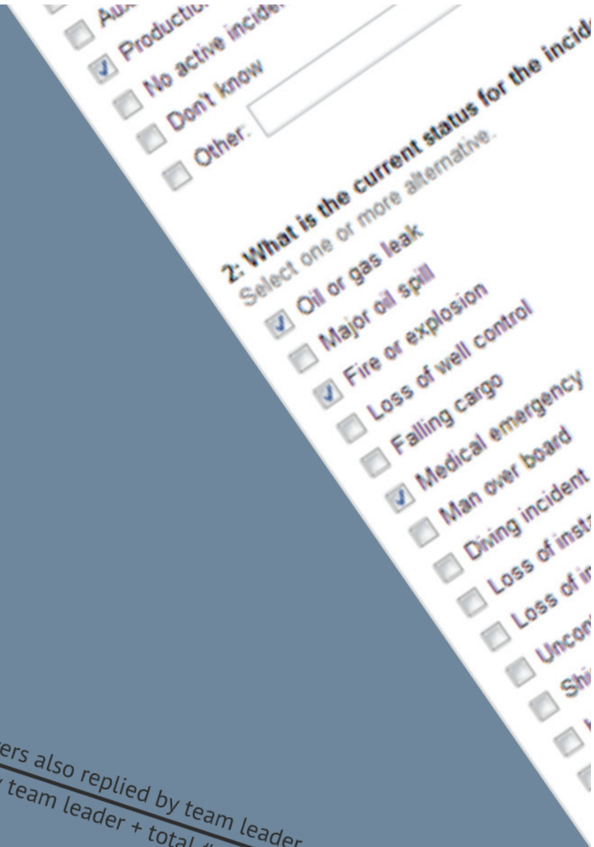
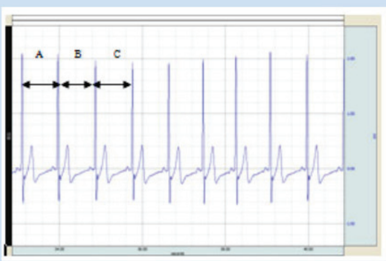
$$\text{Team similarity} = 1 - \frac{\text{answer - team's average answer}}{\text{sum of team's answers}}$$

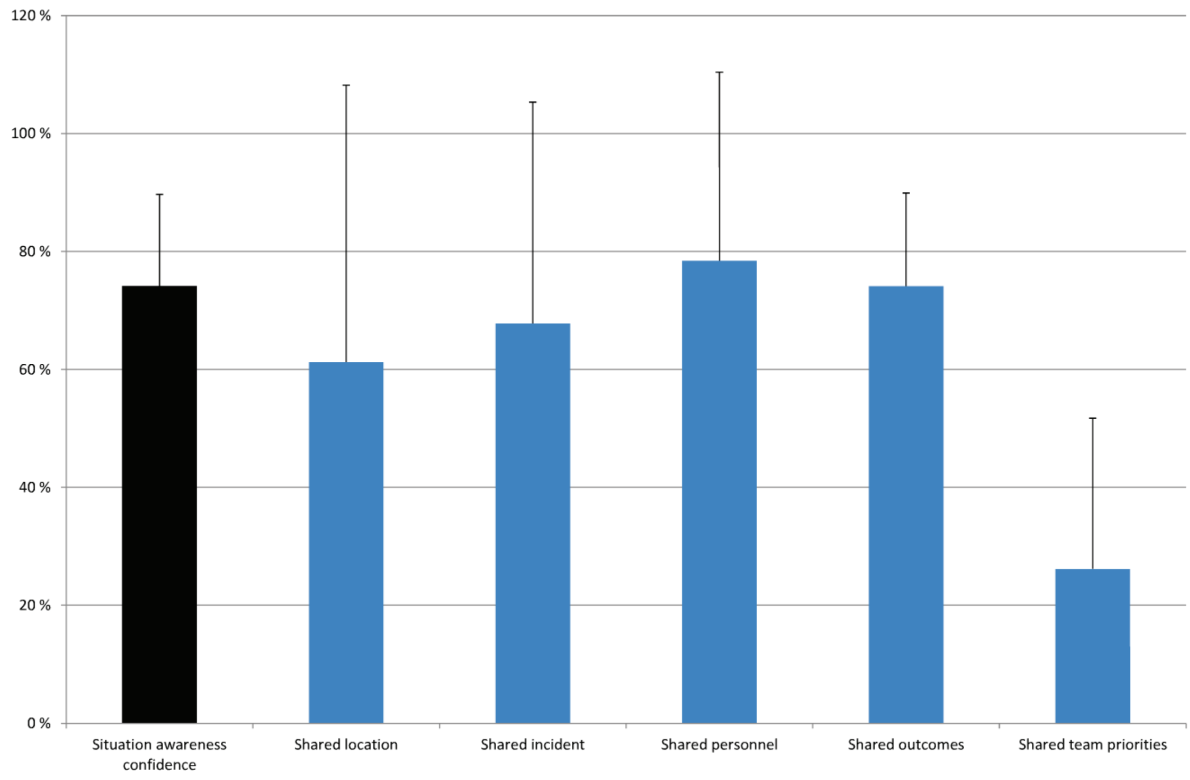
$$\text{Team leader similarity} = 1 - \frac{\text{\# of answers also replied by team leader}}{\text{(answers not replied by team leader + total \# of team leader answers)}}$$

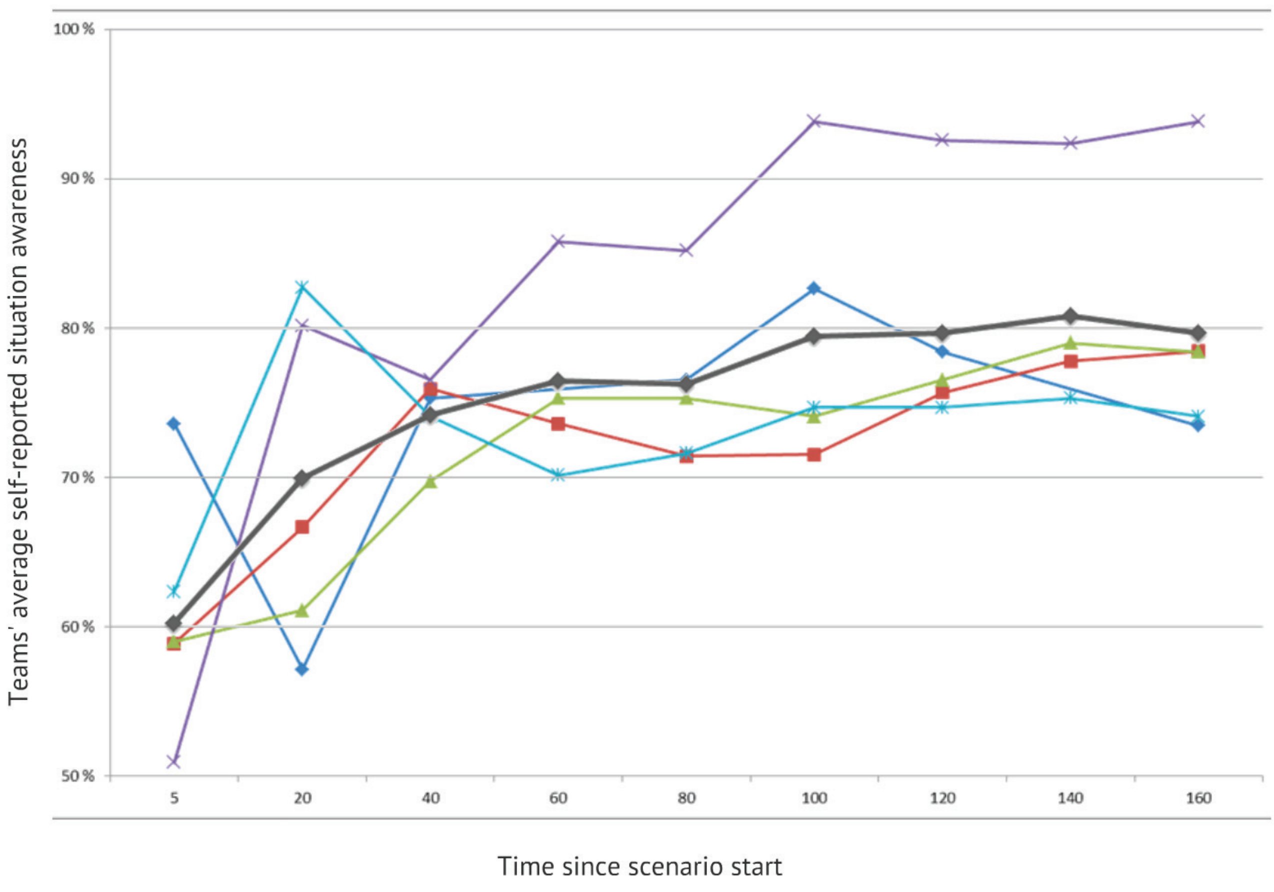


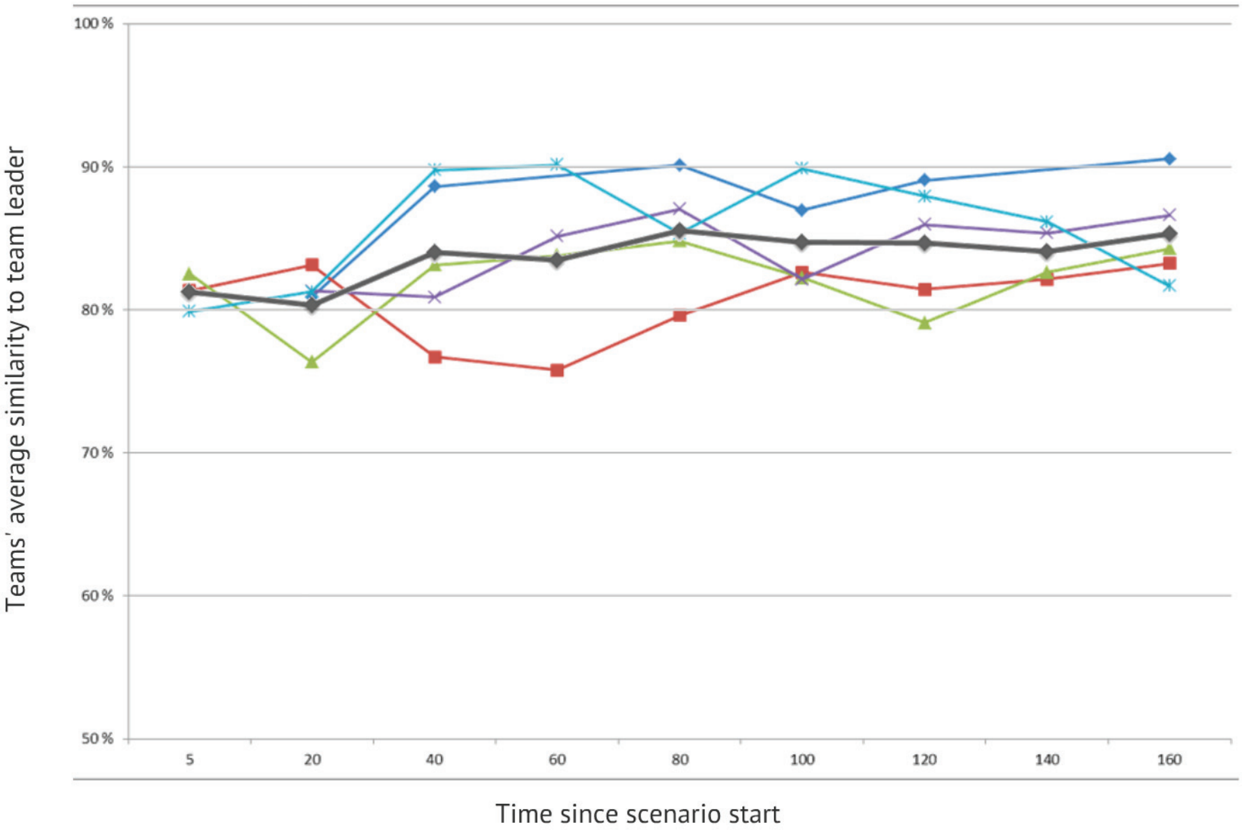



$$\text{RMSSD} = \sqrt{\frac{1}{N-1}\left(\sum_{i-1}^{N-1}((R-R)_{i+1} - (R-R)_i)^2\right)}$$


120 %
100 %
80 %
60 %
40 %
20 %
0 %
Situation awareness confidence
Shared location
Shared incident
Shared personnel
Shared outcomes
Shared team priorities


Teams' average self-reported situation awareness
100 %
90 %
80 %
70 %
60 %
50 %
5
20
40
60
80
100
120
140
160
Time since scenario start




# Analyses

- Amount of shared knowledge (as 9 repeated measures)
  - was predicted by team membership ($F(4, 21) = 10.13$, $p < .001$)
  - and average heart rate variability ($F(1, 21) = 12.26$, $p = .002$),
  - but not by team role ($F(7, 21) = 1.86$, $p = .13$),
  - or average self-reported situation awareness ($F(1, 21) = 1.49$, $p = .23$)
- The effect of scenario design (sample 2-3, 6-7 vs. 4-5, 8-9)
  - self-reported situation awareness increased over time, but was not related to complexity ($F(4, 44) = 2.93$, $p = .093$)
  - shared knowledge was higher in lower task complexity ($F(1, 39) = 5.09$, $p = .031$)
  - heart rate variability was higher in lower task complexity ($F(1, 38) = 6.59$, $p = .014$)

## Inherent assumptions in shared knowledge measure

- If team leader is misinformed, a factually correct response will be scored as incorrect
    - However, this would reflect a poor-functioning team (or leader)
- Not everyone needs to know everything
    - However, the probes were intended to measure information that everyone should know

## Conclusions

- Shared knowledge may be more relevant than self-reported SA
- Team role did not predict shared knowledge
    - Team work is equally distributed
    - Freeze questions were equally difficult for all roles
- Team membership did predict shared knowledge
    - Due to leader behavior?
    - Team familiarity?
    - Shared mental models?
- Task complexity modulated heart rate variation (an indicator of cognitive resources)
- Heart rate variation predicted the extent of shared information

## Feedback to industry partners

- Self-reported situation awareness may not be that useful
- Team members do not all share the same situation knowledge
    - In particular for location, incident type and priorities
- A complex task generates more physiological activation
    - Decreases cognitive resources for situation awareness

- Suggested interventions
    - Team leader should update the team more frequently
    - In particular when the situation changes
    - Train team members for team focus, not just your own task needs (e.g. by cross training)
    - Be aware of psychophysiological load

**HFC**

# Evolution of CRM in aviation

**M. Ydalus, Vision Monitor Aviation**

**Mer informasjon:**

**Se:**
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**EU Safety project - PROSPERO //www.prosperofp7.eu**

**Ulfvengren P., Rignér J., Leva M.C., McDonald N., Ydalus M. -** ***PSPMS an airline operational data model for a "predictive safety performance management system"***

**CHAPTER XX**

# Can safety regulation in aviation be preventive rather than reactive?

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## ABSTRACT

ICAO requires aviation organizations to have Safety Management Systems and states to have State Safety Programs. This new approach to safety is preventive, proactive rather than reactive, it aspires to be performance driven, systemic, and able to deliver verifiable improvement. Could the implementation of this regulation prevent the complex system accidents? This is unlikely for the following reasons. Risk assessment methodologies are largely based on expert judgment unsupported by extensive data. There is no integrated Air Transport System risk metric that allows risks of different types and sources to be assessed with reference to each other. The anticipation and preparation for potential emergencies is not integrated into normal everyday operational planning. Because there is no system-wide risk metric it is not possible for system improvements to be evaluated against some projected risk reduction target. There is no standard for safety performance that a regulator can use to audit, evaluate or require an operator to improve its safety system. The present paper seeks to address these fundamental defects in order to pave the way for what can be done in respect to the successful implementation of current requirements for SMS regulation.

**Keywords**: safety management, risk, system accidents, prevention

## THE PROBLEM

The next generation Air Transport System (ATS) requires systemic, proactive, performance-based safety management that is fully integrated into seamless ATS operational management, capable of delivering measurable performance improvement. While this is the aspiration of the current generation of SMS regulation, available processes, methods and tools are not adequate to realize this. The ICAO regulation (ICAO, 2008), mandates states to implement legislation requiring aviation organizations to have Safety Management Systems and for states to have State Safety Programs. The European Commission defines a safety management system as 'a pro-active system that identifies the hazards to the activity, assesses the risks those hazards present, and takes action to reduce those risks to an acceptable level. It then checks to confirm the effectiveness of the actions. The system works continuously to ensure any new hazards or risks are rapidly identified and that mitigation actions are suitable and where found ineffective are revised.' This new approach to safety is preventive, proactive rather than reactive, it aspires to be performance driven, systemic, risk based and able to deliver verifiable improvement. However, '*...there is not yet a universally accepted risk assessment methodology in common use across the European Union for all the aviation domains which would enable a standardised approach and better priority setting to tackle those risks that pose the greatest threat to safety. This shortcoming will have to be overcome.'* (European Commission, 2011a).

The ATS has to be able to anticipate and manage complex system interactions (where each element on its own may seem acceptable) before they are manifest in operational emergencies and use operational experience more effectively as a preventive resource. Recent aviation accidents have demonstrated that this is a significant weakness of the aviation system. When Air France 447 took off from Rio on June 1 2009 everything was apparently normal: the aircraft was fine – the pitot tubes were an unknown and acceptable defect. The crew, aircraft, route and weather were ok – nothing unusual. Nothing changed. Yet these elements in combination created a situation that ultimately the crew could not manage. There are two ways of looking at this disaster. Hindsight: why did the crew apparently not have basic airmanship skills? The interim investigation report has recommendations about crew training (BEA, 2011). This is the classic reactive approach – address the issues arising from the most recent serious safety event. This is essential. More challenging is to ask: What could have been done before that flight to minimize the possible risks associated with it? The risks were built into the operational situation before takeoff. Could routine measures in advance not just prevent this accident happening again but provide a more general preventive shield against a wide range of system accidents?

Could the implementation of the ICAO regulation (as European Directive and national legislation) prevent the type of accident that befell AF447? It is, of course, impossible to be certain, but, if one examines current methodologies and processes for managing safety, it is hard not to conclude that prevention would be unlikely given the current state of the art of safety management. This is for the following reasons:

- Risk assessment methodologies are largely based on expert judgment unsupported by extensive data and hence find it difficult to encompass complex system interactions.
- There is no integrated Air Transport System risk metric that allows risks of different types and sources to be assessed with reference to each other, singly or in combination.
- The active management of risk in planning and management of operations is not well supported
- The anticipation and preparation for potential emergencies is not integrated into normal everyday operational planning
- Because there is no system-wide risk metric it is not possible for system improvements to be evaluated against some projected risk reduction target.
- There is no standard for safety performance that a regulator can use to audit, evaluate or require and operator to improve its safety system.

## RISK ASSESSMENT

Current approaches to risk assessment tend to be based on either expert judgment or extensive data-mining, but rarely both. The probability of an outcome of a certain severity is core to the conceptual definition of risk. Yet the practice of risk assessment nearly always comes down to an expert judgment, of one or more experts (see, for example, Luxhøj, 2003; Rantilla and Budescu, 1999; Ayyub, 2001). Most often this is due to absence of accurate and timely data.. Bow-tie analysis, which is built around expert judgment, is at the heart of the ARMS (Airline Risk Management Solutions) methodology (Nisula and Ward, 2008). Fault Trees, Failure Mode and Effect Analysis, Human Reliability methods (e.g., THERP, TESEO, HEART, ATHEANA) and Functional Analysis all rely on expert judgment. Its major limitations relate to the reliability of judgments; hence the concern with combining the judgment of different experts. The judgements of experts are not sufficiently rigorous or reliable enough to assess complex combinations of factors.

Because there is an inverse relationship between probability and severity (more severe outcomes are less frequent than minor variations), it is important to get a composite picture that exploits the strengths and weaknesses of knowledge about different types of outcome. The distribution of minor variations can tell something about the vulnerabilities of the system to major breakdown. The investigation of major breakdown will rely partly on analyzing the normal mechanisms of the operation, trying to establish what causal influences came from normal system variation, what came from exceptional events. System risk assessment is thus an integrated, composite process. Understanding system safety requires the ability to explore complex, often remote, interactions. It therefore needs a strong data integration capability, the ability to link a variety of antecedents to consequences, and a strong modeling and analysis capability. Standard safety performance indicators are necessary, but not sufficient – they need to be interpolated in a composite measure of risk that can form a guiding index for a programme of risk reduction. Basic taxonomies and performance indicators need to reflect the full gamut of human, social and technical system functions.

Achieving an assessment of risk that provides meaningful links between antecedents and consequences and is rich in data is not easy. Different tools have addressed different parts of this challenge. Tools such as Vision Monitor and APF (Aerospace Performance Factors) (Eurocontrol, 2009) set performance indicators and integrate data. The SCOPE Model (McDonald and Morrison, 2006, Leva et al., 2011) examines the relationship between human factors and safety in operational systems. The SCOPE model has been developed precisely for the purpose of linking an in-depth analysis of the operation to relevant safety performance indicators and their antecedents (Leva et al., 2011).

## System risk

Despite the interdependencies between all the components of the Air Transport System there is no integrated system risk concept. Even within an airline between flight operations and maintenance risk means different things to different parts of an organization each of which have different baselines and priorities. For example, deferred defects may be an acute immediate risk for a maintenance organization, but not high on the priorities for flight operations. Therefore it is important to establish a common framework of safety performance because it is these mutual interdependencies that ultimately determine system risk. However a challenge in achieving this is the lack of one institutional owner of a system risk concept.

Collaborative risk sharing between competitive organizations (airline and third party maintenance organization) was demonstrated in the HILAS project in an improvement process (Ward et al, 2010). In this case the airline believed it carried the risk but did not manage it and had no effective oversight over how it was managed by the maintenance organisation. Recognising this led to developing a common program for improvement; this established a win-win framework for collaboration that resulted in a very successful series of checks (in terms of both safety and cost) for both partners. This can be seen as the first step in the development of an integrated risk framework that establishes sufficient commonality between safety performance indicators to support an appropriately integrated analysis of risk.

## MANAGEMENT OF RISK

Risk analysis and assessment should be part of a risk management process that concludes with an evaluation of risk reduction following the implementation of measures to mitigate and control the risk; or where it is not possible to mitigate the risk (through design, process change, planning, etc.) there is active and explicit management of operational risks in real time by crew during operations. Hence the quality of the management of risk is dependent on the quality of the initial assessment of the risk itself. Unfortunately current operationally focused risk management methodologies are not integrated with an effective risk assessment methodology.

The active management of risk in flight operations and Air Traffic Management has been much enhanced by the development of Threat and Error Management (TEM) (Helmreich et al., 2001). LOSA (Line Operations Safety Audit) and NOSS (Normal Operations Safety Survey) formalise this procedure, for flight operations and ATM respectively, as an operational audit using observers on the flight deck or at the ATC station under 'no jeopardy' procedures to assess real time management of threat and error (Henry, 2005; Knauer et al., 2005). However, the validity of these tools is questionable in some circumstances because, within their methodology, there is no independent criterion of quality or safety beyond the procedure. This problem was explored in a HILAS case study: what was seen through the LOSA findings to be a problem of error and performance standards, was in fact a problem of procedure within a very challenging flying situation, requiring high skill and experience to manage effectively (Cahill, 2011). This demonstrates the importance of having an independent criterion of system risk, as outlined in the previous sections.

The Intelligent Flight Plan concept, developed in the HILAS Project (from an Iberia use of TEM), is a smart concept for improving operational management of risk, incorporating an operational risk assessment in the normal flight preparation process rather than having it as an extra task with more effort involved (Cahill, 2011). This could be developed further by incorporating a comprehensive, authoritative and up-to-date data driven account of operational risk.

## Anticipation of emergencies

The accident involving AF447 is just one example (amongst many) of a lack of preparedness for a potential emergency becoming manifest in inappropriate control actions inadvertently escalating the situation. Mental preparedness for an emergency is critical in ensuring appropriate response. The cognitive processes of dealing with critical or emergency situations correspond more to a process of recognising a type of situation priming a schema or mental script for how to deal with this appropriately – not a process of listing and weighing up alternative courses of action (Zsambok and Klein, 1997). It follows that stimulating a mental rehearsal of potential scenarios involving relevant risks should significantly improve readiness to act appropriately and highlight areas of lack of preparedness.

Airports have a statutory requirement for periodic major emergency exercises, and simulation training for flight crew includes special training of non-normal processes and coping with particular types operational emergencies. Nevertheless there seems to be a gap in the routine priming of emergency preparedness. The provision of smart up-to-date and targeted risk information about an operation being planned will provide the opportunity not only to plan and prepare for how to manage such threats in a normal way, but also to rehearse potential emergency scenarios that are relevant to that particular operation.

It is important to find ways to maintain awareness of potential risks, at the operational level, including many hidden risks from time delays or deficiencies in the technical safety process. However there is no clear methodology for ordering and comparing the risks arising from different system defects or process deficiencies and hence for prioritizing improvements or for maintaining a high level of risk awareness at operational level.

## IMPROVEMENT OF RISK

Improvement processes are weak in aviation as in other industries (McDonald, 2006). Research in the AMPOS project showed that each stage in the improvement is more difficult than the last. It is almost impossible to get evidence of evaluation of implementation of recommendations. In ADAMS 2 research on response to serious incidents showed up a pattern of 'cycles of stability' in which little is actually achieved in terms of change from organizational effort into investigation and recommendations. Complex human factor and operational issues often fall off the improvement agenda or the incident is closed prematurely before any change has been implemented, let alone documented. For these reasons the HILAS project developed general organizational protocols for tactical and strategic and the MASCA project is following this up in developing a 'Change Management System', which is being deployed in a number of case studies of operational change (Ulfvengren et al. 2012).

## REGULATION OF SAFETY

Because there is no independent system standard for safety performance, the regulation of safety is currently subject to a fundamental contradiction – it is impossible to regulate safety, but only possible to regulate safety management. Even formulating policy goals is difficult. In Flightpath 2050 (European Union, 2011b), which guides the goals and objectives of the EU Framework RTD program, one of the key safety goals is the reduction of accidents by 80% - an aspirational figure, not based on any serious scientific analysis that would justify this as a realistic target.

In Europe, of all the elements of an ATS, only Air Traffic Management is regulated at European level (in the 'Single European Sky' - SES). The Performance Review policy for safety in the SES is currently based mainly on one dimension - implementing Safety Management Systems. Without independent operationally grounded criteria neither regulator nor regulated can show measurable improvement in safety. Furthermore the performance of the ATM system is itself dependent on the performance of airlines and airports. Hence the development of a meaningful performance concept at the core of aviation regulation really requires an integrated whole system approach.

## SAFETY MANAGEMENT AND SYSTEM CHANGE

The aviation system is changing rapidly. New business models are transforming operational norms. There are major technological initiatives, such as SESAR and NextGen, which are bringing new processes and operational concepts. Do current safety management capabilities meet this challenge? It is possible to trace an evolution of safety management as it attempts to address these challenges.

In Stage 1, Classic safety management, safety acts as a brake on change. Static safety standards provide a fixed reference point against which the system is evaluated. "Safety margins" maintain an uneasy balance between the opposing forces of safety and cost. Safety is managed as an independent system within the organization with little leverage over operational change. Stage 1 is typical of the JAA Regulations from the late 1980s and 1990s.

In Stage 2, safety management has to provide assurance in a time of change. Change erodes safety margins, for example in flight time limitations. Boundaries between what is safe and what is not are no longer clear. Active risk management is necessary to monitor system safety, for example in the development of fatigue risk management. Safety failure is a major corporate threat, because the leading business model is about reduced margins & lean processes. Safety Management System models are built on aspirations to be proactive and systemic, with no adequate guidelines on how to implement these goals. Safety culture is seen as instrumental in safety performance, but it is not clear how to measure or influence this. A good exemplar of this model is the work done by easyJet, both in the HILAS project and outside of it, in developing a corporate strategic risk management approach and implementing this in a much more dynamic fatigue risk management processes (refs).

In the evolution of Stage 3, safety management is a partner in change. Rigorous operational safety analysis delivers robust processes that give high reliability from all points of view. Safety is part of an integrated management concept with common performance indicators, integrated risk management and a common change program. All of this manages the transition from present to future – projection of future process is based on full modeling and analysis of all implications and risks. The approach integrates culture and system showing how to change the way the system works in order to influence culture. In this model a strong performance concept delivers an independent operational criterion of adequacy. This gives confidence that change can be managed against a rigorous criterion of operational effectiveness. Thus, when SESAR (or any other major technology initiative) delivers its new information systems and new operational concepts into the air transport system, it will be necessary to have a robust performance management framework to monitor its safety effectiveness. Safety management in Stage 3 seeks to provide a methodology for operational evaluation of new systems, offering the potential to link safety assessment at the design stage with safety assessment at the operational stage.

## PROACTIVE SAFETY PERFORMANCE FOR OPERATIONS

A research and development program has been initiated to address these challenges. It is called PROSPERO (Proactive Safety Performance for Operations) and is funded by the European Commission. Its common performance management concept is designed around two active management cycles, one concerning the real-time management of risk in operations (operational loop) and the other concerning system change and redesign (learning loop). The Operational loop is as follows:

*Risk information production*:

System risk assessment is an integrated, composite process. Performance indicators are linked meaningfully to system functions, combining operational data and reports. Consequences are linked back to their antecedents. In order to control the outcome, it is necessary to control the inputs or antecedents that are causally related to the outcome. It is important to understand those causal links and to be able to create tight statistical relations between antecedents and consequences, encompassing complex interactions.

*Risk information distribution*: Up to date risk information is embedded in the normal supply of information for the planning and management of flights through the IT systems for managing aircraft technical status, crew rostering, route planning, weather, etc.

*Risk information use:* Anticipation and mitigation of threats (including complex combinations of system risks) becomes an explicit part of flight operations planning and management all the way through to crew briefings and actions before and during flights. This provides for heightened anticipation of and preparedness for, not only routine management of threats, but also the specific characteristics of potential emergency situations. Where risks have been identified, specific feedback is triggered about the management of those risks in both normal and abnormal circumstances, feeding the production of up to date risk information.

The Learning loop is also triggered by risk information production:

*Solution identification*: the objective is to initiate a process of progressive systemic risk reduction, encompassing both what may be considered background risks (e.g. deferred defects, technical warnings) with immediate operational threats (e.g. weather). Solutions to optimize the system risk picture are proposed and taken up by those who are capable of implementing solutions.

*Solution implementation*: Proportionate effort is invested in implementing solutions at whatever level will create maximum leverage over system risk reduction – infrastructure, technologies, information systems, business and management processes, human resources, etc. As such initiatives are driven by projections of system risk reduction, their implementation is accompanied by comparing these projections with actual system risk outcomes (in so far as other influences can be discounted).

While ownership of risk often appears most salient at the level of a single organization, gaining leverage over system risk requires an integrated risk model or picture and a co-ordinated response of all air transport system stakeholders to risk management and mitigation. Creating this collaboration in what is often a competitive environment requires clear and repeated demonstration of actual and potential common system benefits. Thus a major goal for PROSPERO will be to demonstrate the efficacy of both operational and learning loops at an air transport system level – ATM, airport, flight operations, ground operations, maintenance.

At the regulation level (for example, Single European Sky), the whole system across a region is encountered. Here requirements are set to drive down accountable performance parameters. Performance is a function of the integrated activity of the ATS, not just one component. This is also the level where a larger, more powerful, dataset can be collected and integrated. Real leverage comes in enabling the regulator to have effective oversight of both the operational loop and the organizational learning loop at local and regional ATS levels and within individual organizations. This can give assurance that the risks identified are actually being managed and provides the basis for smarter and more cost-effective regulation.

## ACKNOWLEDGMENTS

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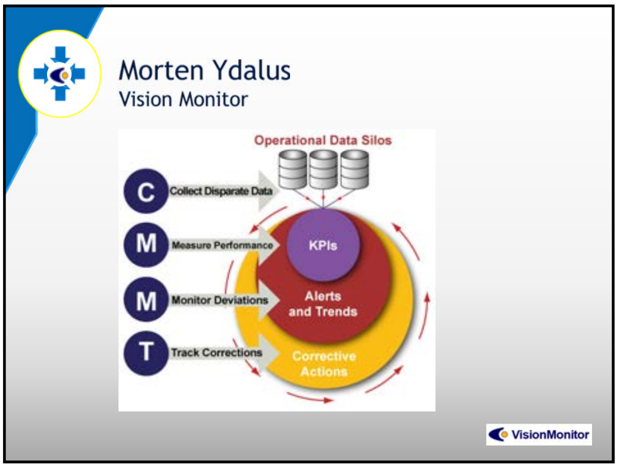
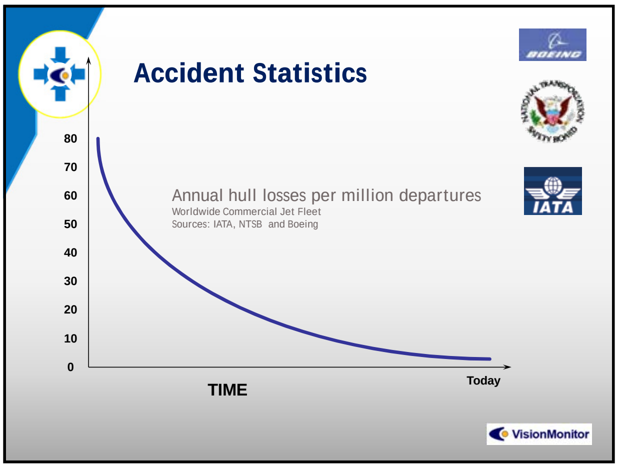
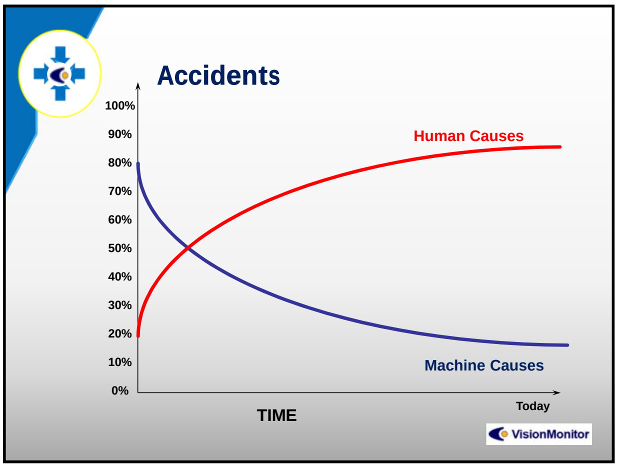
CRM Evolution in Aviation


Morten Ydalus
Vision Monitor
Operational Data Silos
C Collect Disparate Data
M Measure Performance
M Monitor Deviations
T Track Corrections
KPIs
Alerts and Trends
Corrective Actions
VisionMonitor


Accident Statistics
80
70
60
50
40
30
20
10
0
Annual hull losses per million departures
Worldwide Commercial Jet Fleet
Sources: IATA, NTSB and Boeing
TIME
Today
BOEING
IATA
VisionMonitor


Technical causes most common in the past


UNITED
60-80 % Human Error Today


Accidents
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Human Causes
Machine Causes
TIME
Today
VisionMonitor

## Objectives

- Understand the origin of CRM training for flight crews in the early 1980's , its evolution and current CRM training practiced in commercial aviation.

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## Outline

1. Introduction to Evolution of CRM
2. First generation of CRM
3. Second Generation of CRM
4. Third Generation of CRM
5. Forth Generation of CRM
6. Fifth Generation of CRM
7. Sixth Generation of CRM
8. Conclusion

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## Introduction

- CRM Generation/Evolution: refers to the process of growth & development in CRM program over last 2 decades.
- Till now, CRM have arrived at the 6th generation.

1st Generation➔2nd Generation➔
3rd Generation➔4th Generation➔
5th Generation➔6th Generation

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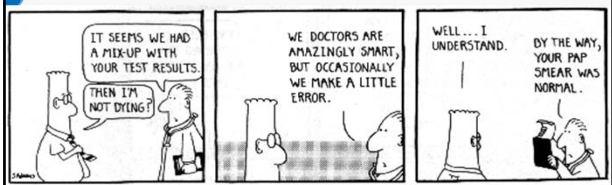
## Human Factors:
What's it mean?

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## Human Factors
Definition 1:

- Human Factors is the scientific discipline concerned with the understanding of *interactions among humans and other elements of a system*, and the profession that applies theory, principles, data and methods to design in order to optimize human well-being and overall system performance.

International Ergonomics Association (http://www.iea.cc)

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## Human Factors
Definition 2:

- "Human Factors is about people: it is about people in their working and living environments, and it is about their relationship with equipment, procedures, and the environment. Just as importantly, it is about their relationships with other people … Its two objectives can be seen as safety and efficiency."

ICAO Circular 227

VisionMonitor


## Human Factors
### Why *do* smart people do dangerous / dumb things?

- Excessive Workload
  - Physical and cognitive effort involved in task performance.
- Lack of Situation Awareness
  - What's going on?
  - What's likely to happen next?
  - What will happen if I take a particular action?
- Excessive Stress, Fatigue, Uncertainty, etc.
  - Impacts perceptual-motor performance, decision-making, etc.
- Diminished Attention
  - Too much to attend to at once (overload)
  - Too little to attend to for too long (underload)
- Poor Teamwork and Communication
  - Often due to poor layout of work space and/or poor layout of command and communication structure
- Quality engineering can help avoid virtually all of these problems

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## Human Factors
### Avoiding Errors

- **Plan, design, manufacture, and implement systems that:**
  - Utilise human capabilities;
  - Cater to human limitations:
    - Redundancies;
    - Layered defences;
    - Fail-safe design etc etc etc
- **Train & equip humans to:**
  - Utilise the system;
  - Recognise and minimise their limitations;
  - Learn from errors.

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## Major Accidents that Initiated the CRM

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## 1st major air disaster that initiated CRM (Loss of Situational Awareness)

1972: Eastern L-1011 crashed during approach in Miami Airport

Flight crew's fail to monitor the flight instruments during a malfunction of the landing gear position indicator system. The crew realised their error too late and were too low to recover. Of the 163 persons on board 112 were killed in the crash.

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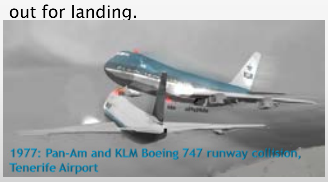
## 2nd major air disaster that initiated CRM (Poor Communication)

The KLM B747 Captain initiated a takeoff without permission while the Pan Am B747 aircraft was using the runway to taxi out for landing.




337 peoples on the Pan Am B747 and 248 on the KLM B747 were killed.

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## 3rd major air disaster that initiated CRM (Loss of Situational Awareness & Poor Communication)

1978: UAL 173 DC-8 crashed during approach near Portland

First Officer Rodrick Beebe:
*Portland Tower United 173, Mayday! We're...the engines are flaming out...we're going down. We're not going to be able to make the airport.*

- Captain fixation on landing gear problem.
- His crews (F/O & F/E) informed about low fuel condition.
- Captain ignored them or misunderstood them & continue to solve landing gear problem.
- The DC-8 ran out of fuel and finally crashed.
- 189 Peoples, 10 killed, 23 seriously injured

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## Human Factors:
Involves humans.

"Human beings by their very nature make mistakes; therefore, it is unreasonable to expect error-free human performance."
Shappell & Wiegmann, *1997*.

## So why do we need CRM Programs???

Many accidents result not from a technical malfunction but most accidents are caused by the inability of crews to respond appropriately to the situation in which they find themselves.

For example, inadequate communications between crew members and other parties could lead to a loss of situational awareness, a breakdown in teamwork in the aircraft, and ultimately to a wrong decision or series of decisions which result in a serious incident.

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## First Generation of CRM:
Cockpit Resource Management

Year Begins: 1981

Initiator/Developer: United Airlines (Develop from a workshop conducted by NASA in 1979).

Objective: To correct lack of junior officer assertiveness and pilot authoritarianism

Focus/Concern: **Leadership (Pilot) and Psychological**

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## First Generation of CRM cont.

- Concept:
  - Emphasize on changing individual styles and correcting deficiency.
  - Study on captain failure to accept input from junior crew members.
  - Fix the "*Wrong Stuff" leaders and make junior crew members assertive.
  - Training Method: **Classroom training and full mission simulator training or *Line Oriented Flight Training (LOFT).**

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## First Generation of CRM cont.

- *"Wrong Stuff" term refers to the captain's failure to accept input from junior crewmembers.*
- **Line Oriented Flight Training (LOFT) is carried out in a flight simulator as part of initial or recurrent flight crew training.*

•Participant: Pilots
•Program's Problem/Lack:
Many training module (games and exercises) unrelated to aviation to illustrate the concept

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## Second Generation of CRM:
### Crew Resource Management

Year Begins: 1986
Developer/Initiator: NASA and Delta Airlines

Objective: To organize the role of all crew members to break the chain of errors that could cause an accident.

Focus/Concern:
Team Orientation (all crew members)
Team building, briefing strategies, situational awareness (SA) and stress management

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## Second Generation of CRM cont.

- Background:
  - Change in name from "Cockpit" to 'Crew Resource Management'.
  - The trainers realized that better outcomes could be produced if the entire crew was involved.
  - Training concentrated on team building, briefing strategies, situational awareness (SA) , stress management and decision making strategies.
  - The aim was to break the chain of errors that could cause an accident.
  - Training Method: **Intensive seminar**

Participant: All crew members
Problem/Lack: still rely on exercises unrelated to aviation in demonstrating the concept.

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## Third Generation of CRM:
### Broadening the Scope

Time Start: 1990
Objective: Recognize the need to extend the concept of the flight crew function.

Focus/Concern:
The need to improve flight crew.
Specific skills and behaviors that pilot could use to function more effectively

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Not a good day at the office!

## Third Generation of CRM cont.

- Background:
  - Address the recognition and assessment of human factors issues.
  - Advance training in CRM.
  - Began to extend to other group in flight operation such as flight attendants, dispatcher, and maintenance personnel.
  - Conduct joint cockpit-cabin CRM training.
  - Training for new captain to focus on leadership role that accompanies command.

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## Third Generation of CRM cont.

- Several airlines began to include modules addressing CRM issues in the use of '*FLIGHT DECK AUTOMATION'

**Flight deck automation*
*- means machines on the -commercial transport aircraft flight deck (cockpit) that perform functions (not pilot).*
*-includes autopilots, flight management systems, electronic flight instrument systems, and warning and alerting systems.*

Participant: Cockpit crew, flight attendants, dispatcher (Flight operation officer) and maintenance personnel.
Problem/Lack: deviate from the original focus on reduction of human error.

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## Fourth Generation of CRM:
### Integration and Proceduralization

Year Begins: 1993
Initiator/Developer: Federal Aviation Administrator (FAA)
Objective: To develop innovative training that fits the needs of the specific organization culture.

Focus/Concern:
Provide both CRM and LOFT training to all flight crew.
Integrate CRM concept into technical training

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## Fourth Generation of CRM cont.

- Background:
  - Transition to *Advance Qualification Program (AQP).
  - Detailed analysis of training requirements for each aircraft.
  - Develop programs that address CRM issues in each aspect of training.
  - Special training: Line Operational Evaluation (LOE)

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## Fourth Generation of CRM cont.

**AQP*
- *is a systematic methodology and qualification (standard) for developing the content of training programs for air carrier crewmembers and dispatchers .*
- *Introduced by FAA*
- *ATQP (alternative training & qualification program) EU-OPS 2010*

- **LOE*
  - LOE (flight simulator) with AQP standard.

Participants: all flight crew members
Problem/Lack: More complex and the resolution not straight forward.

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## Fourth Generation of CRM cont.

- "The magic roundabout in the UK"
  - Five roundabouts centred around another.  It is an example of an too complex/complicated system lead to error.

You cannot have a good safety record if the organisation does not embrace/understand the concept of specific organizational culture.

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## Fifth Generation of CRM:

**Error Management**

Year Begins: 1997

Objective: To normalize the error and develop strategy for managing error

Focus/Concern: Error Management.

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## Fifth Generation of CRM cont.

- Background:
  - Assume human error is pervasive and cannot be totally eliminated.
  - Focus on **error management** with the development of error countermeasures. (an action taken to counteract a danger)
  - There are three lines of defence in these counter measures.
    - 1: Firstly we can attempt to minimise error
    - 2: Secondly we can try to trap the errors, and
    - 3: Thirdly we can mitigate (reduce) result of errors.

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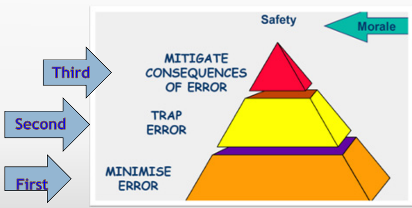
## Fifth Generation of CRM cont.

3 lines of defence to counter act the dangers




The point of the exercise is to achieve safety – which is a major determinant of morale.

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## Fifth Generation of CRM cont.

- For example, consider an advanced aircraft experiences *Controlled Flight Into Terrain (CFIT) because wrong data is entered to *Flight Management System (FMS).
- But this error actually can be managed through these 3 actions:
  - 1st :A careful briefing on procedures combined with communication & verification of FMS entries can avoid/minimize the error.
  - 2nd: Cross-checking entries should trap the error.
  - 3rd : Inquiry & monitoring of the position should result in mitigating the error consequences before CFIT.

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## *Controlled flight into terrain (CFIT)

- CFIT describes an aircraft collision, under pilot control, who inadvertently flies into terrain, an obstacle, or water.
- The pilots are generally unaware of the danger until it is too late.

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## *Flight Management System (FMS)

- The flight management system (FMS) is the avionics that holds the flight plan, and allows the pilot to modify as required in flight.
- Given the position and the flight plan, the FMS guides the aircraft along the flight plan.
- The FMS is normally controlled through a small screen and a keyboard.

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## *Ground proximity warning system (GPWS)

- Since 1960s, a series of controlled flight into terrain (CFIT) accidents killed hundreds of people.
- Thus, a device called a ground proximity warning system (GPWS) had been used to overcome CFIT problem.
- A Ground Proximity Warning System (GPWS) is a system designed to alert pilots if their aircraft is in immediate danger of flying into the ground or an obstacle

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## Sixth Generation of CRM:
### Looks Beyond the Aircraft

- Year Begins: 2001
- Objective: To reduce human error and optimize human performance.
- Focus/Concern: Crew and managing the resources.
- This is the latest generation that every airliner in the world currently practices.

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## Sixth Generation of CRM cont.

- Cover all the elements of CRM/TEM:
  - communication, decision making, situational awareness, leadership, workload management, risk management, threat management ,error management, crew personality, stress, and fatigue management
- It also looks to all the resources (people and equipment).
- This is where TEM comes into play:
  - *Anyone who is involved with the aircraft's mission, anyone who is part of the crew, has a role to play in TEM.*

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## Threat and Error Management


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## TEM


TEM is a comprehensive model for improving flight safety, security and efficiency.

Skillful execution of the model will reduce risk exposure by improving the management of threats and errors

Conceptual framework for all crew members training

The TEM model shall be visualized through the behaviors of all crew members during normal flight duty.

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## TEM Conclusions

What was in it for us?

Threat Management is the management of the future

Error Management is the management of the past (or present)

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## Conclusion

- CRM is not and never will be the mechanism to eliminate error and assure absolute safety in a high risk endeavor such as aviation.
- Error is an inevitable result of the natural limitations of human performance and the function of complex systems.
- CRM is one of an array of tools that organizations can use to manage error.
- When CRM is viewed in the context of the aviation system, its contributions and limitations can be understood.

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## Key Points

Concepts of:

1. First generation of CRM (**Cockpit resource management**)
2. Second Generation of CRM (**Crew resource management**)
3. Third Generation of CRM (**Broadening of the scope**)
4. Forth Generation of CRM (**Integration and Proceduralization**)
5. Fifth Generation of CRM (**Error management**)
6. Sixth Generation of CRM (**Looks Beyond the Aircraft**)

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## Quotes of the Day

- *What is the cause of most aviation accidents: Usually it is because someone does too much too soon, followed very quickly by too little too late.*

Steve Wilson, NTSB investigator, Oshkosh, WI , August, 1996.

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HFC

# Å utvikle et CRM-kurs: Erfaringer fra et prosjekt med Kystverket

**A. Wahlstrøm, DnV og M. Dreijer, T. Haugsnes, Kystverket**

**Mer informasjon:**

# Team dynamics in critical situations – Crew Resource Management (CRM) and other approaches

## Developing a CRM course: experience from a project with Norwegian Coastal Authorities

Kystverket- Malin Dreijer, Tommy Haugsnes
DNV- Anne Wahlstrøm

10.04.2013

MANAGING RISK

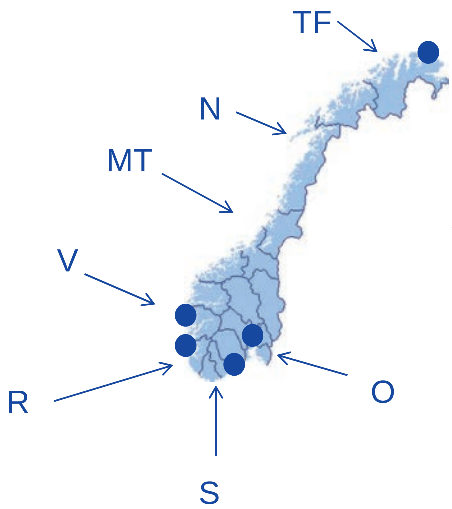
# About Norwegian Coastal Administration

- 7 pilot regions with 290 pilots

  Troms og Finnmark (TF)
  Nordland (N)
  Møre og trøndelag (MT)
  Vestlandet (V)
  Rogaland (R)
  Skagerrak (S)
  Oslofjorden (O)

- 5 Vessel Traffic Service Centers with 70 VTS operators

  Vardø
  Fedje
  Kvitsøy
  Brevik
  Horten




Vardø (TF)
Fedje (V)
Kvitsøy (R)
Brevik (S)
Horten (O)




MANAGING RISK

# Norwegian Coastal Administration, objective and strategier

- Contribute to the efficient transport
- Ensure safe navigation in Norwegian waters
- Prevent or limit the environmental damage caused by pollution accidents in Norwegian waters or on Norwegian territory
- NCA's vision is to develop coastal and marine areas of the world safest and purest.



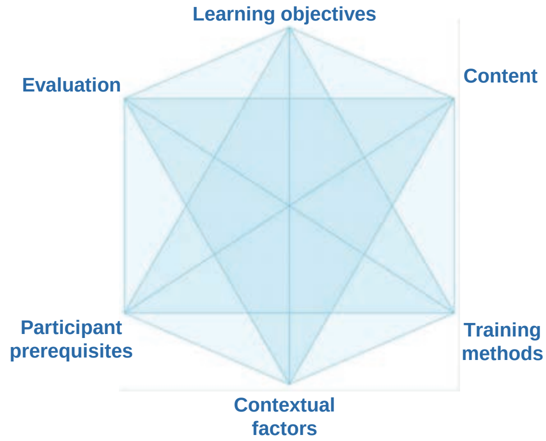



# Background for competence building: "Pilots and VTS resource management"

- CRM is part of renewed pilot education since 1990
- Other incidents / accidents
  - Karmsundet
  - Vatlestraumen
  - Boarding Area
- Based on the Federal Kivalina accident with a pilot onboard ,outside a VTS area was investigated by The Accident Investigation Board Norway and they pointed out **common CRM training** for pilot &VTS as on of the risk reducing actions.
- Interaction between pilot and VTS, understanding of each other´s tasks and responsibility.
- Other initiatives in NCA, founded by top management:
  - Simplification and updating of procedures
  - VTS and Pilot have internal control of procedures and workprocess
  - Review and improvement of common phraseology

# Competence building is developed using acknowledged pedagogical principles and frameworks

**Didactical learning model**




**In essence, the goal is to:**

- A process for establish and agree framework for course content and schedule
- Define the right levels of learning objectives (skill-level, knowledge-level etc)
- Reveal organisational/ professional obstacles for learning
- Ensure that learning can be evaluated and that effects can be measured





# "Pilots and VTS resource management"

**Facts about this program:**

- 6 pilots and 2 VTS operators per course
- 70 participants per year
- 5 year program
- Refresh course after this program
- NCA Top management one-day course
- CRM-coach on each VTS centre today and pilot stations to-be soon

**Basis for the success:**

- Management commitment and attention
- User group participated in development
- Good ambassador for this competence development through out the organisations
- Training closely linked to other initiatives

# Development of competence building projects

**Workshop 1**

**Workshop 3**

**Handover and adjustment** by course deliver

**Yearly review**

Management commitment and communication strategy

**Workshop 2**

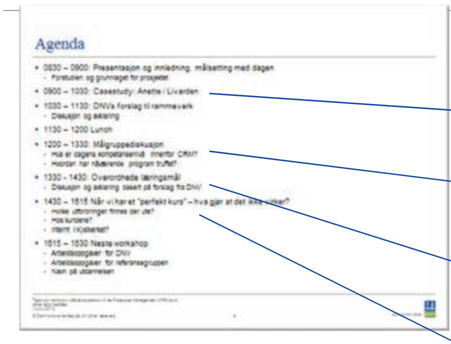
**Develop course**: Theory Case Simulations

**Yearly program**





# Workshop 1



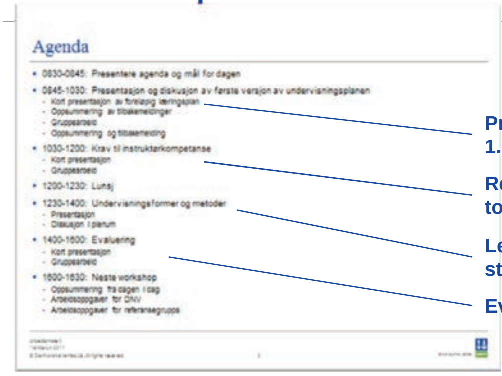

**Casestudy**

**Participant prerequisites**

**Learning objectives**

**Obstacles for learning**


# Workshop 2


## Agenda

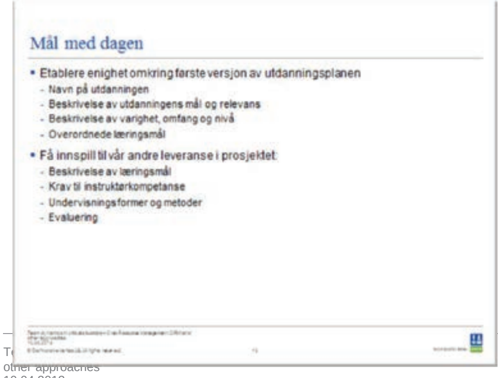
- 0830-0845: Presentere agenda og mål for dagen
- 0845-1030: Presentasjon og diskusjon av første versjon av undervisningsplanen
  - Kort presentasjon av foreløpig læringsplan
  - Oppsummering av tilbakemeldinger
  - Gruppearbeid
  - Oppsummering og tilbakemelding
- 1030-1200: Krav til instruktørkompetanse
  - Kort presentasjon
  - Gruppearbeid
- 1200-1230: Lunsj
- 1230-1400: Undervisningsformer og metoder
  - Presentasjon
  - Diskusjon i plenum
- 1400-1600: Evaluering
  - Kort presentasjon
  - Gruppearbeid
- 1600-1630: Neste workshop
  - Oppsummering fra dagen i dag
  - Arbeidsoppgaver for DNV
  - Arbeidsoppgaver for referansegruppe

Presentation
1. Draft framework

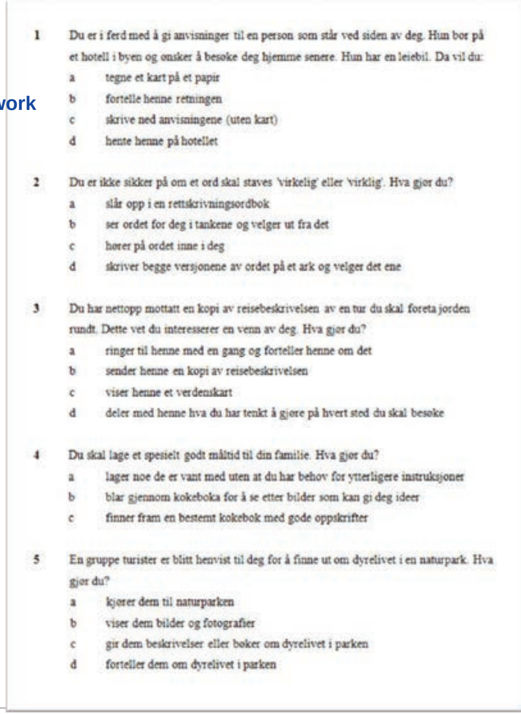
Requirments
to instructors

Learning
styles

Evaluation


## Mål med dagen

- Etablere enighet omkring første versjon av utdanningsplanen
  - Navn på utdanningen
  - Beskrivelse av utdanningens mål og relevans
  - Beskrivelse av varighet, omfang og nivå
  - Overordnede læringsmål
- Få innspill til vår andre leveranse i prosjektet
  - Beskrivelse av læringsmål
  - Krav til instruktørkompetanse
  - Undervisningsformer og metoder
  - Evaluering


1 Du er i ferd med å gi anvisninger til en person som står ved siden av deg. Hun bor på et hotell i byen og ønsker å besøke deg hjemme senere. Hun har en leiebil. Da vil du:
- a tegne et kart på et papir
- b fortelle henne retningen
- c skrive ned anvisningene (uten kart)
- d hente henne på hotellet

2 Du er ikke sikker på om et ord skal staves 'virkelig' eller 'virklig'. Hva gjør du?
- a slår opp i en rettskrivningsordbok
- b ser ordet for deg i tankene og velger ut fra det
- c hører på ordet inne i deg
- d skriver begge versjonene av ordet på et ark og velger det ene

3 Du har nettopp mottatt en kopi av reisebeskrivelsen av en tur du skal foreta jorden rundt. Dette vet du interesserer en venn av deg. Hva gjør du?
- a ringer til henne med en gang og forteller henne om det
- b sender henne en kopi av reisebeskrivelsen
- c viser henne et verdenskart
- d deler med henne hva du har tenkt å gjøre på hvert sted du skal besøke

4 Du skal lage et spesielt godt måltid til din familie. Hva gjør du?
- a lager noe de er vant med uten at du har behov for ytterligere instruksjoner
- b blar gjennom kokeboka for å se etter bilder som kan gi deg ideer
- c finner fram en bestemt kokebok med gode oppskrifter

5 En gruppe turister er blitt henvist til deg for å finne ut om dyrelivet i en naturpark. Hva gjør du?
- a kjører dem til naturparken
- b viser dem bilder og fotografier
- c gir dem beskrivelser eller bøker om dyrelivet i parken
- d forteller dem om dyrelivet i parken





KYSTVERKET MANAGING RISK DNV

# Læringsstiler

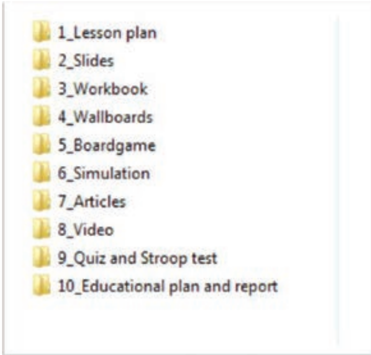
| Læringsstil | Metode | Virkemiddel |
|---|---|---|
| **Den visuelle:** | Lærerens "drømmeelev"<br>Sitter nær læreren<br>Vil ha med seg alle instrukser og beskjeder<br>Stiller oppklarende spørsmål<br>Liker at læreren forklarer med notater på tavla, transparenter<br>Liker skriftlige oppgaver | •Ønsker kopi av alle presentasjoner<br>•Foretrekker å arbeide alene |
| **Den lese/skrive-orienterte:** | Skriv lister og definisjoner<br>Skriv setninger for å gjengi det du ser på diagram og grafer<br>Les tekster for seg selv | •Ønsker å notere |
| **Den auditive:** | Lett å undervise<br>Elsker å snakke<br>Muntlig tilegning<br>Diskuter<br>Verbal behandling<br>Leser sjelden raskt | •Diskusjon<br>•Gruppearbeid |
| **Den taktile:** | Må alltid plukke på saker og ting- ofte til andres irritasjon<br>Læringsreseptorene sitter i hendene/fingrene,<br>Behov for taktil stimulering for å forankre nytt stoff<br>Læring bygger på følelser | •Bevegelse og aktivite<br>•Praktiske sans |
| **Den kinestetiske:** | Bruk eksempler ved læring av vanskelig teori<br>Bruk rollespill så mye som mulig<br>Kombiner læring med bevegelser og øvelser | Bevegelse og aktivite<br>•Rollespill<br>•Praktiske sans |

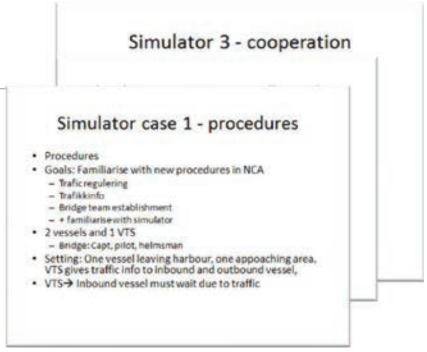




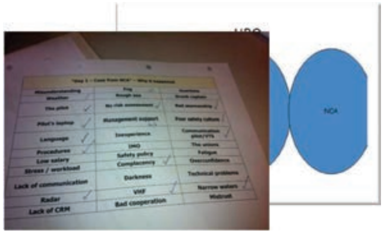
MANAGING RISK DNV

# Learning material





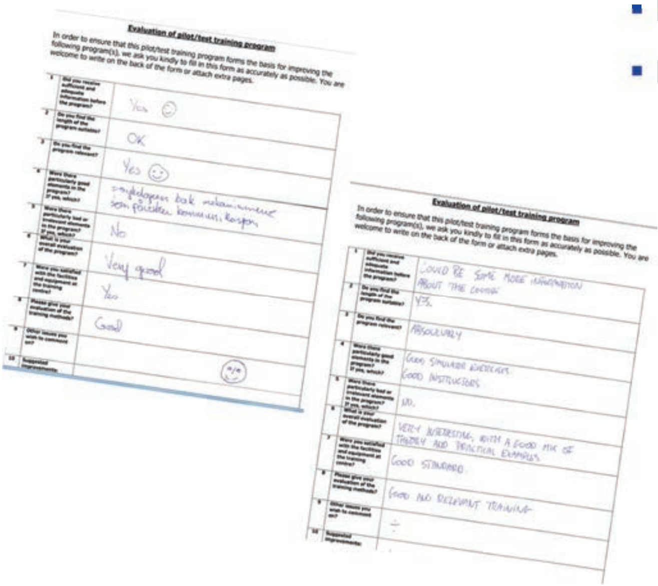







# Evaluation

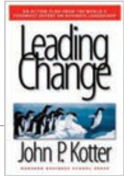
- Evaluation prior and after training
- Internal review




# Preliminary results after 6 months

- CRM climate between pilot and VTS operator
- Request for refreshment courses
- Practical introduction of SMCP

# Leading Change – John P. Kotter




Leading change successfully requires 8 steps:

1. Establish a Sense of Urgency
2. Form a Powerful Guiding Coalition
3. Create a Vision
4. Communicate the Vision
5. Empower Others to Act on the Vision
6. Plan and Create Short Term Wins
7. Consolidate Improvements
8. Institutionalize the New Approach



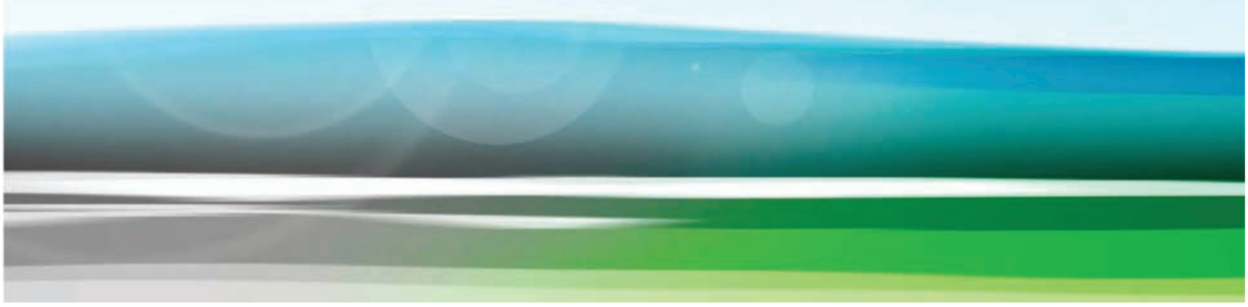



KYSTVERKET

MANAGING RISK DNV

# Safeguarding life, property and the environment

www.dnv.com



MANAGING RISK DNV

HFC

# CRIOP med CRM fra 2004 – bakgrunn og erfaringer fra bruk

**S.O. Johnsen, SINTEF**

**Mer informasjon/referanser:**

**www.criop.sintef.no og www.hfc.sintef.no**

Aas, Andreas L.; Johnsen, Stig Ole; Skramstad, Torbjørn. (2009) CRIOP: A Human Factors Verification and Validation methodology that works in an industrial setting. Lecture Notes in Computer Science. 2009; volum 5775.

Fischhoff, B., Brewer, N.T, Downs, J.S. (2011) "Communicating Risks and Benefits: An Evidence-Based User's Guide" FDA

Mearns (2001) Mearns, K., Flin, R., & O'Connor, P. (2001). Sharing worlds of risk: Improving communication with Crew Resource Management. Journal of Risk Research, 4(4), 377-392

PSA (2005) "Human Factors in drilling and well operations"

PSA (2007) "Human Factors i bore- og brønnoperasjoner – borernes arbeidssituasjon"  ("Human Factors in drilling and well operations" )DnV and PSA

Salas, E., Sims, D.E. and Burke, C.S. (2005). "Is there a big five in teamwork? Small Group Research, 36 (5), 555-599.

Salas E, Wilson KA, Burke CS, Wightman DC. (2006) "Does crew resource management training work? An update, an extension, and some critical needs." Hum Factors. 2006 Summer;48(2):392-412.

# Crew Resource Management in CRIOP from 2004

Stig.O.Johnsen@sintef.no



## Agenda

- Why CRM focus in CRIOP in 2004?
- Experiences of use
- Suggested use of CRM

# Human Factors and CRM

Human Factors – (in short) a discipline focusing on the nature of interactions between humans, technology and organizations – (see definition at IEA - International Ergonomics Association – copy at www.hfc.sintef.no)

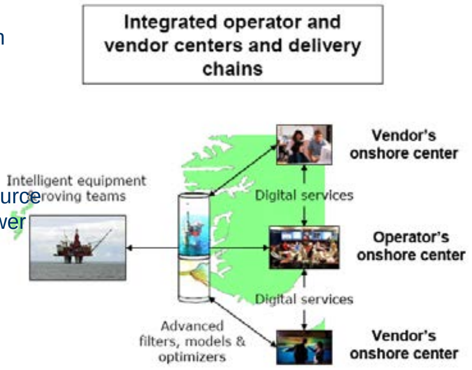
Human Factors domains:

- Physical ergonomics
- Cognitive factors (perceptions, information processing, ..)
- Organizational factors (communication, teamwork, **CRM**…)



# More teamwork/more collaboration - CRM

- What is CRM:
  - **CRM is team training to improve crew coordination and performance. (Salas 2006)**
  - A goal is to reduce accidents through preventing errors, trapping errors or mitigating errors.
- CRM use and focus:
  - Aviation, Medical fields, Bridge Resource Management, US Navy, Nuclear Power Plants, Rail, Space
  - Common themes: Communication, Situational Awareness
- Oil and gas
  - Increased collaboration and performance demands



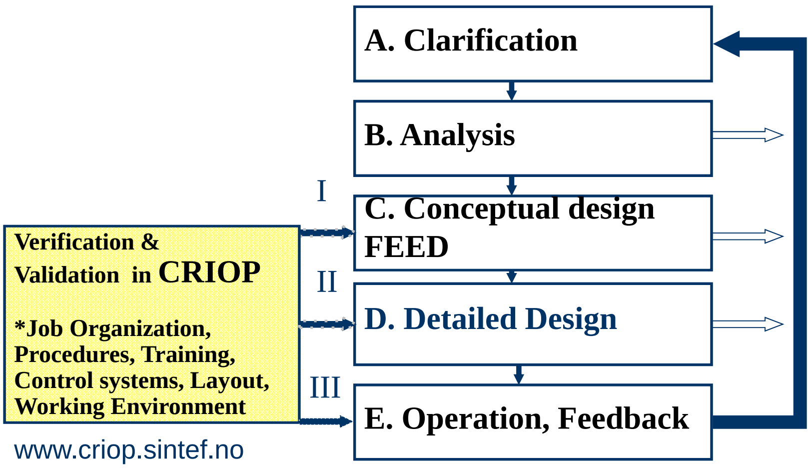
# Collaboration and higher performance

**What to do in a more "networked" environment in the future?**

- In 2003-2004 performed review of theory, practices in medicine/aviation, review of accident reports and review of successes (i.e. high reliability organizations)
- Two projects to explore health and safety issues in future operations of oil and gas:
  - **"Threats and opportunities of eOperations (Integrated Operation)** in the oil and gas industry" Review to Petroleum Safety Authority (2004)
  - **"Health, Safety and Environmental issues in the future"** – Project trying to identify key issues in design and operation of control centres (2003-2004) - Restructuring the method CRIOP
- Implemented CRM issues in design an operation of control rooms – in the CRIOP method (from 2004)



# CRM in organization, design and operation of control centres




www.criop.sintef.no

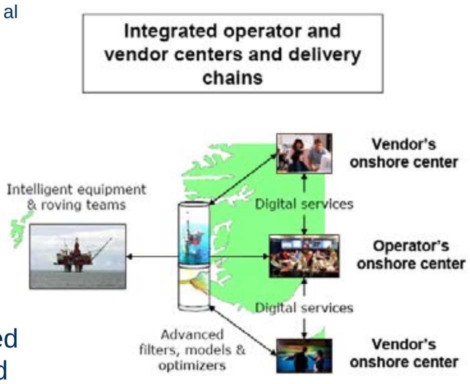
## CRM – perspectives from risk communication and improved teamwork

- **Perspective: Risk communication** Fischhoff, Brewer and Downs (2011)
  - Share information - inform about risks
  - Change beliefs, attitudes and understanding
  - Change behaviour - reduce risks, when we know the best course of action
- **Communication process:** attention, comprehension, attitudes/beliefs, motivation and behaviour, (Wogalter 2006).
- **Mental models of risks** used in risk communication (See Breakwell 2007)
- **Teamwork** in high reliability organisations (Weick, Roberts, 1993) & "The big five of teamwork" (Salas et al 2005).



## CRM specific elements in oil and gas

- Suggested CRM topics based on accident analysis (Flin 1997; Mearns et al 2001)
  - communication
  - situational awareness
  - teamwork
  - decision making
  - leadership
  - personal limitations (stress)
- These CRM topics is implemented and checked when designing and implementing CCR/ Drillers cabin through CRIOP



# Agenda

- Why CRM focus in CRIOP in 2004?
- Experiences of use
- Suggested use of CRM




# CRM discussed in CRIOP

- New - functions distributed in a team
  - Responsibility in Teamwork – who does what, support
  - Communication - who, why, how?
  - Situational awareness – How, what and why?
- CRM must be designed in:
  - **Responsibility** through - Organisation, Procedures, Training
  - **Communication** - based on responsibility, working procedures and technical issues (Control systems, CCTV, Network,..)
  - **Situational awareness** based MTO (Awareness, HMI..)
  - Layout and working environment
- CRM training suggested in different arenas – classrooms, scenarios/ simulations, part of AR ..

## Issues when discussing CRM

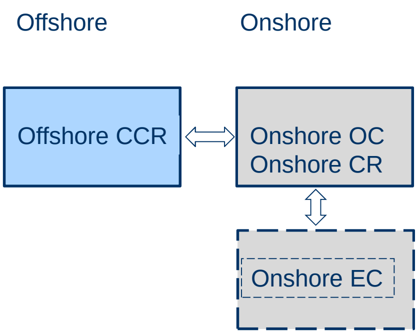
- **What is a crew?**
  - **Oil and gas:** Control room offshore and onshore, then onshore operation centres and..

- **Is CRM accepted/ prioritized in oil and gas?**
  - Acceptance by stakeholders – users, management, regulatory authority?
  - Development - Maturity



# Crew in CCR - Remote operations

- BP – Valhall: “The crew in offshore CCR and onshore CR is one team”



# Adaptation/development of CRM

- CRM Maturity: Team is expanded, focus on human factors, user development, proactive approach, regulatory focus

- CRM adaptation and development aviation (Helmreich 1998)
  - 1st generation - Cockpit resource management – junior flight officer vs. experienced pilot
  - 2nd generation, more team oriented including decision making
  - 3rd generation, Human factors issues – stress and situational awareness – and extension to other teams such as air traffic controllers and maintenance personnel
  - 4th generation, CRM program customized based on FAA mandates
  - 5th generation, emphasis on error management and safety
  - 6th **generation, identifying/preventing threats to safety at the earliest time and managing errors (TEM)**

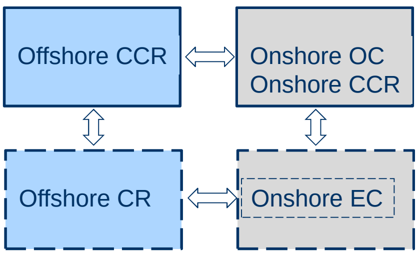


# Experiences of use

CRM issues prioritized when discussing Control Rooms?

- Performed CRIOP analyses of (10) control rooms in addition to interviews – findings prioritized by participants

- Performed (CRIOP) analyses of collaboration (2) between drillers and onshore support (OC)/expert centres (EC) extended by interviews and observations



# Prioritized issues by participants

**("Member Checks" in groups 10-30; Action Research)**

SINTEF Teknologiledelse 15

# In CCR operations – CRM prioritized

- Around 30 % of control room operators wanted to discuss problems and challenges in a team setting (needed access to experts locally or onshore) – one instance "13% - only 2 of 15 operators was confident that they could handle the CCR (13 of 15 was not confident) – 87%"
- In 6 of 10 projects, some sort of CRM training explicit suggested and prioritized (collaboration, communication)
- CRM issues:
  - Design for CRM - Clarity in responsibility, procedures, design for situational awareness (common mental models, risk perceptions, HMI), communication in distributed setting (MTO perspective)
  - Training needs: Communication in distributed setting, Anticipation and attention (Situational awareness), Response/Decision making, Team working, Personal limitations

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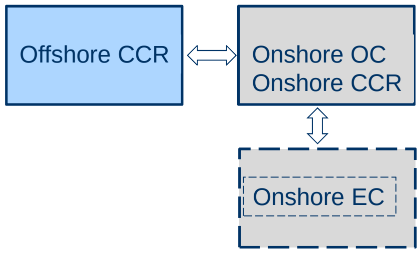
# Drilling – Preparing for CRM

- From drillers onshore operation centre : Different procedures and systems between rigs –difficult to establish common situational awareness
- Collaboration driller OC/operators EC: Poor common perceptions – missing communication and support of situational awareness
- Drillers Cabin: Poor sharing of data between offshore and onshore – also as suggested by PSA (2007, 2005) – Poor alarm systems; poor support in critical situations; poor proactive indicators






# Agenda

- Why CRM focus in CRIOP in 2004?
- Experiences of use
- Suggested use of CRM

## Collaboration in/between teams to increase safety

**Ref: Antonsen S., Ramstad L. and Kongsvik T., (2007) "Unlocking the organization: Action research as a means of improving organizational safety", Safety Science Monitor, vol. 11(1).**

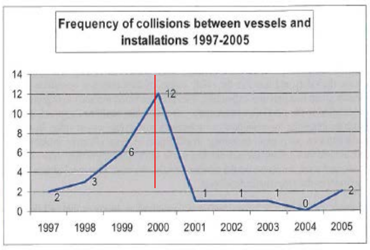



Figure 3: Development in the frequency of collisions between service vessels and installations in the period from 1997 to 2005.

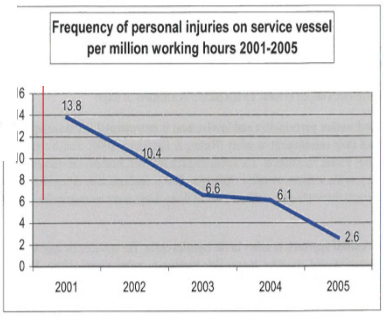



Figure 4: Development in the frequency of personnel injuries on service vessels per million working hours in the period from 2001 to 2005.

- Communication and culture
- Involvement – Action Research
- Measurement



## CRM – Shipping, Helicopter, …

- CRM in helicopter
- CRM in shipping
- CRM onshore process plants

- CRM in CCR/Drillers Cabin/..??

## Suggested use of CRM

- CRM is used in the oil and gas industry – i.e. by crews in helicopters, in shipping (supply ships) and parts of CRM are used in training. CRM has been prioritized when discussed with control room staff, but: **CRM must be supported ( by MTO)...**
- **A standardized set of CRM training** should be designed and implemented by the industry – among control rom operators and drilling crew (including team onshore)
- Since CRM training impacts key areas to improve safety – the regulatory authority should support **CRM as a requirement** for teams involved in safety critical operations such as in control rooms and driller cabins.



## Why wait 20 years to implement CRM?

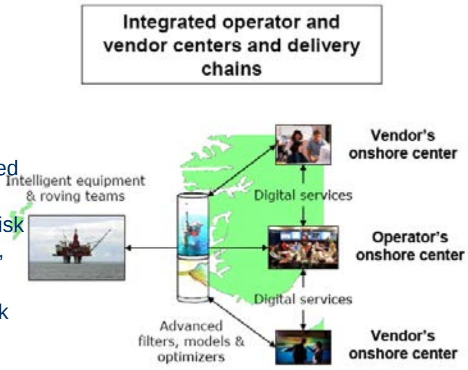
Longford accident 1998
Risk awareness

Piper Alpha 1988

Deepwater Horizon 2010: Group think.
Responsibility, Confirmation bias, Mental models, HMI,

## CRM to avoid accidents & support resilience

- Humans as barrier to anticipate and respond – (learn from successes)
- CRM topics designed by users
  - communication (in distributed environment, MTO perspective, closed loop communication)
  - anticipation/ situational awareness (risk perceptions, shared mental models),
  - resilience – handling of surprises
  - attention and response – in teamwork
  - decision making, responsibility, confirmation bias, group think
  - trust
  - personal limitations (stress)






## Proactive CRM to build resilience and avoid accidents

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# Crew communication in critical phases of flight

**G. Christiansen/ Manager Crew Training, CHC Helikopter service AS.**

**Mer informasjon:**

**www.chc.ca**

**Flysikkerhetsresultater som viser antall ulykker for helikoptertrafikk – offshore (høy sikkerhet) og for "vanlig" luftfart:**

- **Luftfartskonferansen 2013 – E. Svare & O-J. Ingebrigtsen "Norske flysikkerhetsresultater"**

## CRM in critical phases of flight Glenn Christiansen

CRM in Helikopter Service




## Managing director is saying;



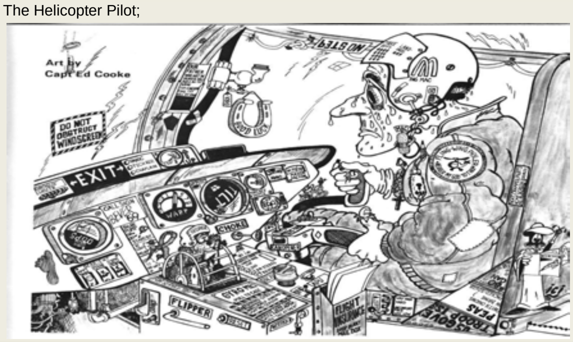

## Managing director is saying;

**We shall act in a way that are bringing us safely at home, - ALWAYS!**



## CRM in critical phases of flight

The Helicopter Pilot;






## Oooops 1




## Oooops 2

## Your reactions and behaviour??





## CRM by legislation.

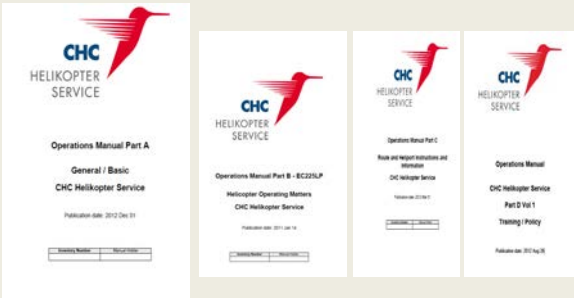
INTERNATIONAL CIVIL AVIATION ORGANIZATION

European Aviation Safety Agency
Flight Standards

Luftfartstilsynet
CIVIL AVIATION AUTHORITY - NORWAY



## CRM by legislation.






## CRM in critical phases of flight

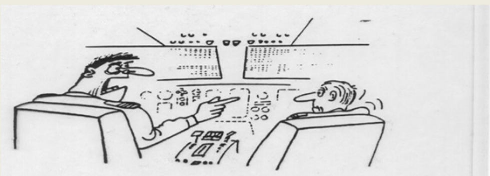
- CRM what?

- Cockpit Resource Management
- Crew Resource Management
- Customer Resource Management
- Company Resource Management
- Concern Resource Management



## CRM in critical phases of flight

- CRM what?
  - Crew Resource **Management** ???



**- I like CRM allright,**
**You are the Resource and I am the Management!!!**



## CRM in critical phases of flight

A definition of CRM may be…..

**= A systematic and described way of communication and behaviour to achieve a safe and effective operation**

## CRM in critical phases of flight

A definition of CRM may be…..

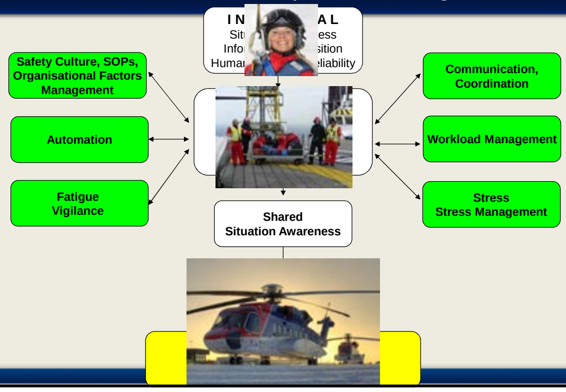
**= A systematic and described way of communication and behaviour to achieve a safe and effective operation**

**Not so much as Crew Resource Management**
**as**
**HOW TO MANAGE THE CREW RESOURSES**





## CRM in critical phases of flight




## CRM in critical phases of flight

- **Screening and testing of pilot candidates before being accepted**
- **Initial training in the company (rules, reg, standards, policies.)**
- **Initial training in simulator**
- **Initial training in line operation**

- **Recurrent training (and checking)**
  **8 hours in sim twice a year**
- **Line Check once a year**
- **Underwater escape, emergency equipment, special ops at regular intervals**

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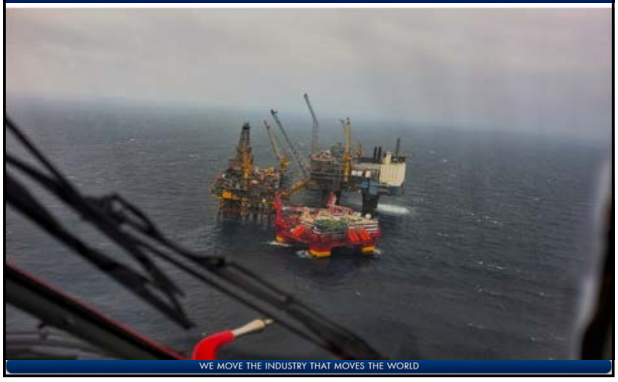
## CRM in critical phases of flight



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## CRM in critical phases of flight

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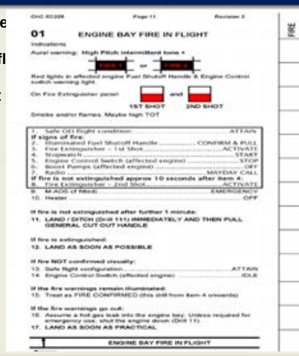
## CRM in critical phases of flight

**The training is based at standards de**

**Normal Checklists for all phases of fl**

**Emergency Checklist covering most**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## CRM in critical phases of flight

NOG guidelines 066 revision 19/2-2010

***5.1.3 Simulator training***

The pilots shall take part in simulator training **(Full flight level D or Flight Training Device 3 with motion)** minimum every 6 months and it shall consist of **minimum 8 hours of crew time per session**. The simulator must be approved by the aviation authorities for such training. The simulator and the helicopter company shall also comply with the following requirements:

The simulator shall reflect the specified helicopters under the **contract 100% as regards cockpit layout and instrumentation**.

The simulator shall be able to recreate and the training shall cover the flight structure of the contract and relevant types of landing objects with movement patterns, as well as weather/light conditions and training in landing at night.

Of the 8 hours of crew time, **minimum 3 hours shall be development training linked to relevant operations/emergency situations/incidents, etc.**

The Helicopter Operator shall also facilitate **necessary additional training for individual pilots**. The Helicopter Operator must **develop his own training program adapted to the company's operations, including developing and using instructors from his own organisation** with a minimum **of 5 years of offshore** helicopter experience on the Norwegian Continental Shelf.

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## CRM in critical phases of flight

**The training is based at standards defined in our publications;**

**Normal Checklists for all phases of flight**

**Emergency Checklist covering most emergencies**

**In flight data monitoring system**

**"Penalty" free reporting system.**

- **Suggestions and experiences are considered, and normally with a reply to sender.**

**AND**

**-Quality audits (external and internal)**

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## CRM in critical phases of flight

**Thank you for your attention!**

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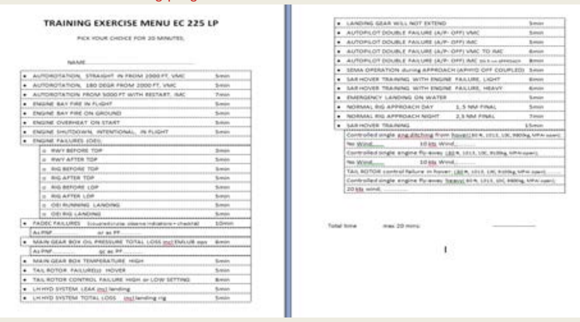
## CRM in critical phases of flight

Revision of the training programs in CHC HS.



TRAINING EXERCISE MENU EC 225 LP

PICK YOUR CHOICE FOR 20 MINUTES.

NAME

| | |
|---|---|
| • AUTOROTATION, STRAIGHT IN FROM 2000 FT, VMC | 5min |
| • AUTOROTATION, 180 DEGR FROM 2000 FT, VMC | 5min |
| • AUTOROTATION FROM 5000 FT WITH RESTART, IMC | 7min |
| • ENGINE BAY FIRE IN FLIGHT | 5min |
| • ENGINE BAY FIRE ON GROUND | 5min |
| • ENGINE OVERHEAT ON START | 5min |
| • ENGINE SHUTDOWN, INTENTIONAL, IN FLIGHT | 5min |
| • ENGINE FAILURES (OEI) | |
| o RWY BEFORE TDP | 5min |
| o RWY AFTER TDP | 5min |
| o RIG BEFORE TDP | 5min |
| o RIG AFTER TDP | 5min |
| o RIG BEFORE LDP | 5min |
| o RIG AFTER LDP | 5min |
| o OEI RUNNING LANDING | 5min |
| o OEI RIG LANDING | 5min |
| • FADEC FAILURES | 10min |
| As PNF ... or as PF ... | |
| • MAIN GEAR BOX OIL PRESSURE TOTAL LOSS incl EMLUB app | 8min |
| As PNF ... or as PF ... | |
| • MAIN GEAR BOX TEMPERATURE HIGH | 5min |
| • TAIL ROTOR FAILURE(S) HOVER | 5min |
| • TAIL ROTOR CONTROL FAILURE HIGH or LOW SETTING | 8min |
| • LH HYD SYSTEM LEAK incl landing | 5min |
| • LH HYD SYSTEM TOTAL LOSS incl landing rig | 5min |

| | |
|---|---|
| • LANDING GEAR WILL NOT EXTEND | 5min |
| • AUTOPILOT DOUBLE FAILURE (A/P- OFF) VMC | 5min |
| • AUTOPILOT DOUBLE FAILURE (A/P- OFF) IMC | 5min |
| • AUTOPILOT DOUBLE FAILURE (A/P- OFF) VMC TO IMC | 6min |
| • AUTOPILOT DOUBLE FAILURE (A/P- OFF) IMC | 8min |
| • SEMA OPERATION during APPROACH (APHYD OFF COUPLED) | 5min |
| • SAR HOVER TRAINING WITH ENGINE FAILURE, LIGHT | 6min |
| • SAR HOVER TRAINING WITH ENGINE FAILURE, HEAVY | 6min |
| • EMERGENCY LANDING ON WATER | 5min |
| • NORMAL RIG APPROACH DAY 1,5 NM FINAL | 5min |
| • NORMAL RIG APPROACH NIGHT 2,5 NM FINAL | 7min |
| • SAR HOVER TRAINING | 15min |
| Controlled single eng ditching from hover | |
| No Wind ... 10 kts Wind ... | |
| Controlled single engine fly-away | |
| No Wind ... 10 kts Wind ... | |
| TAIL ROTOR control failure in hover | |
| Controlled single engine fly-away heavy | |
| 20 kts wind ... | |

Total time max 20 mins

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# HF Case studies - On-shore supervision of off-shore gas production

**R. Pikaar, ERGOS**

**Mer informasjon:**

Se www.control-centre-design.com

Wood, J. (2007); *CCTV Ergonomics: Case Studies and practical guidance*. In: Pikaar, R.N., Koningsveld, E., Settels, P. (Eds): Meeting diversity in ergonomics; Elsevier, Amsterdam.

Pikaar R.N., Landman R.B., , de Groot C.J.G., de Graaf L. (2012), *On shore supervision of off-shore gas production – Human Factors Challenges* – from "Human Factors of Systems and Technology", edited by Dick de Waard et.al. Published by Shaker Publishing (Maastricht), 2012. (Added as Internal document – copy)

# On-shore supervision of off-shore gas production
## Human Factors challenges

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*ldegraaf@ureason.com*

**Abstract**
Technology enables remote process control of off-shore gas production assets, thus reducing off-shore manpower. The human factors in control centre engineering include operator consoles, information presentation, interaction, alarm management, and job content. The human factors are all related to each other. Moving off-shore tasks to on-shore control centres requires a human factors approach, which includes an operator task analysis. For natural gas production, some new control room tasks appear, such as contract management and related production volume control.
Two cases of Human Factors engineering of *a move to shore* are presented. At the first case, a hierarchical task analysis was performed to get insight in the operator tasks. This enabled determination of the number and size of workplaces and revealed the importance of contextual off-shore platform information. Several years later, increased data transmission capacity between on- and off-shore, led to the implementation of an advanced alarm management philosophy, including an optimal visualisation of (grouped) alarms. The second case also concerned the design of an on-shore control centre for over 40 off-shore gas production assets. A major effort concerned the redesign and standardization of process graphics, in order to enable on-shore operators to supervise all processes adequately.

### Human Factors Engineering

The aim of Human Factors (HF)/Ergonomics is to optimize the work system. Ergonomics can be defined as *user-centred design*, or user-centred engineering. This definition expresses a focus, both on the human being and design. In general terms, this requires an approach including both social and technical aspects of the system. Job design, operator workload, control centre layout, workplace layout, instrumentation, information display, environment, and many more topics have to be addressed. The HF professional may not have much background in process control or other engineering sciences. Therefore, he relies on a systematic analysis and design approach (ISO 11064, 1998). He tries to get insight in the relationships between relevant human factors, such as operator workload and job design, or the number of screens on a console and the measurements of the workplace. In addition, HF may fill the gap between technical engineering disciplines and users. Of course, a close cooperation between HF professional and technical engineering disciplines will be needed. The aim of this paper is to show the impact of a structured HF involvement in control centre design projects.
De Looze and Pikaar (2006) assume a gap between the work of HF scientists and the needs of HFE professionals. Closing the gap between practitioners and researchers is a challenge. Two steps should be taken: 1) organize access to the best practices developed in the field and 2) organize research programmes with potential societal and market value. Scientist are missing one important item: case material.

Professional ergonomists have a tremendous amount of case material. Related to process control and control centre design, several systematic case reports have been published by Kragt (1992). Ten control centre case studies have been compiled by Pikaar (2007). Also, several cases from process industries are discussed by Rijnsdorp (1991) and Pikaar et al. (1997). These publications have in common a structured approach to present cases. For each case, the same topics are discussed with an emphasis rather on methodology, than describing the final design result. It should be noted that the system ergonomics approach to engineering projects has been the same for many of the cases mentioned by Kragt, Rijnsdorp and Pikaar. Another approach to use case material related to process control is presented by Henderson (2002). Anecdotal material of many cases results in an overview of important human factors issues to be considered when changing the degree of remote operation.

Practitioners, evaluating work and designing or implementing solutions, may develop good or even best practices. Publishing a report on a successful, or perhaps an unsuccessful project, seldom is part of the work contract. It is not a standard line of business if one is not affiliated to scientific research. In addition, getting a project report published may easily fail, because this type of work is not commonly accepted in the international journals. A project is never carried out twice (with or without ergonomics) to find out whether ergonomics makes a difference. The authors believe that HF experiences in industrial settings should be reported in literature notwithstanding the methodological problem of N=1. Anyhow, this paper is based on case studies.

## Control centre ergonomics

Technology enables remote process control of off-shore gas production assets, thus reducing off-shore manpower. Moving off-shore tasks to on-shore control centres requires a human factors approach, which includes an operator task analysis and a reallocation of operator tasks. Some new control room tasks may appear, such as contract management and related production volume control.

The following related topics need to be addressed in control centre design projects (EEMUA, 2002; Pikaar et al., 1998): 1) job content and operator workload, 2) workplace design – operator console, 3) process graphics, 4) interaction design – navigation and control, and 5) alarm management. Each topic may be a (large) project on its own: the design of a work organization, control room layout and workplace design, the development of process control graphics, and so on.

Henderson et al. (2002) conclude that communication is of utmost importance for remote control. This can also be illustrated by the Esso Flexicoker Project, amongst others reported in Rijnsdorp (1991) and in Kragt (1992). For a major refinery extension, a decision had to be made between a new control room for the new process units, away from the old control room of the old process units, versus one new integrated control room for all units. The latter solution, although being far more expensive, was selected on the basis of communication issues.

Moving an off-shore control room to shore is not different from other control centre design projects from a HF point of view, which will be illustrated by case material. In both situations, process units are remote operated.

## Ergonomics Engineering steps

Usually, an engineering project passes through several phases, starting with a feasibility study, via several design steps, to detailed engineering and implementation, as shown in figure 1 (Pikaar, 2007). Highlights of the HF engineering steps are discussed below. The HF professional needs knowledge of the actual operator tasks. Based on this knowledge, an accurate estimate of the new control room situation can be made (functional analysis). The main issue will be to what extent operator tasks change, when moving an off-shore control room to shore.

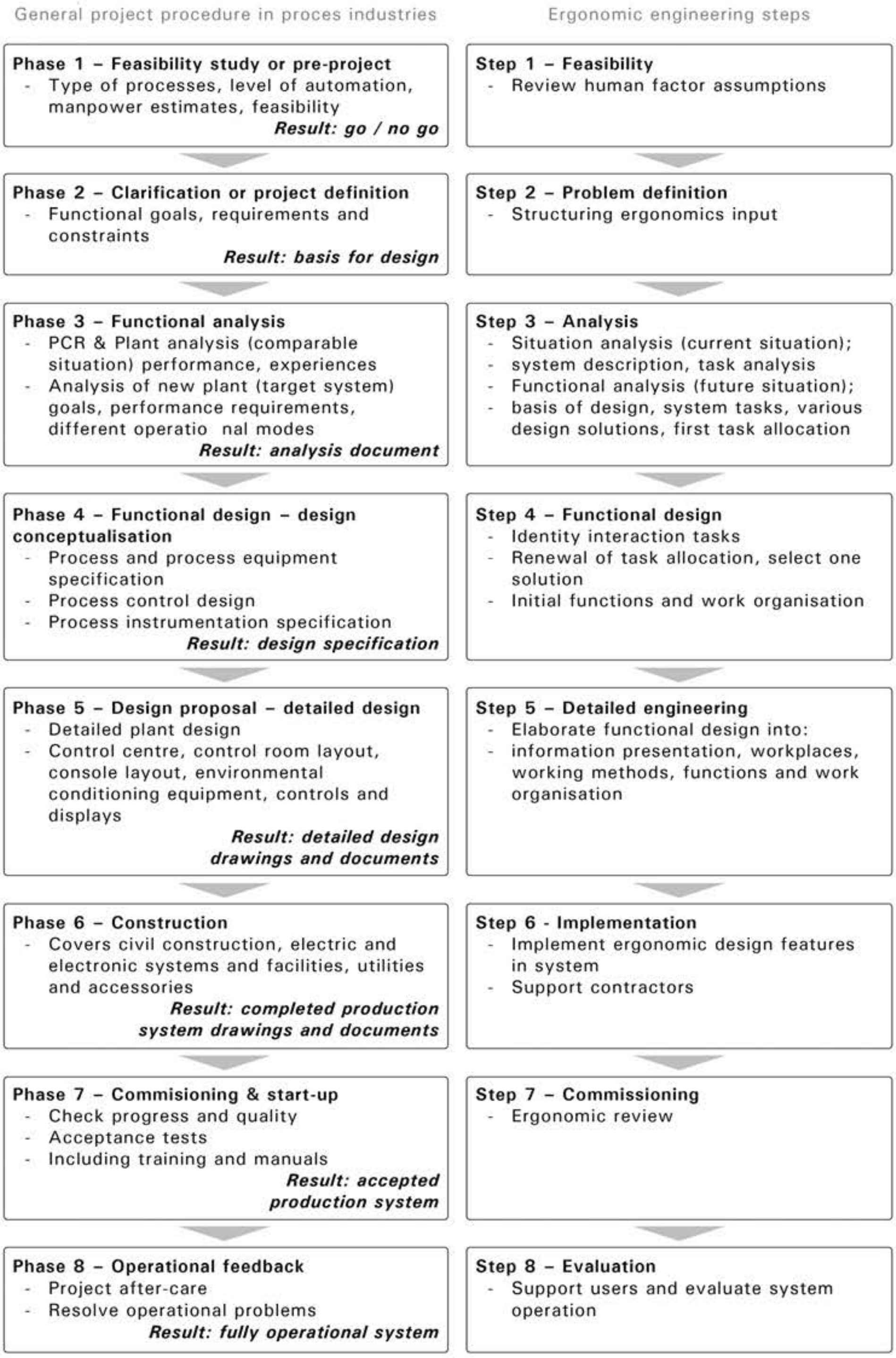


Figure 1. General project procedure and related ergonomic engineering steps.

*Step 1. Feasibility*

Step 1 typically includes a review of the project owners' HF assumptions regarding work load, level of automation, and capabilities of operators. For the HF professional, it is important to be aware of such assumptions, and if needed, give feedback on a general level. For example, one could temper a too optimistic view on the number of operators needed.

*Step 2. Problem definition*
This step starts with a general description of the project and the purpose of the system to be designed. The outline of the design steps have to be negotiated with project management, including design constraints.

*Step 3. Situation analysis*
The aim of the situation analysis is to gain insight in existing and future tasks. It includes collecting formal documents and drawings of the existing system, analyzing work tasks by observations and interviews, and gathering knowledge on the new system (to be designed).

*Step 4. Functional Design Specification*
The functional design specification concerns the allocation of system tasks. An allocation procedure includes a discussion on the level of automation, job requirements, and the design of a local work organization. Topics are 1) the allocation of tasks to workplaces, 2) the lay out of a system, 3) shape and size of workstations and instruments, and 4) environmental requirements.

*Step 5. Detailed Design/Engineering*
On the basis of functional design requirements, various design solutions can be developed. Choices have to be made, which implies weighing all aspects involved, including ergonomics. Tools to illustrate the results may be 3D-drawings, mock-up evaluations, or prototyping of graphics.

*Step 6. Implementation (building the system)*
Typically, the construction phase starts with the production of workshop drawings and building site drawings. A HF contribution is needed to avoid some typical errors. For example, an operator console may have been specified with two supporting legs. The workshop engineer decides that a third leg is needed for stability. He locates the additional leg in the middle of the console, which happens to be the central work position of the operator, thus reducing his leg room.

*Step 7. Commissioning & step 8. Evaluation*
Once finished, the formal commissioning of a working system is organized. Typically, the HF professional should review workplaces, information display and GUI's. Ideally, after a year, an evaluation of the running system should be organized, for example resulting in feedback on design and engineering of the project.

**Case studies – general context**

Over the years, the authors have been involved in several cases of moving operator tasks from North Sea natural gas production facilities to land based control centres. Several companies are active in this area, each operating several dozens of platforms. Satellite platforms produce onto larger platforms, which have recovery units for glycol and ethanol. Larger platforms are manned and have a local control room for remote control of process units on the platform and satellite platforms. Piping connects the platforms to a main entry point for shore going sales gas. At main platforms, usually a 24/7 manned control room can be found. In the 90's, the authors redesigned their first on-shore control room for off-shore production. The off-shore control rooms were equipped with cctv-cameras, surveying the displays panels. Thus, off-shore operators could go to sleep, while colleagues watched their safety. In case of an alarm, a wake up call was placed.

Recently, the authors have been involved in two projects of moving a control room to shore. The main projects of case 1 case concern: 1) control centre and workplace layout, 2) central process overview graphic, and 3) alarm management. The main projects of case 2 are: 1) control centre and workplace layout and 2) process graphics redesign. The company of the second project was aware of the earlier findings at the first company. They visited this companies' operational control centre and copied several findings. The following sections give some highlights of both projects, however they are no full account of HF contributions.

**Case 1A – Control room design**

Starting point was a small on-shore control room for land based gas production assets and the off-shore gas receiving station. After selling the on-shore assets, the control room was moved to another location, tasks to be extended to supervise approximately 25 off-shore assets. Process supervision was based on <10% of the off-shore process control variables. The HF contribution to this project can be summarized by some key factors (more details can be found in Pikaar, 2007):

| | |
|---|---|
| – project scope | upgrading and moving of an existing control room to another location |
| – investment | € 200.000 exclusive of instrumentation and communication systems |
| – % HF engineering | 10% of total investment / 200 hours |
| – management | project owners' engineering department |
| – project team | HF engineer, architect, and instrument engineering contractor |
| – main topics | room layout, workplaces, detailed design, large screen overview graphic |
| – workplaces | one double operator console, office desk, social area |
| – role HF professional | project management, ergonomic design. |

The project was organized along the system ergonomics engineering steps, as described earlier. A situation analysis was carried out in the existing on-shore control centre (observations, semi-structured interviews). Functional analysis concerned the expected new situation: daytime process control by local off-shore operators, night time process supervision on-shore. Of particular interest was the outcome of the functional analysis: an estimated 1.5 operator needed in the control room, which can only be realized by two operators. Hence, additional (office-type) tasks were added to realize a balanced work load. As a consequence, the control room design was based on a combination of an office desk and a double console, both having an easy access to a shared process overview. This also dictated the functional workplace design with one row of process screens (no tiled screens), in order to be able to look over the screens (see figure 2). Design tools the HF professional used were 3D-drawings and prototyping of a graphic overview display.

Two years later, the control room was moved to another location. Again, tasks were analyzed and a gradual change from supervision to dispatching and production volume control was found. Process control had become more important, due to changes in contracting (many small contracts instead of one large customer). This change required production flow control at platform level, however from an overall point of view. A new problem arose: it wasn't easy to control at platform level, because only 10% of the process data was available on-shore. Therefore, operators mainly acted upon off-normal messages (alarms). Improving off-normal messaging became the starting point of an extensive alarm rationalization project.

In addition, the company was advised to adapt the existing process operation philosophy to the new role of the on-shore control room. Of particular interest would be the division of tasks and responsibilities, including communication protocols. Work on the development of an operation philosophy is in progress.

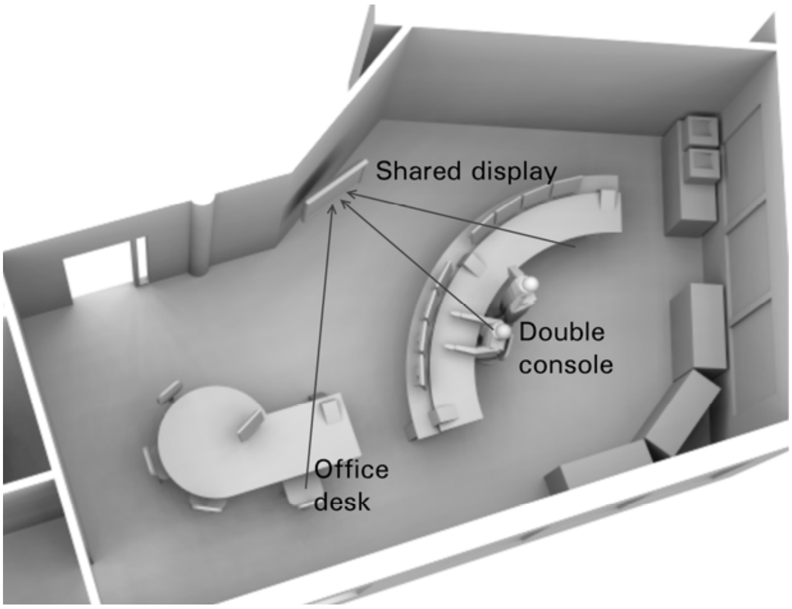


Figure 2. Control room layout – case 1.

**Case 1B – Alarm management project**

The alarm project can be considered a mix of HF and process control engineering. First, there was a need to get more knowledge on the characteristics of off-normal messages and the following up actions. Therefore, a detailed hierarchical task analysis (HTA) was carried out, using walk-through, talk-through discussions with experienced on-shore and off-shore operators. It showed that alarms may be initiated by process events, as well as by local activities or situations. In order to be able to understand an alarm message, an on-shore operator would need contextual information (you need to ask the local operator). In scientific research this topic is addressed as situation (or situational) awareness, and focuses primarily on interaction design (Erp, 1999).

*Alarm Philosophy*

Parallel to the hierarchical task analysis, the project team developed an alarm philosophy, a strategy towards the effective handling of non-normal process situations. One of the dilemmas' faced: the more 'local' an operator is located, the better will be the quality of his context information. However, it is also more likely that messages are missed because the operator is not always in the local control room. On the other hand, operators in the central control room don't have much context information, but the control room is always manned.

*Alarm Management Site Survey*

Next, a site survey on one platforms took place, to benchmark the current situation. The following Alarm Key Performance Indicators (KPI) were used:

1. Long term average; average number of alarms per hour, an indication of operator workload .
2. Alarm rate variation; does the average number of alarms/hour change much over time?
3. Frequent alarms; contribution of the most frequent alarms to the total alarm load.
4. Fleeting alarms; contribution of the most frequent fleeting alarms (active for a short period of time, up to 1 minute) to the total alarm load.

5. Number of alarms following upsets; plant upsets are periods of time where the load on the operator is particularly high.
6. Standing alarms; number of alarms active for a long period (>12 hours).

The results of the site survey have been presented in a spider chart (figure 3). The centre of the chart indicates a good score for the criteria, the outer sides indicate poor performance. Spider charts were used to set priorities for the alarm improvement project.

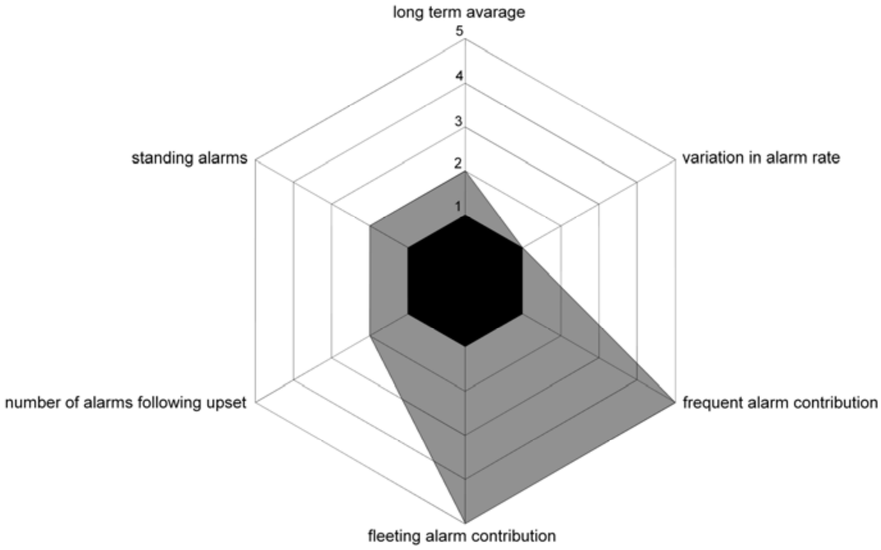


Figure 3. Spider chart of six Alarm key performance indicators.

*Alarm Reporting and Rationalization*

Next step has been gathering data on actual off-normal messages of individual units and platforms. An online alarm reporting environment was installed, to determine and improve bad alarm actors and thereby reduce the alarm load. Next to a weekly alarm report, all alarms were systematically compared to the criteria for alarms set forth in the alarm philosophy. Refer to EEMUA (1999) for usable criteria. Although one expected that all platforms would be more or less the same, a major effort consisted of defining the same alarms and alarm levels at all units, thus improving consistency in process control.

Literature (EEMUA, 1999) suggests many solutions to reduce the number of alarms an operator faces. Dynamic alarm grouping proved to be very effective. Only one off-normal is presented of a group of related messages, though details are always literally at the fingertip of the operator. Also effective proved to be incident prediction, by using (a combination of) early indicators to detect abnormal process and/or equipment conditions.

Finally, safety alarms (such as Anti Collision, Man Over Board, Fire & Gas) should be presented and treated different from process alarms. Signals can only be judged adequately if the operator has access to context information. The operator cannot see whether an alarm is the result of a test (frequently done) or a real problem. Communication and responding to the alarm message is always needed. Safety devices (life jackets, man overboard alarm) are always tested before use. Testing takes place on site. Questions to be solved, for example by procedures, are whether the on-shore control room should be able to acknowledge test alarms (or not), should be aware of local testing (or not), and so on. Another example concerns fire & gas alarms. Fire and gas detectors may be sensitive to strong winds. Again, knowledge of the local situation is essential to make the right decision on-shore.

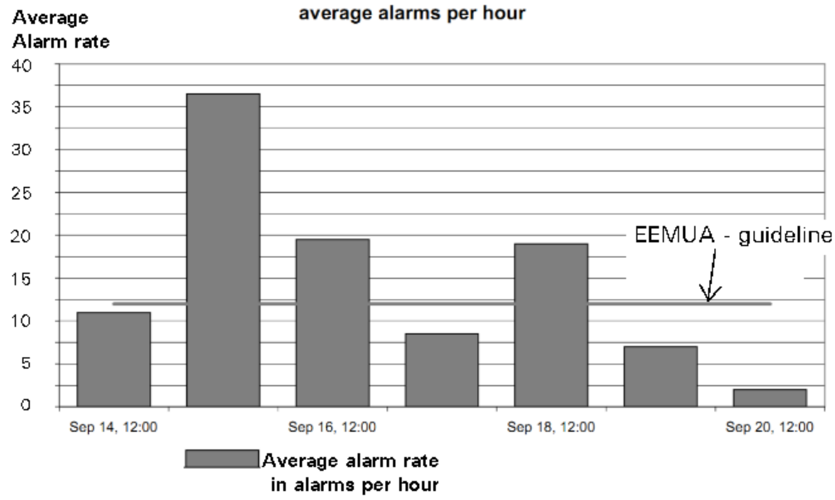


Figure 4. Impression of alarm reporting graphs – average alarms.

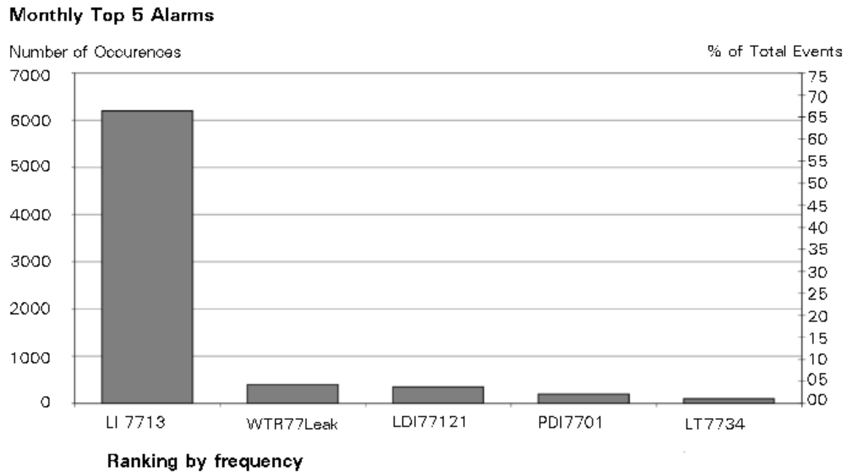


Figure 5. Impression of alarm reporting graphs – monthly top 5 alarms.

**Case 2A – Centralize off-shore control rooms and move to shore**

Case 2 concerned moving supervision of gas production of approximately 30 off-shore platforms to shore, with the aim to improve gas contract handling and reduce decentralized control room manpower off-shore. The project team visited the Case 1 control centre and learned about system ergonomics. They decided that their own situation would be comparable and therefore a new task analysis was not considered necessary. While in Case 1 operators were available on-shore, here they were not. As a consequence, it is far more difficult to organize a task analysis at off-shore facilities (air transport, safety courses for the HF professional, costs). A step by step move to shore was decided for, in order to be able to cope with unexpected outcomes. First step, to reduce 24/7 staffing of off-shore control rooms to 12/7. This concerned three control room operator positions. Hence, by night the control room tasks are carried out on-shore. By daytime there is choice to be made: process control and supervision (also) on-shore, off-shore (at the off-shore central control room), or partially on- and off-shore. In any case, gas contract handling is taken over by the CCR onshore. The company expected that the local operator crew would become more focused on process control of their own plants thus expected to improve maintenance, reliability and consequently availability.

The control room design project included the design of a central control room in an existing office building. HF engineers developed a sketch design for several possibly locations. Next, the functional design of three workplaces took place. Functional design looked a lot like the control room of Case 1. Again, it was decided to develop a shared overview display wall combined with a triple operator console. Unless case 1, an architect was introduced to make the final interior design.
Off-shore instrumentation needed to be upgraded in order to transfer process control to the new control room. The total count of existing graphics at over 30 platforms was 1800, in three different instrumentation systems. It was considered important to give the on-shore operators consistent and easy recognizable graphics. Therefore, a major HF project started to develop improved graphics, reducing the number of graphics considerably.

**Case 2B – Process graphics design**

A project team was composed of several experienced operators, a project leader, the head of instrumentation engineering, and two HF engineers. First, the project team got an introduction in ergonomic design guidelines for interaction design. Symbols, colours, and text size/format were defined by the project team. One large platform was chosen as a pilot for graphics redesign. The leading design principle for graphics redesign is: simplify (Pikaar, 2012; Bullemer et.al. 2008). This can be done on the level of symbols (valve, pump), but also on the level of units (compressor, glycol recovery unit, furnace). Easy recognition of typical process units can be enhanced by applying a consistent layout.
Of course, navigation through many graphics can simply be simplified by reducing the number of graphics. The pilot graphics were thoroughly discussed by the project team. After consent, the rules to design graphics were compiled in a Human Computer Interactions Conventions document, amongst others to be used as a communication tool with the instrument (DCS) vendor. This document gives standards on colours, text size, symbols, arrangement of process values, and should give insight in why the graphics are designed as they are.

After the pilot phase, a selection of 136 graphics of the main production processes of 11 production facilities was made. It was argued that detailed graphics of utilities (and the like) would solely be used by local operators. Therefore, it was decided not to upgrade these graphics and have them still running at the local control rooms. With help of P&ID's and an experienced operator the graphics were designed as accurate as possible. Sometimes the operator needed the assistance of his off-shore colleagues to verify details and P&Ids that apparently were not all up to date (as build). What in fact happened, was a detailed tasks analysis on operator control tasks.

It was expected that the production platforms would be much alike. Designing a series of graphics would be simple: just copy. Though this approach would ensure easy recognition on a process unit level, it might be difficult to find out what platform you are looking at. In order to avoid mix-ups and keeping consistency in mind, some theoretical solutions were put forward:

- emphasize differences, if there are any
- use a watermark (graphic or textual) on each graphic
- use platform names in tooltips and title bars.

Later, it became clear that most of the platforms differed a lot from each other, no special solutions needed. Platform safety proved to be a very important issue. Questions were raised, whether the off-shore operators could trust that the on-shore control room has a full awareness of which platforms are being manned.

The selection of 136 graphics was redesigned by HF engineers, frequently consulting the experts: operators. This resulted in 25 new graphics, or a substantial reduction of 80%, which is in line with earlier findings of Pikaar (2012). Reduction of graphics was accomplished by simplifying symbols, omitting redundant or unimportant information (i.e., for on-shore supervision), and smart graphical solutions. A large contribution to this reduction occurred by using a standardized table for the line up of wellhead valves (figure 7). A typical example of a wellhead graphic is shown in figure 6. Three well heads are shown, each consisting from left to right of three valves in a row, a choke and two parallel valves for either gas to the production manifold or to the testing manifold.

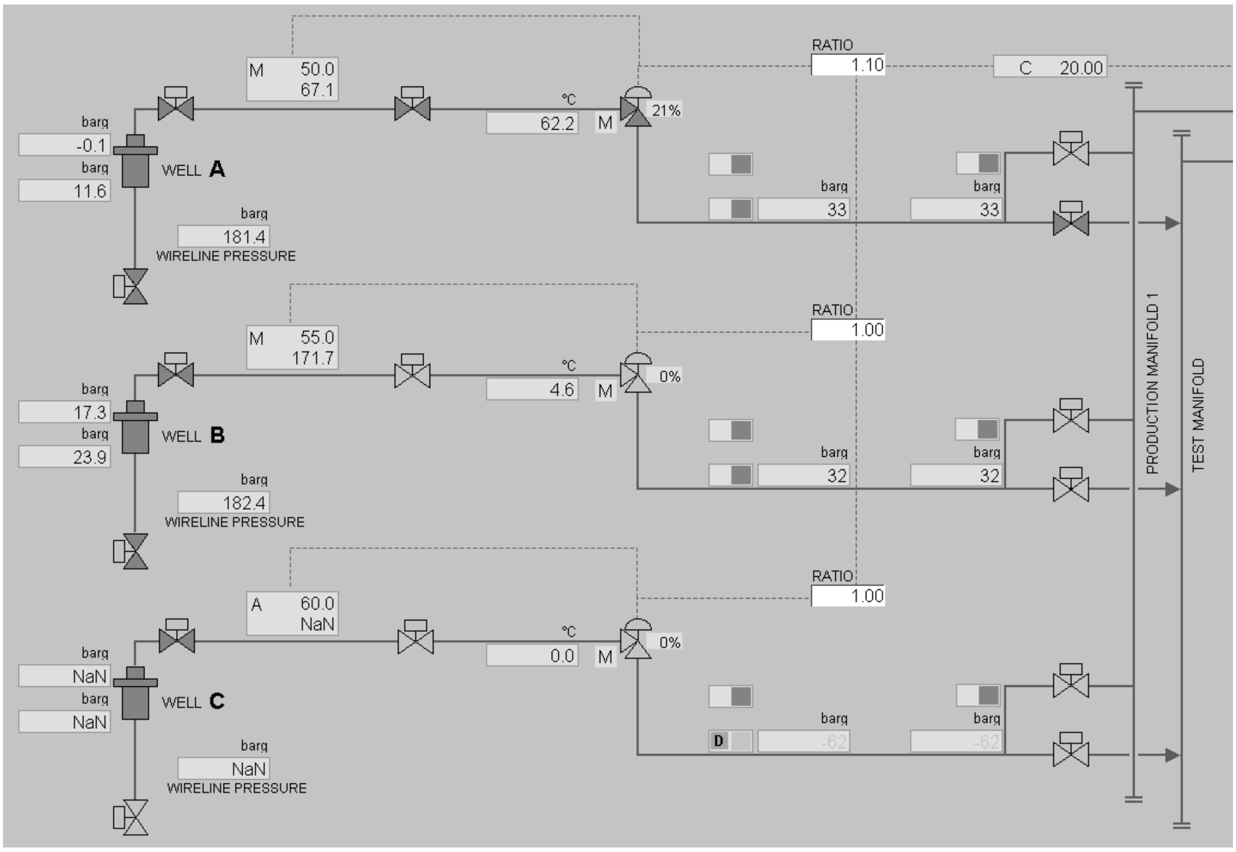


Figure 6. Typical example of traditional wellhead graphic.


Figure 7. Redesigned wellhead graphic.

**Conclusion - lessons learned**

The aim of this paper is to review HF issues related to the move to shore of operator tasks. The authors learned several lessons, which will be indicated here in no particular order.

1. Control room design, i.e. layout and workplaces, is not much different from any other control room project. In case of combining two or more 24/7 off-shore control rooms, all traditional advantages are there, such as work load optimization (staff reduction) and easier communication between operators.
2. It may be difficult to find staffing for off-shore work. Operators may develop health problems (just by aging) that would not allow them going off-shore by helicopter. After many years off-shore, some operators just want to work closer to home (on-shore). And finally, well trained technicians are becoming scarce in industry.
3. At sea, a lot of maintenance will be going on. Question is whether local operators need local control to do an adequate job, and/or what role the on-shore control room should play. Communication is limited to telephone lines. Traditional radio communication between remote control room and field is difficult compared to, for example, a refinery. At the latter, field operators have easy radio contact and they walk into the central control room every now and then. Can this be achieved at a large distance using modern communication technology? Is there someone in the local control room? If so, why not take over control completely from on-shore? Answers will differ from case to case, and can only be given by looking deeper into the operator tasks and developing a process operations philosophy, describing when/how to organize tasks allocation best.
4. Regarding process control and supervision tasks, three things changed over the years:
   1. Data transmission changed from CCTV-camera observation of analogue control panels to 100% on-shore availability of controlled variables. The major problem is a lack of context information, in particular related to safety issues. Is the Man Over Board alarm real, or part of an obligatory safety test? Is the gas alarm real, or just because there is a specific wind fall on the sensors at one side of the platform?
   2. Contract management has become a new task. Nowadays, transport is separated from buying, and there are many contracts to be handled, requiring specific operator knowledge. At the North Sea area, there is a large variance in production volumes over the day. This introduced a new task: production volume management, i.e. how to optimize gas production wells.
   3. Production volume management includes production well optimization. For example, well pressure decreases over time. At high selling prices, it may be worthwhile to start up a compressor unit and produce from partially depleted wells. This is a matter of cost benefit calculations, which can be considered a new control room operator task. Should this task be combined or integrated with process control and supervision?

4. In case 2A the gas dispatching and commercial activities are concentrated in a separate section of the office and daily/hourly volumes are dictated to the CCR crew, using special developed integrated hydro carbon calculation programs.

The system ergonomics approach focuses amongst others on the analysis of operator tasks. The move to shore definitely involves a change or reallocation of tasks. The systematic approach uncovers these tasks aspects very effectively, as has been illustrated by the case studies. A difficulty can be found in the distance between project teams, consisting of HF professionals and on-shore engineering staff, and the operators at the platform control room. It is not easy to visit the operators on-site and it proved to be difficult to keep the operators informed on project progress and project outcomes.

**Acknowledgement**
The authors thank all operators and project participants for their valuable contributions to the project presented in this case study presentation. They all contribute to the development of insight in Human Factors of moving off-shore operator tasks to on-shore control rooms.

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## Human Factors Case studies

On-shore supervision of off-shore gas production

11 March 2013

ir. Ruud Pikaar Eur.Erg.


## Content

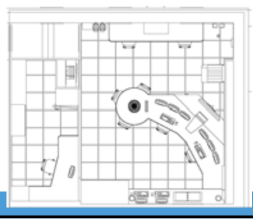
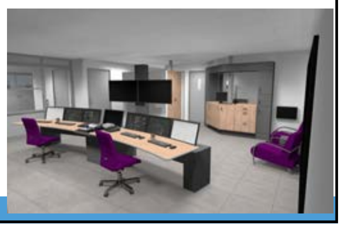
- **HF in control centres**
  - Human Factors Engineering & ErgoS
- Control centre design – general observations
- Case studies
  - control centres – move to shore
  - move to shore & process graphics
  - remote control and CCTV
- Lessons learned & conclusion

## HF & ErgoS

- ir. Ruurd Pikaar Eur.Erg.
- ErgoS Engineering & Ergonomics
  - 9 HF professionals/ 6 registered
  - various backgrounds
- Control Centre Design
- Special interests
  - articles: HF case studies
  - research: CCTV-systems
  - develop: Airport Ergonomics

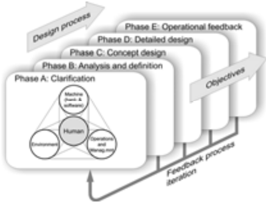

## ErgoS & off-shore

- Shell/NAM in the 90's
  - on-shore night watch for off-shore (CCTV on alarm panels)
- Off-shore control room redesign (Total K5)
- Maritime Ergonomics (heavy duty, ships bridge)
- Statoil Etzel gas lager / detailed engineering
- Move to shore: GdF & Total (→ this presentation)

## HF in control centres

- Guidelines – how to … & what …
  - ISO 11064 – Ergonomic design of control centres
    - ***you are fully aware of HF in control centres ?!***
  - Engineering contractor
    - ***may not be fully aware !***




- Our View on HF Engineering
- Optimal design, productivity & reducing risks
  - not necessarily about comfort & luxury.

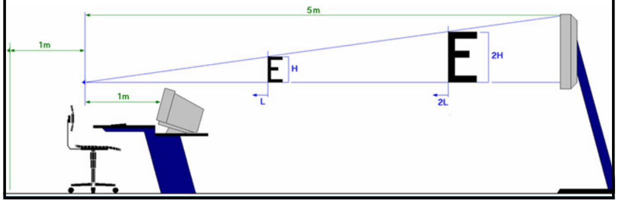
## Content

- HF in control centres
- **Control centre design – general observations**
- Case studies
  - control centres – move to shore
  - move to shore & process graphics
  - remote control and CCTV
- Lessons learned & conclusion

*Note: team dynamics are "hidden" in this presentation*
*Note: CRM may resemble ODAM (see you at NES?)*

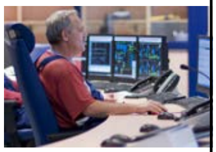
## General observations

- Related topics in CR design
  - Console and control room design
  - Operator job design / Work organization design
  - Interaction design
    - software (HCI), shared displays, graphics
- Rule: don't work on one topic without the context of the other topics



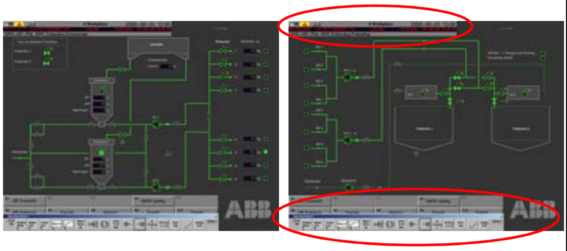

## General observations

- Example – workstation design
- Large viewing distance (up to 1 m)
  - 2 working screens at a glance
  - secondary screens to left/right
  - one row for easy communication
  - readability: 4 mm character size (rule= 1000 : 250 = 4 mm)
- Short viewing distance (600 mm)
  - work at 1 screen position at a time
  - sitting (very) close together
  - limited overview
  - tiled screens / obstructed view



## General observations

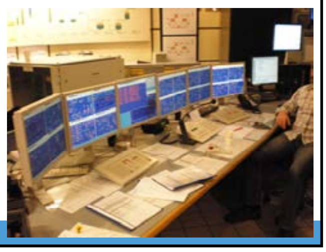
- Interaction software
- Requires space on screen (menu)
- Repeated data on each screen



## General observations

- Remote control
  - can you trust the on-shore guys to guard your safety ?
  - do they really know what is going on off-shore ?
  - situation awareness ?

reliable overview ?



## Content

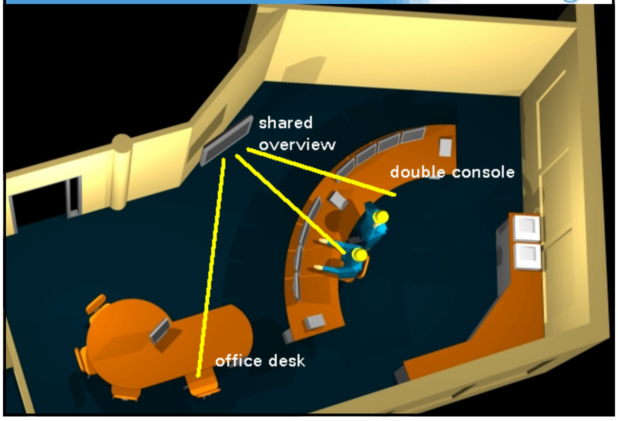
- HF in control centres
- Control centre design – general observations
- **Case studies**
  - **control centres – move to shore**
  - move to shore & process graphics
  - remote control and CCTV
- Lessons learned & Conclusion

## Move to shore – case Total E&P

- System ergonomics procedure
  - 2003 / again in 2007
- Find out about tasks
  - existing on-shore treatment plant
  - hierarchical task analysis (HTA)
  - walk through – talk through
  - next determine: # of workplaces & instrumentation
- Some tasks move to shore (23 off-shore assets)
  - 10% alarm data transmitted to shore
  - 1.5 job: operator + office tasks
    - therefore: shared display for production overview

## Shared overview

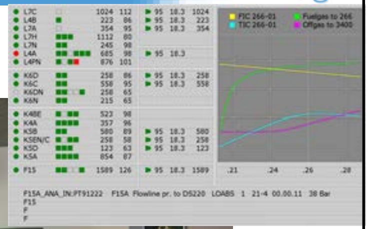
ERGOS




## Move to shore – Case Total E&P

ERGOS

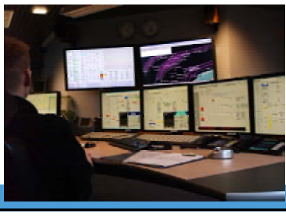
- Shared display



## Move to shore – Case Total E&P

ERGOS

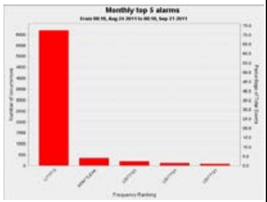
- Gradual development
  - contracting, production choke control
  - new operating philosophy: it is all about communication!
  - control tasks of (unmanned) satellites to shore
- Alarm management project

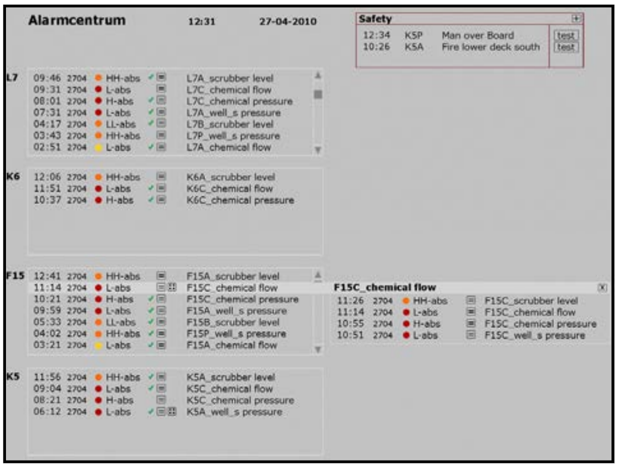


## Move to shore – Case Total E&P

ERGOS

- Alarm management project
  - limited process data available on-shore (10%)
  - hence improve quality of what you can get on-shore!
- alarm rationalization
  - same units, same signals ?
  - solve bad actors, quick wins
- HF tool: detailed HTA
  - scenario based!
- later: 100% variables on-shore
  - advanced alarm management
  - alarm overview graphic

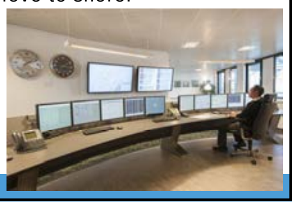



## Move to shore – Case GdF

ERGOS

- On shore control room for off shore production
  - same tasks & situations assumed (by GdF)
  - task analysis not needed (!?)
- > 40 assets; 2 x 24/7 off-shore control rooms
  - estimated 2-3 operator consoles –on shore– needed
- Gradual introduction: tasks move to shore.



## Move to shore – Case GdF

## Move to shore – summary

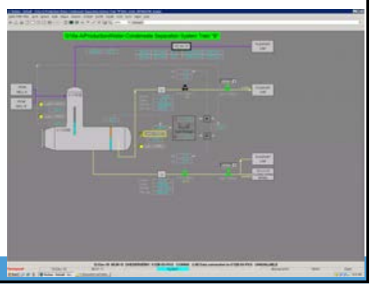
- Control room design not different from any other control centre project
  - remote is "more remote"
  - operators used to work off-shore
- Requirement
  - explicit design of communication tasks
  - operating philosophy / who is in charge? / when?
- Overview essential
  - situation awareness
  - process graphics / overview graphic
- Suggest: as build analysis (CRIOP?)

## Content

- HF in control centres
- Control centre design – general observations
- Case studies
  - control room design – move to shore
  - **move to shore & process graphics**
  - remote control and CCTV
- Lessons learned & Conclusion

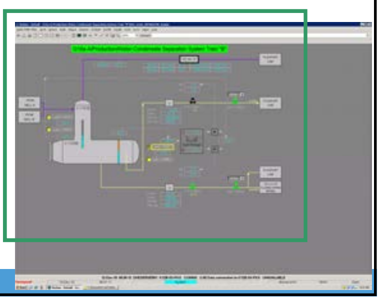
## Move to shore – Case GdF

- Off shore
  - 3 DCS vendors – 1800 graphics – limited content
  - expected problem: navigation & situation awareness
- Graphics redesign – Instrumentation upgrade



## DCS upgrade

- Observation
  - new screens, new operator workplaces
  - **1:1 conversion of old graphics ?**
  - 1280 x 1024 → wide screen High Resolution
- This section
  - HF Guidelines
  - Case material



## The problem.......

- More screens and graphics ...
  ... leading to a better process overview ?
- We observed
  - 24 open windows
  - production loss
  - operator mistakes
  - workload issues
  - we want more & and larger screens

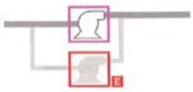
## Guidelines – process graphics

- **Design** rule
  - Keep it simple
  - Simplify as much as possible
- **Content** rule
  - Task related information only
- Develop style guide
  - Vendor related
  - Company or type of industry related
  - User/operator input
- More: AMS, EEMUA, Icoco-2010 (& Pikaar, 2010; 2012)

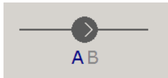
## Guidelines – process graphics

- Guidelines differ regarding "simple"
- old graphic
  - P&ID - based


- ASM-guideline




- ErgoS




## Guidelines – process graphics

- Guidelines differ regarding "simple"
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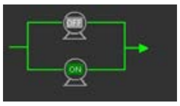
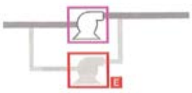
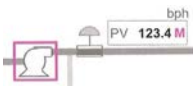
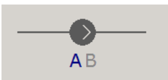


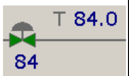

- ASM-guideline



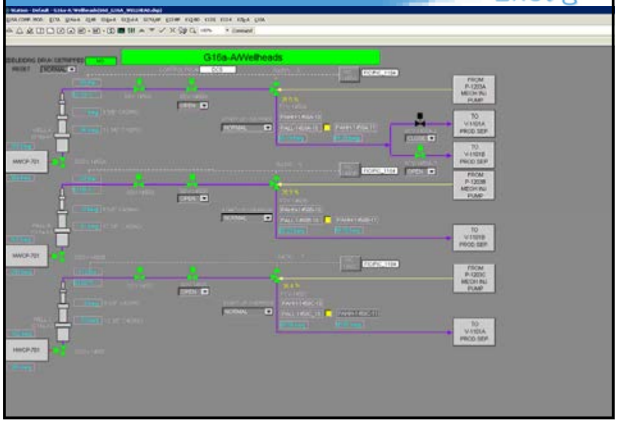




- ErgoS




## Example – Well heads




## Example – Well heads

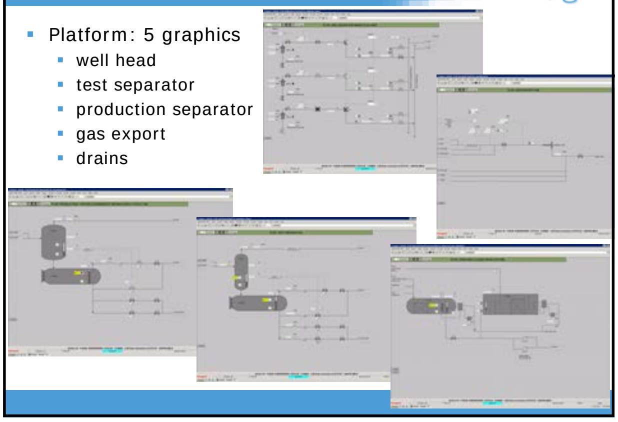
- 3 Well head & line up summarized in one table

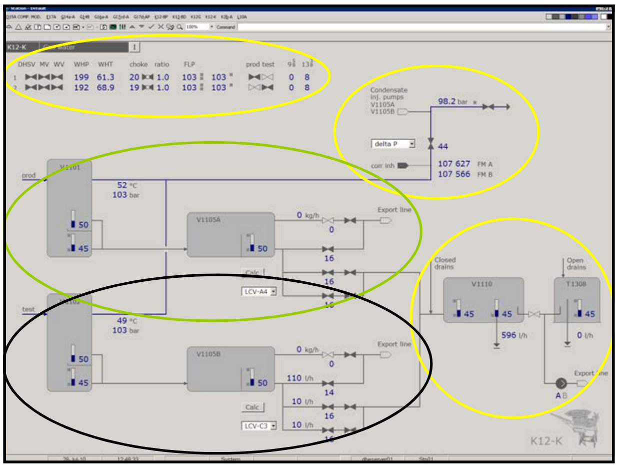
| | DHSV | MV | WV | WHP | WHT | choke | ratio | prod test | 9 | 13 | Max choke |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | | | 265 | 63.6 | 42 | 1.0 | | 9 | 2 | |
| 2 | | | | 211 | 83.7 | 56 | 1.0 | | 9 | 2 | |
| 3 | | | | 294 | 81.5 | 7 | 1.0 | | 9 | 2 | |

- table to be part of another process graphic
- detailed task analysis:
  - operators know exactly what they need
  - uncover obsolete variables (after 15 years...)

## Example – Case GdF

- Platform: 5 graphics
  - well head
  - test separator
  - production separator
  - gas export
  - drains





## Roadmap to Power Graphics

- Operating philosophy
  - specify tasks, instrumentation, shared displays
- Start: existing graphics or P&ID's
  - reduce data on controlled variables to one value only
  - for other data (set-point, alarm limits, etc) use a pop-up, tool tip or overlay
  - remove redundant symbols, edges, (crossing) lines
  - show functional relationships (not actual piping)
- Simplify symbols
- Check: is graphic self explanatory ?

## Road map to Power Graphics

- Remove content not needed *by operator*
- after simplifying
  - more data fits on window
  - less graphics needed ...
  - ... which simplifies interaction/navigation
- finishing touch
  - replace large on-screen touch buttons, menus and logos
  - introduce permanent process overview
  - again less data presented in process graphics ...
- result: limited number of very powerful graphics.

## Conclusion – graphics design

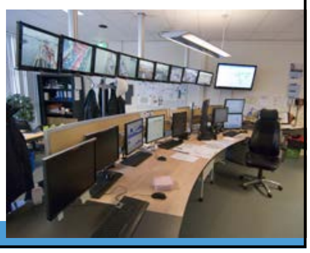
- situation analysis (basic ergonomics tool)
  - reveals ill structured information display
- simplify old technology graphics
  - 50 – 80 % reduction
  - leading to easier navigation
  - and a reduction of operator workload
- add powerful overview display
  - on the basis of an approved Operating Philosophy
- do not copy 15 year old graphics / no 1:1 conversion

## Content

- HF in control centres
- Control centre design – general observations
- Case studies
  - control room design – move to shore
  - move to shore & process graphics
  - **remote control and CCTV**
- Lessons learned & Conclusion

## Remote control and CCTV

- CCTV-operator tasks
  - traffic, surveillance, security
  - object control (locks, bridges)
  - process control / process installations
- What should operator be able to see, detect, or read reliably on CCTV-images?
- HF guidelines ?
  - largely missing .....
  - not evidence based



## Remote control and CCTV

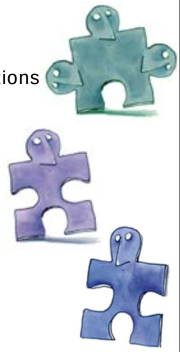
- Pooled funded research
  - 13 project partners (incl. process industries)
  - workshops – active participation, knowledge exchange
- Phase 1 – HF Literature
  - limited to traffic and surveillance (USA, UK)
- Phase 2 – 8 Case studies
- Phase 3 – Pilot experiments
  - test charts & -procedures
- Phase 4 – Draft Guidelines
  - structure of ISO 11064

## Remote control and CCTV

- Draft Guidelines – April 2013
- Open ends
  - contradictions between case studies and literature
  - image complexity / cognitive complexity
  - operator workload (# images per operator)
  - task complexity
  - elaborate new concept “scene”: logical and meaningful set of visual information, monitored with a specific aim
- Project is open for participation
  - in-company workshop for new participants
  - detailed proposal available.

## Content

- HF in control centres
- Control centre design – general observations
- Case studies
  - control room design – move to shore
  - move to shore & process graphics
  - remote control and CCTV
- **Lessons learned & Conclusion**



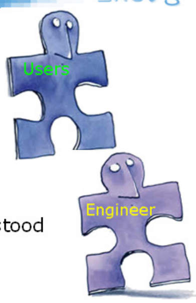
## Lessons learned

- Control room design – traditional results
- Process control - new tasks require full overview
  - 100 % process data transmission
  - process supervision on-shore (… if not local…)
  - new tasks: dispatching, production volume control
- Off-shore tasks also change !
  - more emphasis on maintenance
  - communication – strict rules
  - who’s responsible (local vs central) ?
- Context information & situation awareness
  - you may need a detailed task analysis & task allocation …

## My personal last observation

- user input is needed, however
- users do not develop new ideas
- user participation is not ergonomics

- engineers need field information
- engineers hesitate to do an analysis
- tasks & work organization not understood

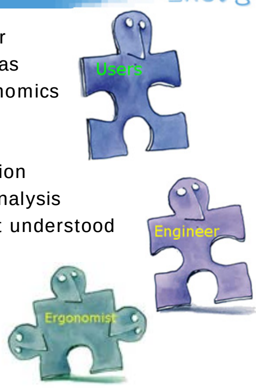



## My personal last observation

- user input is needed, however
- users do not develop new ideas
- user participation is not ergonomics

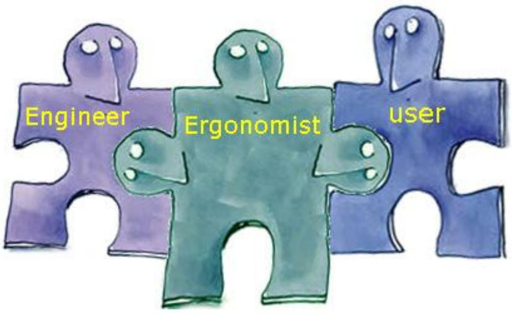
- engineers need field information
- engineers hesitate to do an analysis
- tasks & work organization not understood

- HF Engineer
  - speaks both languages



## Move to shore

- Integrate Ergonomics in Engineering Projects !




## More information

- [www.control-centre-design.com](http://www.control-centre-design.com)
  download papers
  - Pikaar (2012, IEA), *HMI Conventions for process graphics*
  - Pikaar (2012, Leeds), *On shore supervision of off-shore gas production – Human Factors Challenges.*
  - and others

- www.ergos.eu
- www.maritime-ergonomics.com
- www.airport-ergonomics.com

HFC

# CRM brukt i skipshåndtering

**S. Dahle, COO - Chief Operating Officer, Ship Modelling & Simulation Centre AS, SMSC**

**Mer informasjon:**

http://www.smsc.no/

# Human factors in the maritime domain



## Svenn Dahle

## Chief Operating Officer

Head of training human factors



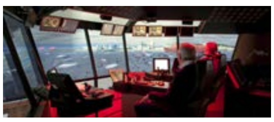


## SMSC

- Ship Modelling & Simulation Centre AS
- Trondheim, Norway
- 60 employees
- Maritime and offshore industry
- Simulator producer
- Approved by Norwegian Maritime Directorate








## 75 – 80 % caused by HF

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## Challanges

- The maritime industry in general seems to go for the absolute legal minimum of safety training

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**Human factors**
**-The way you survive**

**Transfer experiences from others?**

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## Generic Bridge and engineroom Resource Management


**Obligatoric**
**30 hours / 4 days**
**28 hours theory**
**12 hours sim**

**2012 - 2017**
**Be approved by NMD**

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## Company specific BRM / ERM

MRM-simulatorbased training

- Companies own crew
- Companies contingency plans & procedures
- DOC Mapping
- Companies accidents & cases
- Companies own wessels


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## Simulator training scenarios

- Piracy
- Oilspill
- Grounding
- Collision
- SAR
- OSC

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# BRM / ERM content :

- *Human factors*
- *Communication & close loop communication*
- *Hazardous Thoughts*
- *Situational awareness*
- Performance of leadership & Leadership in emergencies
- Work overload situation
- Cultural awareness & cultural gap
- Power distance
- *Stress & fatigue*
- *Management and teambuilding*
- Group dynamics and integration
- Human involvement in error
- Challenge and response
- *SAR & OSC*

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# Assessment

- Pre & Post assessment
- Documentation of learning
- Individual assessment
- Individual feedback
- Individual coping
- Motivation

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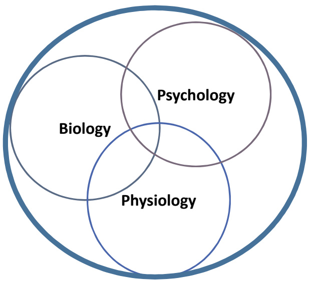
# What makes man human?

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# Human factors

- -Is about to understand what influences the human behavior;
- ***- Think***
- ***- Reacts***
- ***- Perform***
- ***- Act***

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# To err is human

- We can not eliminate human error

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# Safety Gap?

- Attitudes
- Behavior
- Role models
- Awareness
- Culture

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# Culture?

**The way we do things**

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# Challenge and response

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# Human involvement in error

- Is not a conclusion or a cause
- It is the starting point for investigating what lays deeper in the organization

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# Three focus areas:

1. Safety
2. Safety
3. Safety

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# Fell a sleep on watch

Narcolepsy

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# Self-knowledge

Focus areas of human factors

- Self-disipline
- Toleranse
- Perception ability
- Own attitude
- Applying of knowledge

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# The big problem areas

Boredom → Stress

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# Costa Concordia

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# Some times it goes wrong - Why?

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# «MS Sleipner»


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# Pearl of Scandinavia

**15. Nov 2010**

SMSC



# MS Estonia 28. september 1994


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# Herold of Free Enterprise

**The Management:**
**“Do they need a warning system to know if the bow port is locked”. My Goodness**

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# The human element

- Let's assume that you are taking about 50 decisions per hour worked while on the job
- This is likely in demanding operations such as preparing for diving, diving, combat, crises
- Is this real?

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If you have a failure rate of 1 %, what is the risk in numbers:
- **an hour**
- **a day**
- **a week**

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| Number of decisions per hour | Failure Rate | Number of errors per 2. hour | Number of errors per day | Number of errors per week | Risk level High, medium, small |
|---|---|---|---|---|---|
| 50 | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |



Your partner in offshore and maritime training
CLOSER TO REALITY

| Number of decisions per hour | Failure Rate | Number of errors per 2. hour | Number of errors per day | Number of errors per week | Risk level High, medium, small |
|---|---|---|---|---|---|
| 50 | 1 % | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

SMSC

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CLOSER TO REALITY

| Number of decisions per hour | Failure Rate | Number of errors per 2. hour | Number of errors per day | Number of errors per week | Risk level High, medium, small |
|---|---|---|---|---|---|
| 50 | 1 % | 1 | 6 | 42 | |
| | | | | | |
| | | | | | |
| | | | | | |

SMSC

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CLOSER TO REALITY

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|---|---|---|---|---|---|
| 50 | 1 % | 1 | 6 | 42 | |
| 50 | 0,1 % | | | | |
| | | | | | |
| | | | | | |

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CLOSER TO REALITY

| Number of decisions per hour | Failure Rate | Number of errors per 2. hour | Number of errors per day | Number of errors per week | Risk level High, medium, small |
|---|---|---|---|---|---|
| 50 | 1 % | 1 | 6 | 42 | |
| 50 | 0,1 % | | 1 | 4 | |
| | | | | | |
| | | | | | |

SMSC

Your partner in offshore and maritime training
CLOSER TO REALITY

| Number of decisions per hour | Failure Rate | Number of errors per 2. hour | Number of errors per day | Number of errors per week | Risk level High, medium, small |
|---|---|---|---|---|---|
| 50 | 1 % | 1 | 6 | 42 | |
| 50 | 0,1 % | | 1 | 4 | |
| Fatigue | | | | | |
| 50 | | | | | |

SMSC

| Number of decisions per hour | Failure Rate | Number of errors per 2. hour | Number of errors per day | Number of errors per week | Risk level High, medium, small |
|---|---|---|---|---|---|
| 50 | 1 % | 1 | 6 | 42 | |
| 50 | 0,1 % | | 1 | 4 | |
| Fatigue | | | | | |
| 50 | 5 % | | | | |





| Number of decisions per hour | Failure Rate | Number of errors per 2. hour | Number of errors per day | Number of errors per week | Risk level High, medium, small |
|---|---|---|---|---|---|
| 50 | 1 % | 1 | 6 | 42 | |
| 50 | 0,1 % | | 1 | 4 | |
| Fatigue | | | | | |
| 50 | 5 % | 5 | 30 | 210 | Do you accept the risk? |

How many of those errors can lead to critical situations?





# We will influence the future

- Human factors are compulsory as a part in all courses and education at SMSC





VTS_01_1.VOB

## *Marriage from a human factor perspective*

- **Marriage is like workshops**
  - Where men work and women shops





# Thank's for your attention

HFC

# Bruk av CRM trening – praktiske erfaringer

**L.B.Hviid, Human Factor Specialist, Maersk Drilling**

**Mer informasjon:**

**www.maerskdrilling.com**

QMHSE 2013 – Lars Bagger Hviid, Human Factor Specialist

# Application of CRM in Team Based Well Control Training

**April 2013**

MAERSK DRILLING

# Human Factors in Maersk Drilling

- Psychologist, PhD
- Develop personal- and process-safety focus tools
- Survey safety culture and support the further development of the safety culture
  - Support the effort for increased complience with management system, safe practices and safety barrier management
  - Fight against complacency/habituation/risk normalization through safety culture program
- Help develop HF aspect of Team Based Well Control Training.

# Agenda

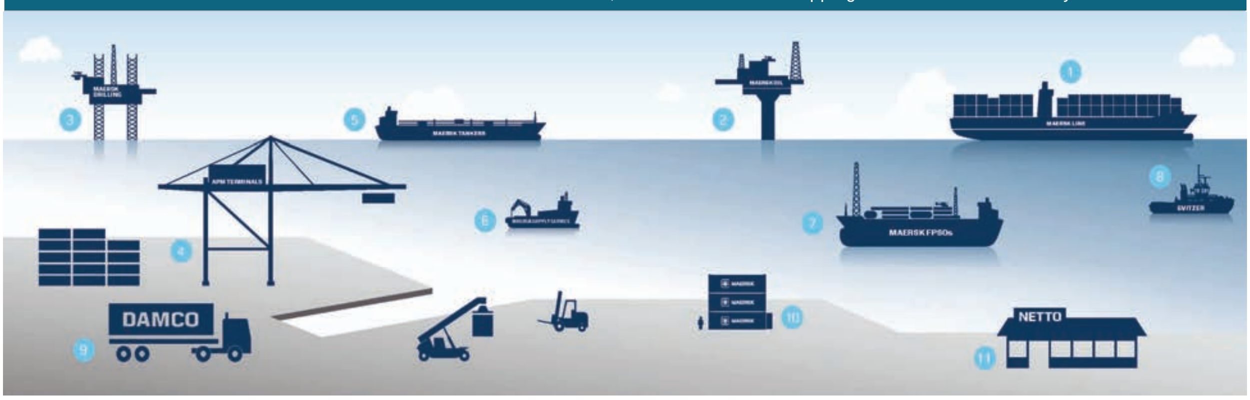
- What is drilling all about?
- What are our challenges as drilling contractor?
- How do we try to meet these challenges?
- How does HF/non-technical skills play into this
  - What is our focus?
  - What is it we are trying to achieve?

MAERSK DRILLING



# Group Overview

Container activities | Terminal activities | Oil & Gas activities | Tankers, offshore and other shipping activities | Retail activity | Other businesses




- 117,000 employees
- Some 70,000 shareholders
- Controlling stake held by A.P. Møller and Chastine Mc-Kinney Møller Foundation

1: Maersk Line
2: Maersk Oil
3: Maersk Drilling
4: APM Terminals
5: Maersk Tankers
6: Maersk Supply Service
7: Maersk FPSOs
8: Svitzer
9: Damco
10: Maersk Container Industry
11: Dansk Supermarked

MAERSK

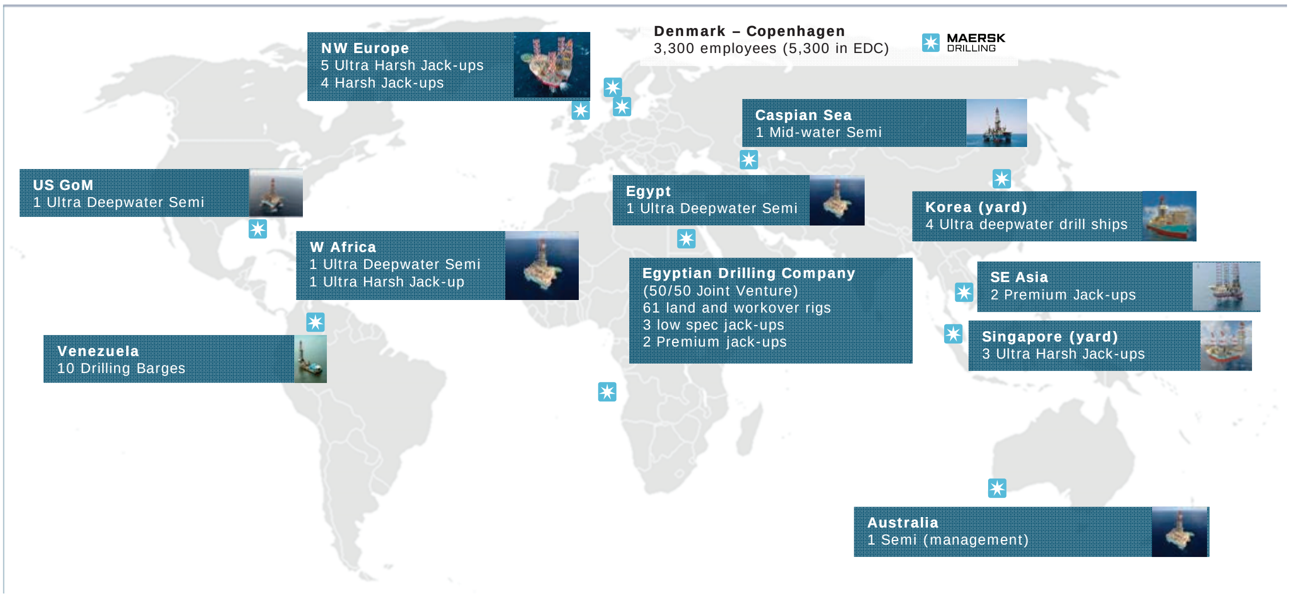
# Maersk Drilling's fleet

26 drilling rigs, 7 newbuildings and 1 unit on management contract


One of the Youngest and Most Advanced Rig Fleets

MAERSK DRILLING

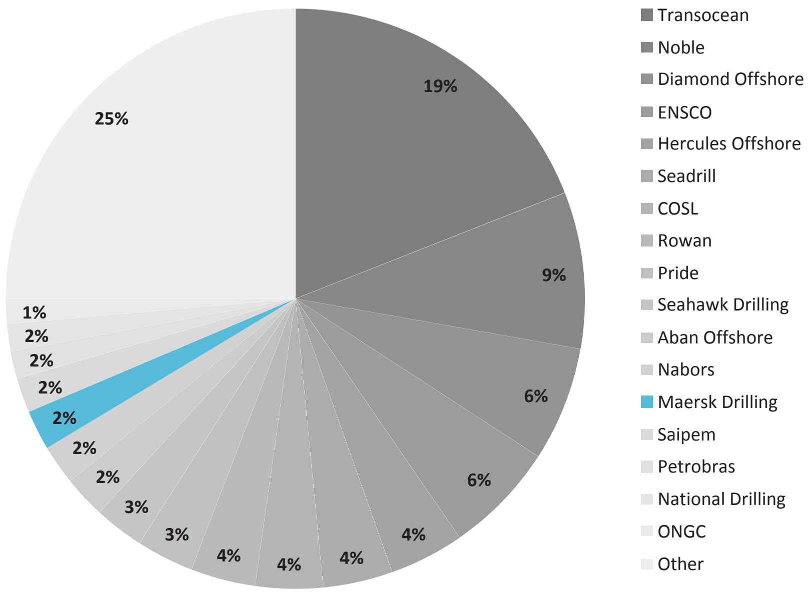
# Maersk Drilling is a worldwide operator




MAERSK DRILLING

# Drilling Market Share

## Global market shares (jack-ups, semi-submersibles, drillships)

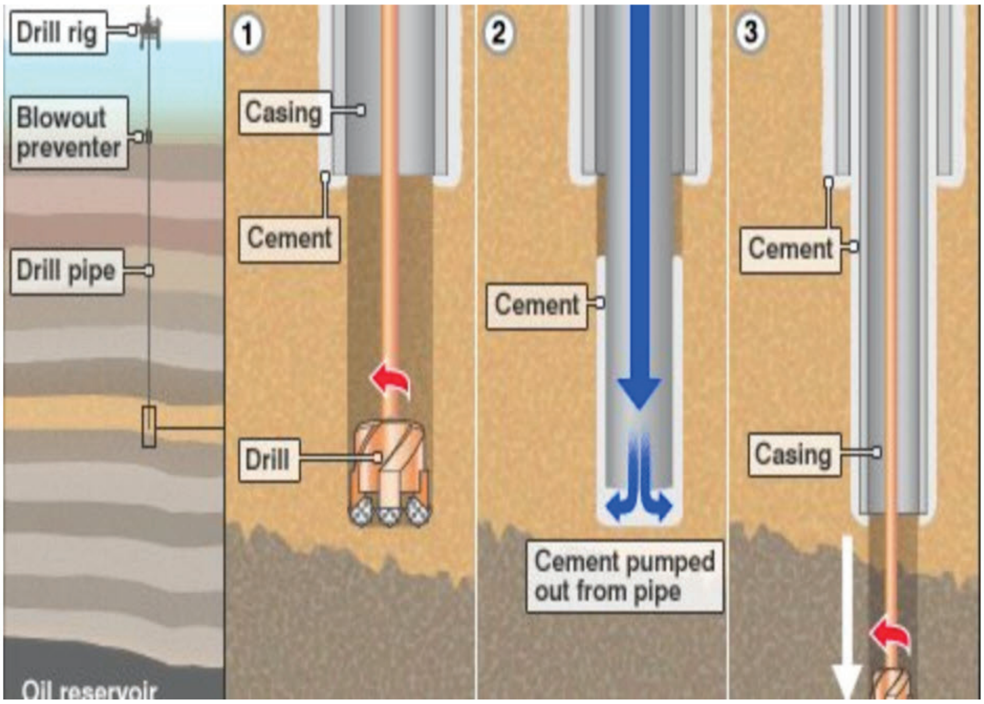



MAERSK DRILLING

# Offshore drilling explained (two slide)

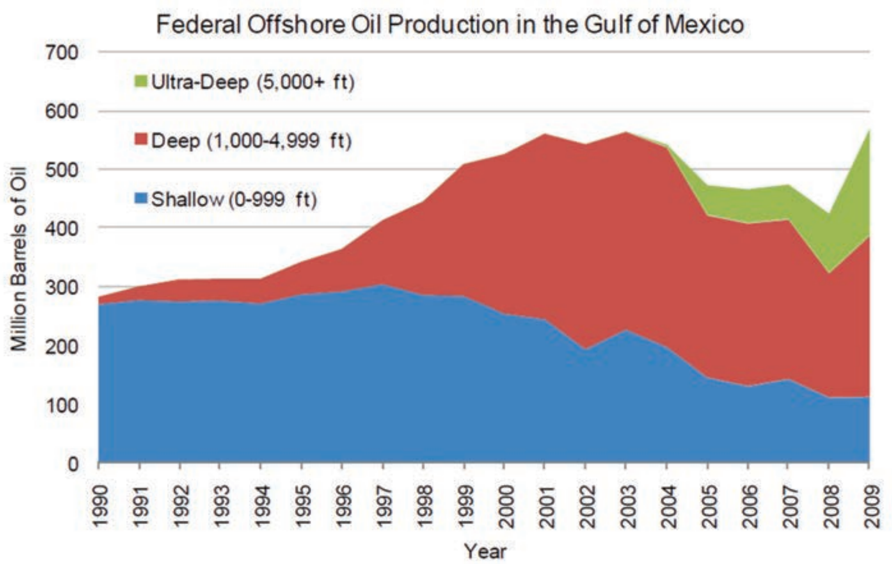
- Drilling a hole in the ground in order to discover and extract hydrocarbons  and gas from the underground.
- Drilling rigs (owned by drilling contractors) are hired by an oil company (has the lease for the plot of land where exploration and extraction takes place)
- Drilling rigs are usually paid a day rate for performing the drilling service – Uptime and downtime – time is a lot money
- Main focus of drilling operation is to maintain hydrostatic pressure in the hole and the integraty of the formation

# Reaching the reservoir






# The "easy" oil has already been found...




Source: Commission staff, adapted from U.S. Energy Information Administration

MAERSK DRILLING

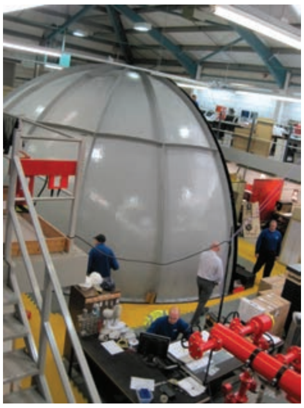


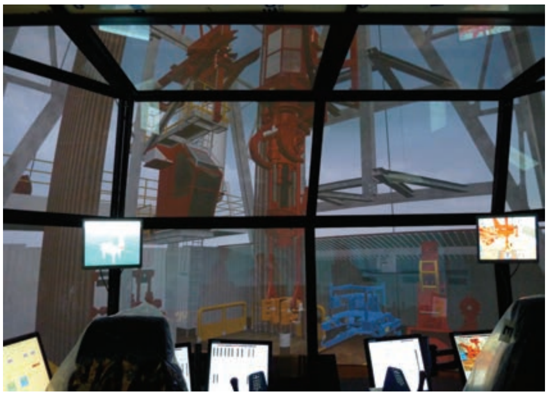
## Why HF in Team Based Well Control Training?

- An internal task force was established post the Macondo incident to identify and develop advanced training simulations with the objectives to:
  - Enhance drilling teams ability to handle worst case scenarios
  - Pro-actively plan and prepare for drilling operations
  - Focusing on crew resource management and human factor aspects in **Team Based Well Control Training**
- Joint partnership between Maersk Training and Maersk Drilling
  - Partly founded by the APMM Foundation



MAERSK DRILLING





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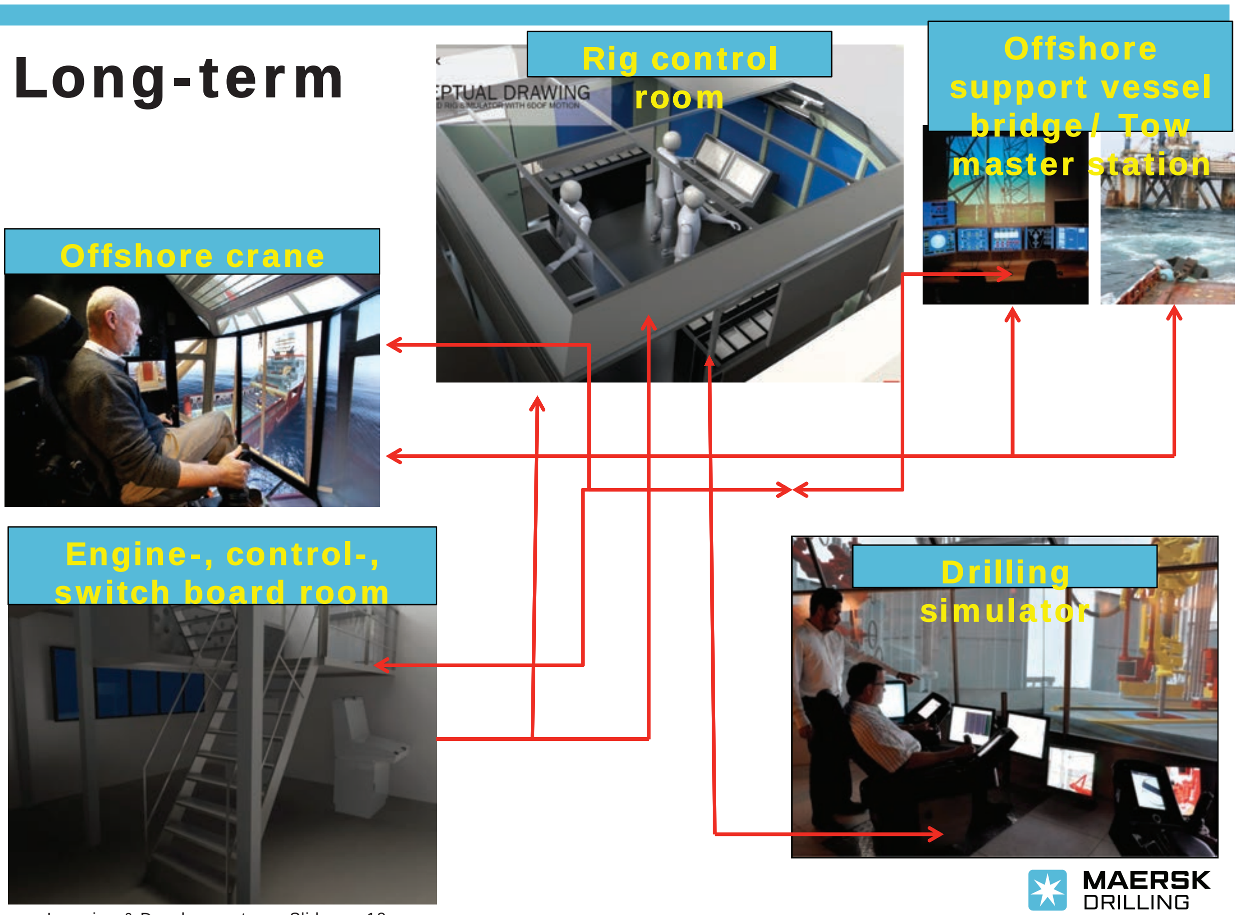
# Drilling simulator

MAERSK DRILLING

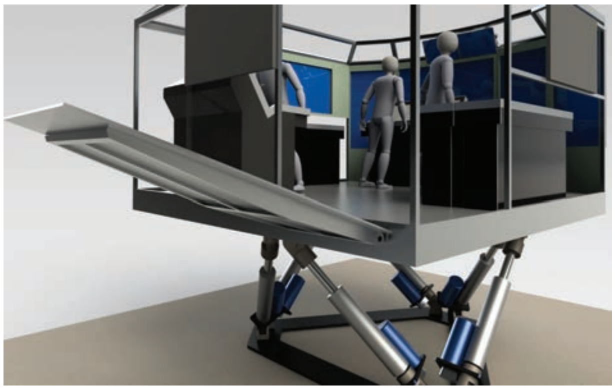
# Long-term






MAERSK DRILLING

# Rig control room / Offshore bridge simulator – Fact sheet

- Dynamic Positioning
- Stability D-Rig and Drillship
- Ballast control D-Rig and Drillship
- Management of Major Emergencies
- Riser Management System
- Towmaster room
- Vendor: Kongsberg



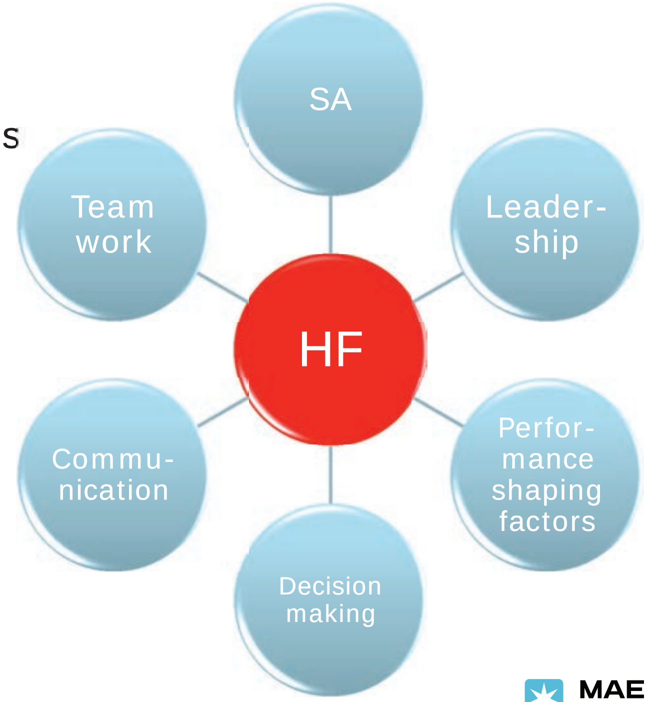
# Engine Room Simulator - Courses to be conducted

- **2013/2014**
- Scenarios training: Normal operation exercises, Scenarios where a fault occurs that needs to be corrected
- Power Management System
- Consumption optimization
- Environmental compliance sustainability
- Engine room resource management to IMO/STCW
- Cases for semis engine room
- Root cause and trouble shooting on drilling equipment
- People skills (communication, leadership, conflict handling etc.)
- Interdepartmental training (Well-from-hell scenarios)

MAERSK DRILLING

# Present..

- Team based well control training of drilling crews
  - Standard package
  - Specialized package
- Rests on two compenents
  - Technical skills
  - Non-technical/HF/CRM
- Training
  - Theory
  - Virtual environment
  - Feedback and review
  - Technical assessment






# Training structure

- 5 day course
- Process is facilitated by 3 instructors – two technical (with drilling background) and one HF
- Key positions taken up by drill crew and customer representative
- Significant characters like: Mud logger, DFO, OIM, Rig Manager, etc..
- Close integration of technical and non-technical skills
- Group exercise around well control scenarios
- Exercises are recorded and used in feedback/review sessions – technical and HF components
- Individual feedback related to HF components

# Human Factors 1.

- Situational Awareness
  - Gather information
  - Analyzing and understanding the information
  - Anticipating future state, indentifying leading indicators /weak signals set in the planning
- Decision making
  - Identify possible options and assess the options (deliberate decision) – concensus?
  - Section option and communicate it
  - Impliment and review decision
- Team work/dynamics
  - Understanding team roles
  - Support and conflict solving
  - Utilization of resources – experts on shore; sleeping police men



# Human Factors 2

- Leadership
  - Role in planning an preparation
  - Supporting and directing the team
  - Struture team effort
- Communication
  - Shared mental model (shared information – establish "one map"
  - Asking/listening – practising techniques in order to avoid confirmation bias
  - Assertiveness
- Performance shaping factors (review one to one)
  - Self awareness (identify stress and fatigue)
  - Self control (coping with stress and fatigue)
  - Contribute/utilize own resources – group dynamics

# Set up and HF objectives

- The team has to:
  1. Identify well control situation (weak to strong signals) and close in the well.
  2. Plan potential solutions. Define what good looks like Identify potential "Lagging" and "leading" indicators ; define parameters and cut off – attach sleeping policemen
  3. Monitor progress according to plan and defined parameters – ID deviations/new Decision? New plan?



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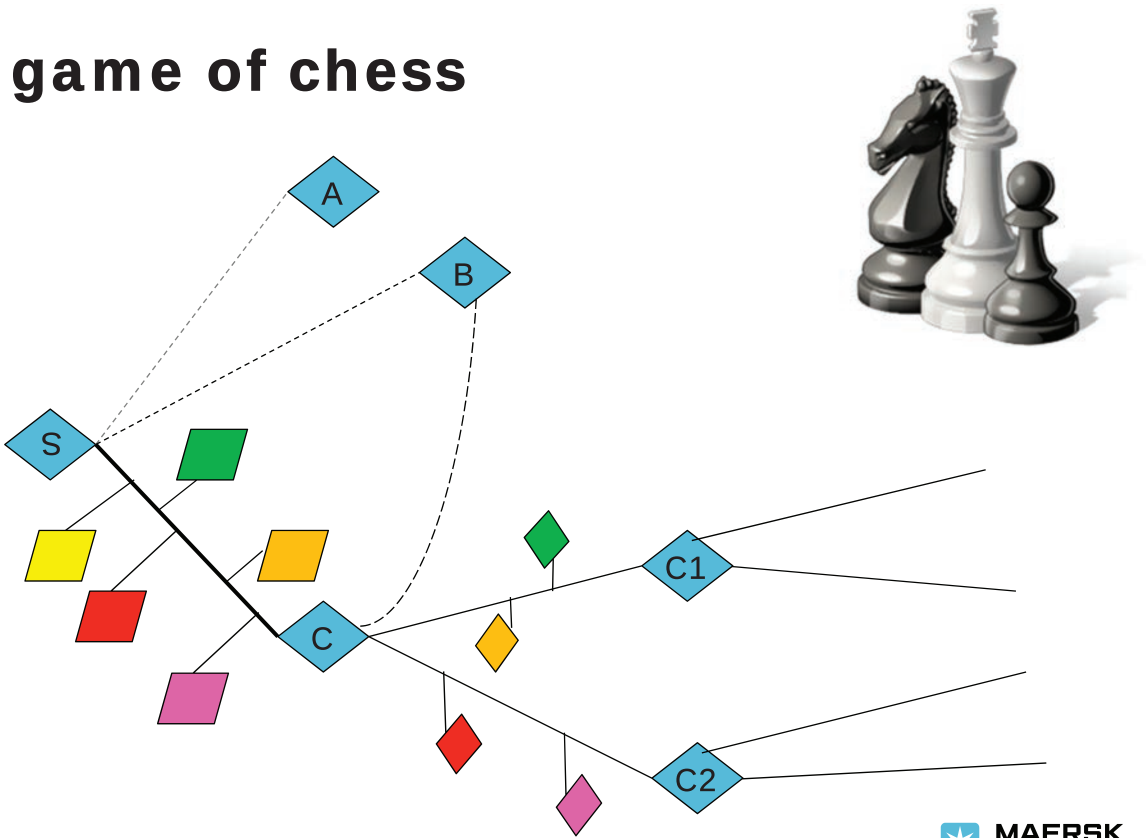
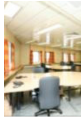
# A game of chess






MAERSK DRILLING

# Vision

- Efficient and safe operations (Emergency response)
- To give a far more realistic training (rig/unit specific) experience compared to any other simulator environment on the market today
- To train crews in teams in mutual interactions between the different departments and operations
- Improve individual, leadership and team performance
- Succession planning (acceleration programs)
- To obtain a commercial advantage in the market place and receive appreciation by our key customers




Please send questions & comments to:

Lars.bagger.hviid@maersk.com

# Thank You

HFC

# Workshop – "Implementing a CRM Course in your area of Operations"

**L. R. Heemstra, Human Factors Specialist – Flight Training College, United Arab Emirates**

**Mer informasjon:**

EK Monitoring & Automation Questionnaire (326 Pilots : 145 Captains & 161 FO’s)

# DESIGNING HUMAN FACTORS TRAINING – CREATING CRM COURSES

Lex Rock Heemstra

## Contents



## CRM at Emirates

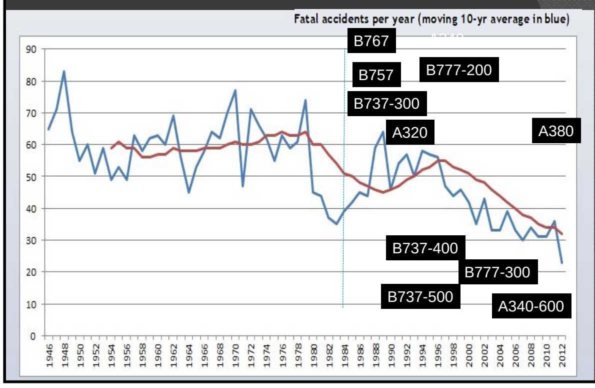
- 2 Day Initial CRM
- 1 Day Type Specific CRM
- Annual full day refresher – Flight Deck only
- Next day, 2 hour Joint CRM – Cabin & Cockpit Crew
- Full day – Command Development CRM
- Command Course – 2 Full days (with Personality Profiling)
- Core Instructor Course – Full day

- Flight deck – approximately 10 courses per week
- Cabin Crew – approximately 40 courses per week

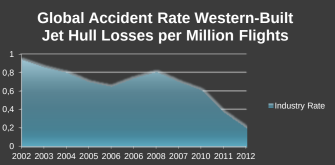
## Ownership of training

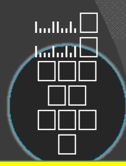
- Trainees take more ownership of their training when they can identify with the training
- An off-the-shelf program may not fit the type and scope of operations that you have
- One size does not fit all – you may have to adapt to each profession within the company
- Keep it simple – identifiable – and fit for purpose
- Do not force a concept or idea which has no relevance to your scope of operation
- Train like you work – and work like you train

## Airline Accidents and Trend



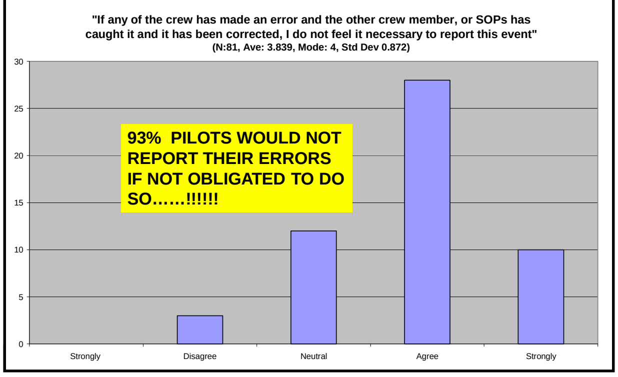

## State of Aviation Today



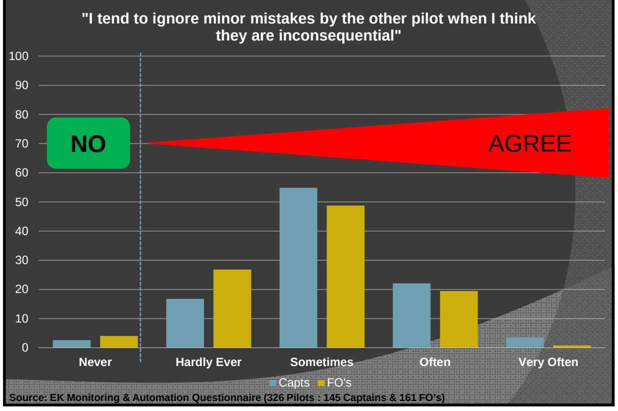



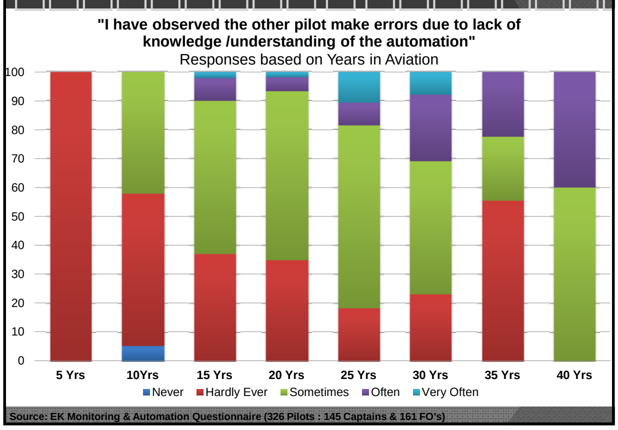
If Emirates was subjected to the current rate: 1 Hull loss in 34.25 years

## Operators admitting their mistakes?

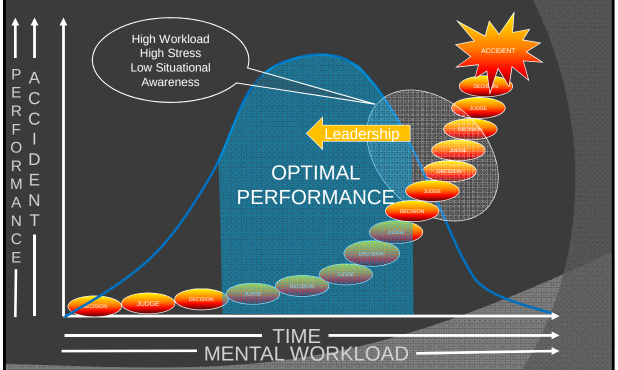



## Do Operators report everything?

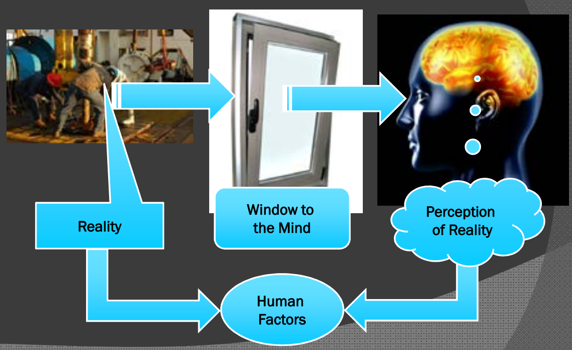



## Synopsis of an Accident




## Human Factors




## Threats

- A threat is any situation that could create a deviation of the intended task or intention.
- The threat itself is normally outside the control of the operator.
- It is always a future event.
- Threats cannot normally be removed, but the effect of the threat can be managed.
- A threat is external to the individual.

## Threat exercise

- Re arrange yourselves in groups of similar company or type of operation. 2 per table.
- List the typical threats a car driver faces. Remember, it is the threats that force them to deviate from their intended plan of action.
- If you are going to design a CRM course for your operators, list the typical threats that they face in their daily tasks.
- List all the threats on a piece of paper.
- Feel free to ask for clarification at any time.

## Error Exercise

- Take each threat and now:
- List the typical errors the human operator makes when dealing with these threats.
- Try see yourself in the position of the operator if you are not an operator yourself.
- All errors must be listed, there is no such thing as an inconsequential error.
- Do not edit the list – write down each others contribution.
- For the purpose of this exercise – 5 errors per threat will be sufficient (there may be more in reality)
- This exercise continues till and during lunch. Final lists after lunch please.

A quick introduction to the Crew Resource Management Modules

## CRM Modules

## CRM Modules

- Judgement
- Leadership
- Teamwork & Support
- Conflict Management
- Risk Management
- Decision Making
- Communication
- Assertiveness
- Culture - National, Organisational & Professional
- Situational Awareness
- Workload Management
- Cognition - Memory
- Distractions
- Automation
- SOP's

## Judgement

The ability to assess what is right and what is wrong.

You will only know what is wrong, if you know what is right.


## Leadership

- The ability to identify if any real change is required in a situation and then implement it within the time available, using the resources available to you.
- Integrity, honesty, responsibility, motivation, empathy,
- Passion
- Self driven
- Role Model
- Professional
- Personal

## Teamwork & Support

Giving or accepting aid when it is required.

Goals, communication, resources, delegating, offering, accepting,

Effective teams talk to one another


## Conflict Management

The ability to realise that one of you has to remain calm.

Values, beliefs, resources, pride, status, ego, emotions, goals, self stress, opinions, Misunderstandings,

## Risk Management

Evaluating the probability of something going wrong and determining the consequences, if it does go wrong.

Assessment, evaluation, prediction, estimating, severity, consequence, probability


## Decision Making

The ability to assess a set of options and choose the most suitable one in the time available.

Assessment, analysis, option generation, selection, implementation, revision, follow up

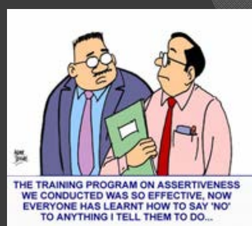

## Communication

- The ability to get people to do what you intend them to do,
- and do so clearly and efficiently,
- and to make sure you hear, and understand, what people are saying to you.
- Changing what one knows, feels, does & thinks.

## Assertiveness

Being honest (truth & facts), about what is relevant and not negotiable.

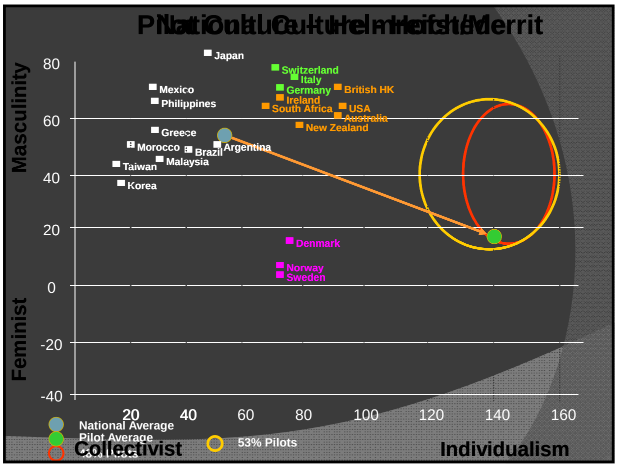
Assessing, asking, suggesting, insisting, convincing, intervening

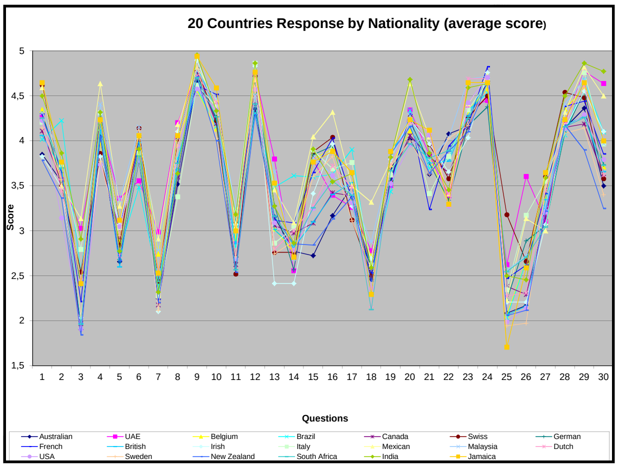


## Culture

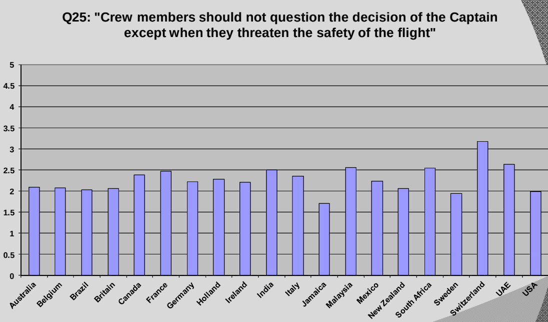
Addressing the values and beliefs of national, organisational and professional culture to ensure safe and efficient outcomes.

Values, beliefs, attitudes, habits, manners, expectations, recognition,

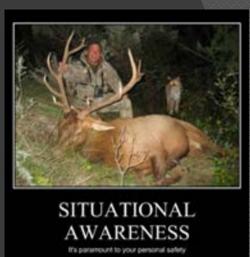

## Power Distance




## Situational Awareness

Knowing what is going on around you, the past, present and future, that can affect the outcome of your intention.

Assessment, consequences, relevance, negotiability, prioritising, briefings (initial and mini briefs), shared mental models

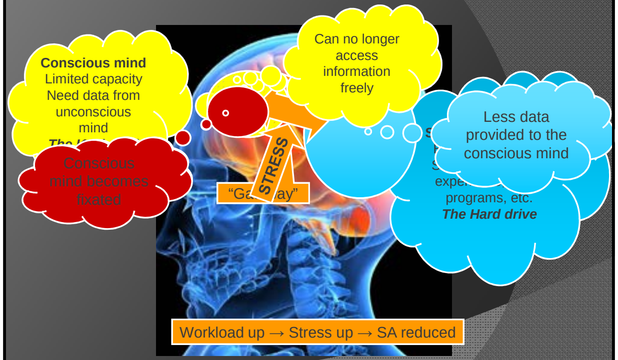



## Workload Management

The ability to balance your workload, using the resources available to you, so that you stay within your comfort zone.

Task Splitting, delegating, stress, comfort zone, resilience, fatigue,

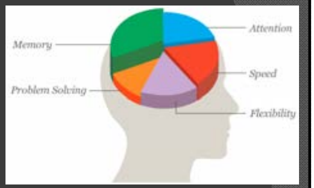
# WORKLOAD




# Cognition

Understanding the process of the brain and how this affects our perception of reality.

Short-, Long-, Working - & Procedural memory, filtering, conscious, subconscious, shared mental model, internal distractions.




# Humans Are Not Good Monitors!

# Distractions

The ability to pause, deal with the "distraction", rewind and play again.

Distraction vs Attraction, attention, task switching, re-assessing, acceptance, balancing, situational awareness,


# Automation

Delegating monitoring tasks to the "machine" which humans are not very good at monitoring themselves.

Awareness, delegating, understanding, knowledge, prediction, expectation, intervention, anticipating,


# Standard Operating Procedures

It is the glue that holds a team together.

However, also understanding that following SOP's will be right 99,9% of the time, but when it does not, then think outside the box.

RESILIENCE
Awareness-Professionalism-Suspicion

## Error Exercise Continued

- Now assess each error and categorise whether it is a HF error
- And if so, what category (use the CRM modules)
- Review the list once complete and count how often each one of the CRM modules appears
- The top three or four should be the basis of your training, the rest of the CRM modules can be used as fill ins.

## CRM Modules

Link each error to one or more of the CRM modules below

- Judgement
- Leadership
- Teamwork & Support
- Conflict Management
- Risk Management
- Decision Making
- Communication
- Assertiveness
- Culture - National, Organisational & Professional
- Situational Awareness
- Workload Management
- Cognition - Memory
- Distractions
- Automation
- SOP's

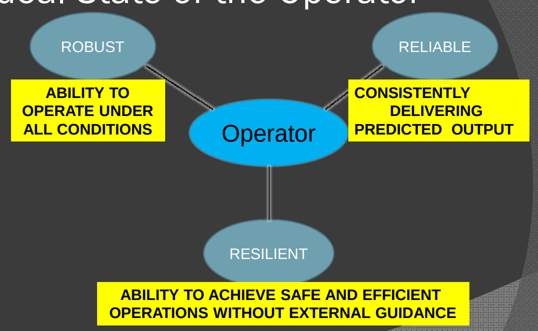
## Integrated Human Factors – Using Pilot Assessment Markers

- Knowledge
- Application of Procedures
- Workload Management
- Handling
- Leadership/Teamwork / Support
- Communication
- Situational Awareness
- Judgement & Decision Making
- Automation
- All training assessed
- Assessed on Grade from 1 – 5
- 2 or below a fail
- First Checked – next day trained
- 6 Monthly – 2 days ground school, 2 days simulator
- Manual handling – twice a year

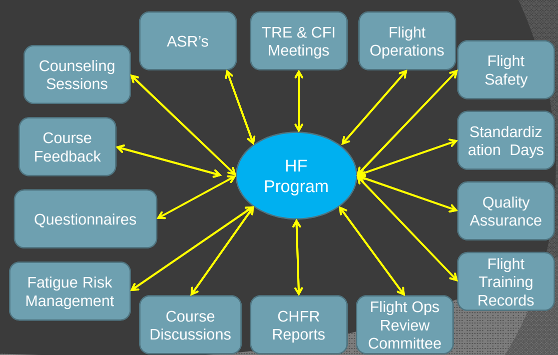
## PAM's Example: Communication

- Communication is very effective.
  - Briefings are clear, concise and timely.
  - Very high standard of SOP calls, RT phraseology and RT discipline.
  - Actively shares information and encourages team communication.
  - Asks relevant and effective questions and consistently verifies correct understanding.
  - Listens actively and patiently.

## Ideal State of the Operator

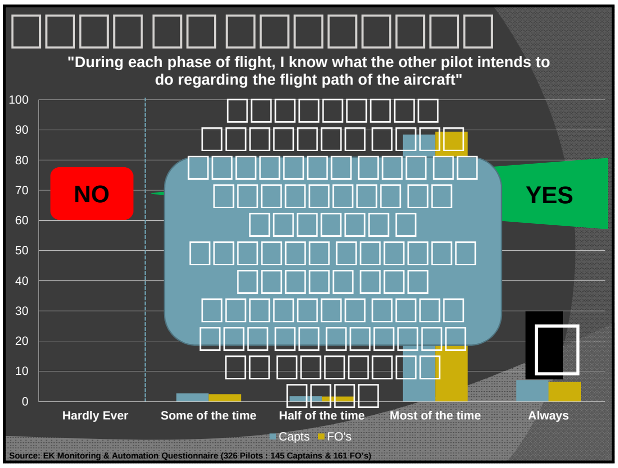


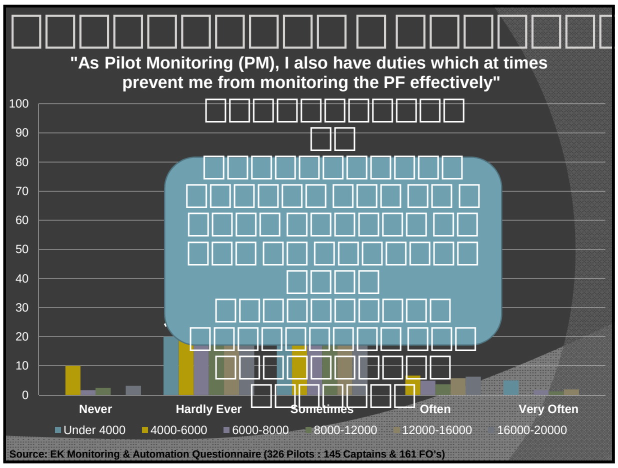

## Integrated HF Program



## Using Questionnaires

- From data provided from various forums
- Create a questionnaire relative to next training theme
- Use the CRM Recurrent days for data collection (100% return)
- Use demographics in your questionnaires
- Some Examples:




## Summary of CRM models

**Aviation Golden Rules**
- Aviate
- Navigate
- Communicate

**Threats & Errors**
- Avoid
- Trap
- Mitigate

**Decision making**
- Assess
- Action
- Manage

Stay below the line

**Assertiveness**
- Ask
- Suggest
- Insist

**Automation goals**
- Understand
- Anticipate
- Evaluate

**Cabin Crew Briefing**

Nature - Intentions - Time required - Special instructions

## Setting up your CRM course

- It should take a team of 3-5 personnel 4-5 months to develop a one day training course
- Identify your main themes early
- Use questionnaires to prove or disprove assumptions
- Create case based studies and exercises
- Make videos where you can – using you own people can have consequences
- Test the course with SME's
- Final changes
- Once implemented, No changes for at least three months

## Summary

- Find out from you operators what their threats are.
- Ask them what errors they observe when dealing with the threats.
- Identify the human factor issues in the threats and errors
- Get relevant, recent and factual data to support your training
- Identify your main themes for your CRM courses
- Make it interactive – videos, case studies, exercises (Adults like to get their hands dirty)
- Train like you work – work like you train

**HFC**

# Developing CRM Training

**R. Valle, Student NTNU – kopi av prosjektoppgave**

# Designing Crew Resource Management training for N-USOC

*Theory- and data-driven recommendations*

By Rune Kristiansen Valle,

Student, Work and Organizational Psychology, NTNU

# Table of Contents

# Chapter 1: Why Crew Resource Management?

## 1.1 The origins of CRM

The classic image of the single, hardy and decisive aircraft pilot of the early 1900s was subject to change in the course of the century, as the aircrafts themselves grew more complex, the surrounding crews grew larger, and the pressures connected to, and use of, public aviation increased manifold. As the introduction of reliable jet transport caused a dramatic decrease in accidents, focus shifted to other areas than the purely technical as potential causes of accidents, and the working relationship between the pilot and the co-pilot in commercial jetliners became a subject of attention. By the early 1970s, formal training in the human factors aspects of flight began to emerge in several major carriers (Kanki, Helmreich, & Anca, 2010). Still, a series of fatal accidents involving non-technically related errors during the 1970s, and the investigation of the causes of these accidents, became the main motivation to formalize this human factors training into what was dubbed CRM, or Cockpit Resource Management. The main causes of accidents were identified as being failures of interpersonal communication, crew coordination, decision making and leadership (Flin, O'Connor, & Mearns, 2002).

## 1.2 The development of CRM: Generation 1-4

While identifying several team factors as potential causes of accidents, the first generation of cockpit resource management focused primarily on changing individual patterns of behavior in aircraft personnel, specifically, openness on the part of the captain, and assertiveness on the part of the first officer/co-pilot. In the second generation, training began including group dynamics, while taking an important step towards specificity by focusing on cockpit-specific procedures (Salas, Burke, Bowers, & Wilson, 2001). The third generation of CRM meant a broadening of scope; the recognition that the cockpit crew needed to interact with several other systems to ensure safe flight, including air controllers, technical crew and cabin crew. In light of this new perspective, the acronym CRM changed its content to Crew Resource Management, and crew training started including members of all relevant professions (Kanki et al., 2010). This realization meant a different, more complex view on who actually comprised a crew – or team – in any given situation. With CRM training at this point (early 1990s) accepted as an integral part of basic training, the fourth generation was all about proceduralization and standardization of CRM training, integrating the human factors trainings with technical training and follow-up safety auditing on actual routine flights (Salas et al., 2001).

## 1.3 Current CRM: Generation 5 – 6 ½

### 1.3.1 Threat and error management

The fifth and sixth generation of CRM takes a somewhat different perspective. Whereas earlier perspectives on CRM sought to eliminate human error through group processes, the fifth generation meant more of a three-pronged approach, often referred to as the error management troika: firstly, detecting threats that could generate human error; secondly, catching errors that are made through early detection; and thirdly, managing the consequences of the errors that still do occur (Salas et al., 2001). This is also thought of as the 'Swiss cheese' mentality, the serious errors being those who are allowed to slip through consecutive holes in several layers of Swiss cheese (Reason, Hollnagel, & Paries, 2006). This version of CRM is also referred to as TEM, or 'threat and error management', (Kanki et al., 2010).

Lately, a major area of interest within CRM application and research is what can arguably be described as 'generation 6 ½ CRM', dedicated to managing the consequences of so-called 'black swan' events – threats that are inherently undetectable – through organizational resilience (Taleb, 2010).

### 1.3.2 CRM topics

As to the content of CRM training, the core modules are more or less universally agreed upon (Flin et al., 2005; Flin et al., 2002; Heemstra, 2013):

1. Team work: the ability to work effectively in a team and maintaining a positive work climate through supporting and monitoring team members
2. Leadership: the ability to coordinate, motivate and persuade team members to achieve better team outcomes, determining procedures, managing risks and conflict.
3. Situational awareness: monitoring the environment, interpreting the impact of changes and communicating relevant outcomes.
4. Decision making: the process of reaching a judgment and selecting an option on an individual level.
5. Communication: ensuring that relevant information is submitted, received, confirmed and understood through good practices, like assertiveness, listening and closed-loop communication.
6. Personal limitations: understanding how circumstances like stress, workload and distractions may influence performance.

This is not to say that every CRM course is the same, quite the opposite. In order to achieve the desired results, each CRM course has to be developed and adapted to the specific context where it is to be implemented as recurring training. However, these are the general areas that CRM training seeks to cover, though the detailed content is bound to vary, depending on the needs of the CRM recipients. Designing a successful CRM intervention, then, is highly dependent on evaluating which areas should be covered, and there are a few methods available for uncovering this information.

TABLE 1: POPULAR CRM TOPICS

| Core CRM modules (Flin et al., 2002) | Detailed topics (Heemstra, 2013) |
|---|---|
| Team work | Teamwork & Support |
| | Culture: National, Professional, Organizational |
| Leadership | Leadership |
| | Conflict management |
| | Risk management |
| | Standard operating procedures |
| Situational awareness | Situational awareness |
| | Cognition-memory |
| Decision making | Decision making |
| | Judgment |
| Communication | Communication |
| | Assertiveness |
| Personal limitations | Workload management |
| | Distractions |
| | Automation |

## 1.4 Evaluating CRM training

The evaluation of CRM training has, in line with Kirkpatrick's typology for training evaluation, been conducted on four levels; the attitudinal level, the learning level, the behavioral level, and the effectiveness level. The attitudinal level covers which affective reactions and predispositions participants report towards the training and its content, the learning level cover both objective knowledge of the training topic and subjective assessment of how much was learned, the behavioral level measures overt and quantifiable behaviors connected to the training domain, and the effectiveness level seeks to measure the actual result of training on a relevant outcome variable, e.g. number of accidents. However, some of these levels have been more consistently investigated than others, mainly due to the accessibility of data (Salas et al., 2001; Salas, Wilson, Burke, & Wightman, 2006).

### 1.4.1 CMAQ

An important step in evaluating the attitudinal gains of CRM training was having a reliable test battery to assess CRM skills. A popular tool, especially in aviation, has been Helmreich's Cockpit management attitudes questionnaire (CMAQ); a 25-item Likert-scaled test battery, assessing attitudes regarding crew coordination, flight deck management, and personal capabilities under fatigue and stress. This questionnaire has been validated to predict performance in line operations evaluations, and is, as such, a successful tool (Kanki et al., 2010). What seems well-documented by the CMAQ is the positive reception, and perceived usefulness, by CRM course participants. Also, the CMAQ has yielded positive results on the perceived learning of crew resource management through CRM training sessions (Salas et al., 2001; Salas et al., 2006).

### 1.4.2 Behavioral marker systems: NOTECHS

Nevertheless, there was still a need for a reliable tool for examining CRM skills on the behavioral level, and though the aviation industry had been using several versions of Helmreich's Line LOS Checklist, new legislation led to a wish for a common method of evaluating behavior. NOTECHS, therefore, was designed by commission from the Joint Aviation Authorities to be a culturally robust, pan-European tool for assessing pilots' CRM skills through directly observable behaviors, in order to provide specific, individual feedback and to improve CRM training. This was done using accessible, non-psychologist-specific language, so as to improve understanding across user groups. NOTECHS consists of four categories: Co-operation, Leadership and management skills, Situational awareness and Decision-making, each divided into three to four specific elements (Flin et al., 2005; O'Connor et al., 2002). While the NOTECHS version that is being used by the aviation community is designed, element by element, to be aviation-specific, the method in itself is applicable to other domains, and this is also being done. Especially the healthcare industry has been keen to adapt non-technical skill assessment, to anesthetists, surgeons and scrub nurses, specifically; each profession with its own tailored rating system. The success of any CRM training program depends on the ability to tailor the program to the specific context in which it is to be used, and so it is with NOTECHS assessment (Kanki et al., 2010).

### 1.4.3 The effect of CRM training

This behavioral marker system, then, could help mitigate the severe lack of pre- and post-studies on the effect of CRM training on measurable work-related outcomes like failure rates. This is partly due to the nature of the industries involved; high-reliability domains like aviation, space flight and nuclear control rooms fortunately do not have accident rates high enough to reliably assess the impact of CRM training directly. Some work has been done on assessing incident, rather than accident, rates, but the proliference of such investigations is limited due to the financial costs of evaluations on this level (Salas et al., 2001; Salas et al., 2006). Due to the increased interest in CRM adaptations by the healthcare industry, some concrete evidence to the effect is starting to gather there, but that still only partly solves this issue for the high-reliability industries. Having a reliable and valid way of assessing behaviors, then, would be beneficial to course participants, management and researchers alike.

## 1.5 CRM adaptations to other domains

### 1.5.1 The maritime industry and BRM

As CRM training became mandatory in the aviation industry, application of these principles proliferated to many other areas, like nuclear control rooms, the rail industry, the healthcare industry, offshore control rooms and, first of all, the maritime industry. The development of, and rationale for, human factors training in the maritime industry mirrors the evolution of CRM in aviation; the interest in human factors being grounded in accident investigation, and the bridge of a maritime vessel resembling the aircraft cockpit in many respects. The initial outcome of this interest was Bridge Resource Management (BRM), an early 1990s adaptation of CRM training to a maritime setting. This type of training is still widely used, revised and adapted along with the evolution of CRM principles to the current Maritime Resource Management (MRM) (Kanki et al., 2010; Wahlstrøm, Dreijer, & Haugsnes, 2013).

### 1.5.2 The healthcare industry

Another early adapter of CRM principles was the healthcare industry, especially within the subdomain of anesthesiology. Contrary to the 'after the fact' kind of rationale that paved the way for CRM in aviation and the maritime industry, the need for non-technical training for anesthesiologists was a result of studies in the late 1980s, pointing to a lack of non-technical training in simulated crisis scenarios. A domain-specific adaptation of Helmreich's CMAQ showed many of the same attitudinal and behavioral challenges that aviation CRM was originally designed to mitigate, leading to the ever increasing use of Anesthesia Crisis Resource Management (ACRM) in anesthesiology training. Different adaptations of CRM principles are also starting to spread to other domains in the healthcare industry (Kanki et al., 2010). The integration of CRM procedures in the healthcare industry has additional benefits aside from the increased safety for patients: the implementation in a high-risk environment where fatal human error does and always will occur at a measurable frequency means that the actual effect of human factors training can be assessed, which gives perspective to much research that has been done on similar training in high-reliability organizations such as airlines (Rosen, 2013; Salas et al., 2001; Salas et al., 2006).

### 1.5.3 The offshore industry

The development and use of CRM principles in the offshore industry resembles the evidence from aviation and the maritime industry in virtually every respect, starting with a rationale stemming from identification of human errors contributing to several momentous accidents, and continuing with adaptation of the most relevant CRM principles to offshore user groups (Kanki et al., 2010). What makes the offshore industry especially interesting is the complex structure of involved actors in a crisis scenario, including on-site handling personnel, on-site control room operators, to onshore control room operators and external contractors and expertise. This helps create special challenges for ideal CRM training.

### 1.5.4 CRM in the space program: SFRM

This complex team structure is as evident in the version of CRM that has been adapted and used by NASA in the training for their control room, space shuttle and ISS personnel. After a post flight analysis of a satellite deploy, NASA found that the issues they encountered in their evaluation was not limited to isolated crews, but involved members in decision chains throughout the organization. For this reason, the name was changed to Space Flight Resource Management (SFRM), to underline that this was something that had to include all members of the NASA team. Starting with shuttle crews, and expanding to control room operators and ISS crew, the stated goal is crew resource training for every NASA team member. Currently, ISS controllers and operators are by far the most frequent SFRM training participants, and so training is conducted using mostly ISS examples and scenarios, rather than the slightly different shuttle-based training (Rogers et al., 2002).

# Chapter 2: Theoretical framework: teamwork and culture

## 2.1 What is a team?

Teams consist of two or more individuals with specified roles, who interact adaptively, inter-dependently and dynamically towards a common goal (Salas, Sims, & Burke, 2005). This is, of course, a very wide definition, and it serves to illuminate how many varieties of teams there are, in terms of size, duration, homo/heterogeneity and distribution. Especially important in this context are the time and distribution dimensions, which will be discussed after a more general framework is presented.

## 2.2 Conceptualizations of teamwork: the Big Five

Many models of teamwork have been proposed during the last half century. One of the most cited frameworks at present is Eduardo Salas' 'Big Five' of teamwork. In this model, Salas proposes that five discrete teamwork components; team leadership, mutual performance monitoring, backup behaviors, adaptability and team orientation, predict success in any form of teamwork, as long as they are supported by three coordinating mechanisms; shared mental models, mutual trust and engagement in closed-loop communication (Salas et al., 2005).

### 2.2.1 Coordinating mechanisms

Shared mental models entails a common understanding of the environment and expectations of performance, making team members able to anticipate each other's needs, thus coordinating the team's efforts towards their common goal. This is especially important in a stressful environment. That is not to say that the mental models of each team member need to be identical, rather similar enough to promote, rather than hinder, relevant feedback and coordination. Shared mental models is an important pre-requisite for several teamwork components, like mutual performance monitoring, which rely completely of a common understanding of the tasks being carried out.

Closed-loop communication is a discrete form of interaction, implemented to ensure that information is given, received and understood between any two team members at any time, and consists of 1) a message being sent, 2) the message being received, 3) confirmation of message received and 4) sender follow-up to ensure retrieval.

Mutual trust in teamwork is defined as the belief across team members that each will perform actions important to the team, and recognize and protect the interests of the team members and their common cause. This is important because it minimizes the energy and time spent on following up and checking that team member tasks are fulfilled, and also readies the ground for important team behaviors like performance monitoring and backup behaviors, which can easily be misinterpreted in an environment lacking in mutual trust (Salas et al., 2005).

### 2.2.2 Teamwork components

As to the teamwork components, Team leadership is, in this context, a facilitative role. Leadership entails making sure the group's needs and goals are being met by coordinating team efforts, organizing resources, defining goals and guiding the team towards these goals on both an individual and a collective level. The team leader should monitor and synchronize the individual efforts as well as possible, while monitoring the environment to ensure resilience towards sudden changes.

Mutual performance monitoring is the ability to keep track of other team members' work as well as your own, to ensure that the situation is normal, and that procedures are being followed. This has different implications. From an effectiveness standpoint, it increases the ability to maximize resource use, while from a human factors standpoint, it is vital for the second stage of the error management troika; being able to catch errors before they come into effect. This 'safety net' in the form of team member feedback is especially important during stressful conditions.

Backup behaviors are a reallocation of resources as a response to an uneven workload within the team, often discovered through mutual performance monitoring. This can be corrected by backup providers in different ways; by offering feedback and coaching, by assisting a team member in a task, or by completing a task for a team member. Good use of backup behaviors has been shown to reduce the amount of errors made in stressful conditions.

Adaptability is the ability to quickly recognize deviations from expected actions, and adjust actions appropriately, both as a response to errors occurring within the team domain, and as a response to changes in the environment. For a team to be adaptable, they must not only be able to detect and assess the change in the situation, but also choose plans of action that are appropriate to the new situation.

Team orientation is an attitudinal dimension, entailing not only the preference for working with others, but also the tendency to enhance performance through group processes in teamwork. This attitude has a number of helpful behavioral implications in teamwork, improving, among others, decision making, feedback orientation and error detection within a group. Though connected to stable personality traits, this has been shown to be a malleable attitude, and thus subject to training on an individual and collective level (Salas et al., 2005).

## 2.3 Virtual or distributed teams

Although most research on teamwork has been conducted with regard to physically co-located teams, the globalized situation and increased technological opportunities to work across geographical boundaries has led to a sharp increase in what is called distributed or virtual teams; work groups that share the initial characteristics of teams, but have the complication of being partly or wholly distributed geographically (Jarvenpaa, Knoll, & Leidner, 1998). This carries some important implications to teamwork and CRM training for virtual crews, specifically, an increased level of conflict that hinders teamwork processes. According to Hinds and Bailey (2003), the specter of added conflict in distributed teams can be traced back to two main factors: geographical distance and technological mediation. These factors are responsible for increased conflict on task, process and affective levels, and contrary to conventional wisdom in collocated teams, all of these seem to be detrimental to performance in virtual teams (Hinds & Bailey, 2003).

Geographically dispersed team members experience different contexts around their shared virtual workspace, in terms of circadian rhythms, in terms of different culture and co-workers, and possibly different technologies. This affects the way situations are perceived in any given situation, and looking back on the central CRM topics, it poses a threat to situational awareness and shared mental models. This can be alleviated by familiarity, in virtual teams with temporal stability, and so it remains an even greater challenge in the ad-hoc kind of virtual team (Hinds & Bailey, 2003; Salas et al., 2005).

Technological mediation poses a special challenge to the coordination of dispersed teamwork. While face-to-face contact provides equal opportunities for information transfer, and a time frame that leaves no room for error, the mix of two-way and one-way communication that is usually seen in virtual teamwork, along with the sheer transfer speed complications, might mean that one or more team members is out of sync with the rest of the team. As well as hindering the efficiency of communication, it also tends to increase task conflict due to incomplete information and lack of shared mental models, and affective conflict due to perceived injustice in the information sharing methods (Hinds & Bailey, 2003). Both technological mediation and distance affect the relational aspects of distributed teamwork, through several different mechanisms.

Geographical distance means that friendship between team members is less likely, and there is a greater chance of cultural differences and differences in norms. The impact of technological mediation on group member relations has been subject of much interest, and findings suggest that less relational information is being passed, group cohesion is lower, and competitiveness is higher in mediated teams. While using richer media and temporal stability may improve some aspects of this, the tendency is still that technological mediation is an obstacle to group relations (Hinds & Bailey, 2003). A central component here is the impact of virtuality on mutual trust in distributed teams. Trust can be fragile in distributed teams, and this has a decisive influence on how task conflict leads to affective conflict in distributed teams (Hinds & Bailey, 2003; Jarvenpaa et al., 1998).

Looking back at Salas' set of coordinating mechanisms, it is apparent that distance and technological mediation has the strongest impact in these domains, as shared mental models, closed-loop communications and mutual trust are all threatened by both aspects of virtual teamwork. Given the importance of these coordinating mechanisms in central teamwork processes, it would be natural to give priority to these aspects when designing CRM training modules for virtual teams.

As Maznevski and Chuboda (2000) demonstrated, an important predictor of virtual team success is establishing a temporal rhythm in the virtual teamwork, by arranging face-to-face meetings at strategically convenient points, most often at the beginning of a major project (Maznevski & Chudoba, 2000). This gives added rationale for the implementation of recurring CRM training seminars for distributed team members, not least because face-to-face meetings in itself limits the negative consequences of conflicts, and helps mitigate the trust issues that lead to conflict (Hinds & Bailey, 2003; Jarvenpaa et al., 1998). Another aspect of virtual teams is their often temporary nature, which has been considered a given in virtual teamwork research. The aviation roots of CRM training, with its focus on temporary, ad-hoc teams, arguably makes the methods associated with crew resource management well suited to deal with these kinds of recurring, but temporary teams, given its focus on individual teamwork skills training. Still, as has already been suggested in this section, more temporal stability does seem to alleviate some of the challenges associated with dispersed teams, and opens the doors to alternative plans of action (Kanki et al., 2010; Saunders & Ahuja, 2006).

## 2.4 Cross-cultural issues

Geert Hofstede (1983), in his widely spread definition of national culture, specified four dimensions where national culture differed across the world. Individualism/Collectivism describes the strength of the ties between the individual and his/her in-group, Power Distance describes the level of hierarchy and autocracy in a society, Uncertainty Avoidance describes the willingness to accept uncertainty versus absolute truths, and take risks, and Masculinity/Femininity involves both the distribution across traditional gender roles and the difference in ideals from the masculine Nietszchean 'superman' to the feminine 'underdog' ideal (Hofstede, 1983). Even though national culture on these dimensions may differ drastically from Hofstede's findings when only one specific professional domain is considered (Helmreich, Merritt, & Wilhelm, 1999), this framework raises some important issues when considering cross-cultural teams, both collocated and dispersed. In a succinct study of cross-cultural issues among ESA control room operators, Sandal & Manzey (2009) found reported issues along Hofstede's lines, both in "within-ESA" projects and "between-agency" collaborations with the other major space agencies, the most reported teamwork issues varying systematically with the agencies involved (Sandal & Manzey, 2009). This serves to underscore that cultural issues are not to be underestimated in virtual teamwork.

## 2.5 Management and user support

As with any training intervention, the initial support of managers, supervisors and users is crucial to the effect of CRM training. This is not only important to the likelihood of CRM being implemented in the first place, but also has been shown to have a significant effect on the long-term results of CRM training, not least because it was designed as a recurring, rather than one-off, intervention. Also, how the course participants feel about the course beforehand, e.g. in terms of voluntariness and use of time, will impact the effects of CRM training on the individual (Helmreich et al., 1999; Salas, Rhodenizer, & Bowers, 2000). The upshot of this is that the role of the management is important when planning CRM training, communicating the usefulness of the training, and affording the time to the participants in a supportive way.

# Chapter 3: Contextual data: the N-USOC control room

## 3.1 General description

The European Space Agency's (ESA) contribution to the International Space Station (ISS) includes a scientific module called Columbus, containing a laboratory that houses systems and payloads that are controlled through cooperation between the ISS crew and on-ground control centers. The N-USOC control room is one of nine 'User Support and Operation Centres' spread throughout Europe, that, between them, carry out the majority of preparation and in-orbit operation tasks on the Columbus module in a non-overlapping way, coordinated by the Columbus Control Centre (COL-CC) (Ophof et al., 2013).

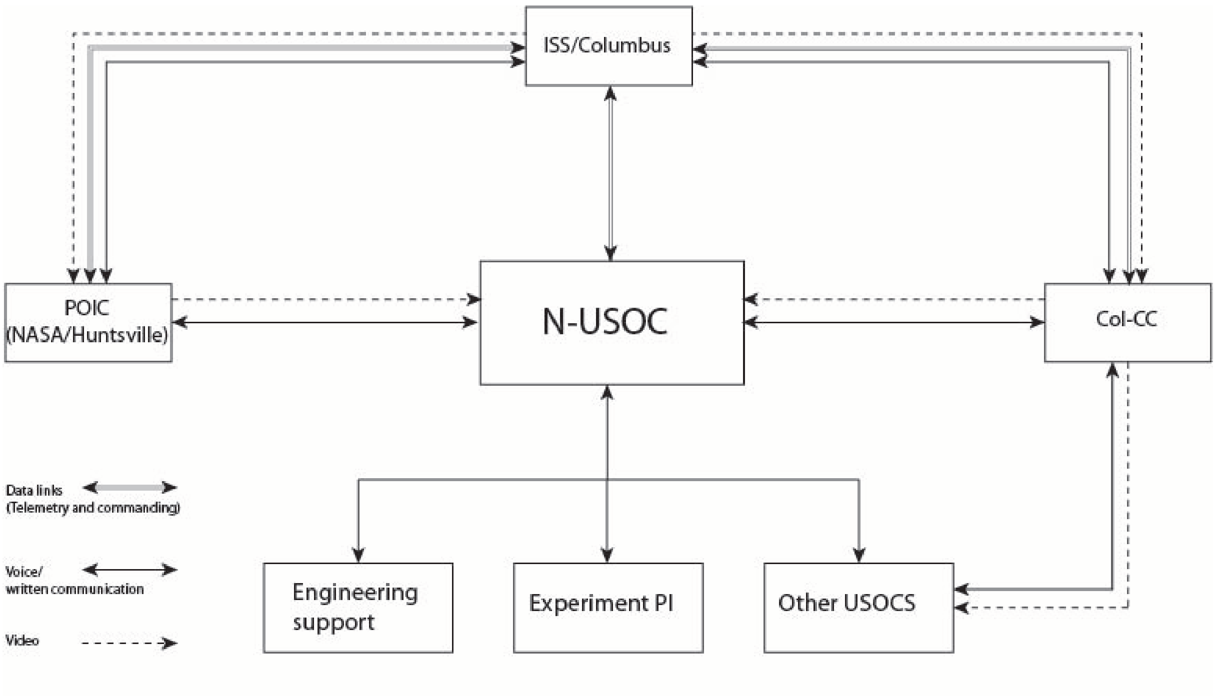
The N-USOC control room is run and staffed by Centre for Inter-disciplinary Research in Space (CIRiS). The structure of CIRiS is, in many ways, quite flat and informal, though the organization chart is actually quite complex, with several different areas of responsibility on the administrative level. During operations, the structure in the control room is flat, except for one person who takes on a supervisory capacity, usually one of the managers. For each experiment, one person is assigned the role as coordinator beforehand, doing most of the preliminary work, planning tests, contact points and briefing the other operators before commencing the experiment. This role is rotated on all of the operators, depending partly on the content of the experiment and time schedules. The workload of the operators is cyclical, meaning that the control room is somewhat overstaffed during regular operations, and understaffed during 3-4 week high-activity experiment periods. Normally, the control room is staffed only in regular working hours, in the peak activity weeks, though, it is staffed 24 hours a day, split in three 8-hour shifts with one hour handover between shifts. CIRiS has 10 people working on console, 7 or 8 of which are certified USOC operators, and some of which are mostly technology or equipment specialists. These work according to their shift schedule, rather than in pre-defined teams.

## 3.2 Defining the virtual team: N-USOC interfaces

The main contact points for N-USOC are the Columbus Control Centre (COL-CC) in Munich, representing the ESA side of operations, and the Payload Operations and Integration Center (POIC) in Huntsville, serving as the main interface for NASA-related tasks. Real-time communication is conducted through a voice link system enabling each operator to contact any relevant actor, monitor who is talking to whom, and listen in to relevant task-related communication. Additionally, there is a level of asynchronous communication through regular written reports of key events. Voice link access to the astronauts in the ISS crew is restricted to certain NASA and ESA units, which means that any instructions or discussions as to how the scientific equipment should be physically handled by the astronauts must be agreed on between the scientific community and the USOCs before the conclusions are conveyed to the astronauts. This means that the astronauts are not really part of the team structure, which puts added pressure on the coordination between members of the ground crew, and the precision of their team collaborations. Specifically, pressure is put on team members' situational awareness and shared mental models.

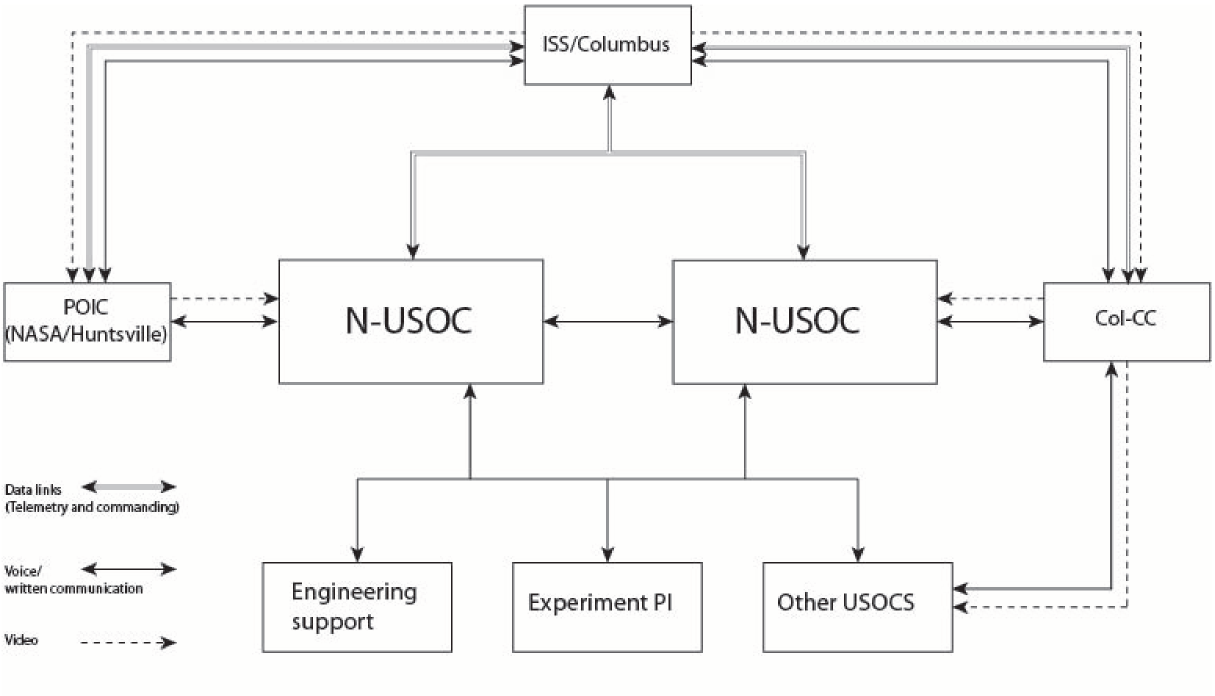
Technical support for the biological equipment EMCS (European Modular Cultivation System) is located in Germany, and they are either consulted by the operators by telephone communication, or physically present at N-USOC, depending on availability of support personnel and complexity of operations. Communication with technical support is reported as being very satisfactory, mainly due to years of cooperation, including regular opportunities for face-to-face meetings, however, it is uncertain whether this sort of positive relationship would still occur if the support personnel should be changed at any point. CRM training could help ensure that this good working relationship is built on and carried on to later instances. Ophof et al. (2013) described the virtual interfaces of the N-USOC control room in the following model (adapted from Ophof et al., 2013).

FIGURE 1:N-USOC INTERFACES




Here we can see the complexity of the information flow between different actors, requiring awareness of several sources of information on many levels, and a great deal of coordination between N-USOC, COL-CC and ISS, as well as technical support and the science community. Although this is an accurate description of the dispersed interfaces of the N-USOC as a unit, it does not capture all of the complexity in the teamwork involved. During peak activity periods, there are often two N-USOC operators in the control room, one communicating with the NASA side, and the other communicating with the ESA side. In addition, there is sometimes technical support physically present during demanding operations. Taken together, these circumstances add another level of communication, complicating the teamwork process.

FIGURE 2: THE TWO OPERATOR INTERFACES




This has some implications for the teamwork challenges involved. On the positive side, both the lack of task-related support from co-workers, and the increased workload caused by the multitude of information channels (discussed below), is mitigated by the presence of another operator. Added team support, both in the sense of having someone to ask for help, and in the sense of more supportive behaviors among team members, carry the important added benefit of improving the psychosocial work environment, according to the demand-control-support model, thereby, among other things, reducing the perceived work stress by more than the degree expected from the simple workload sharing (Karasek & Theorell, 1990)

However, some novel challenges may arise in the communication between the collocated team members, mainly connected to the information transfer and situational awareness between the two operators. Altogether, these two contexts might be seen as two separate situations with separate challenges, both of which should be addressed in training.

## 3.3 Lessons learned from collected data

While quantifying and reporting human, as well as technical, errors has become something of a priority in major NASA projects in recent years, the USOCs, being classified as payload developers, do not have to conform to the same standards. Therefore, only technical certifications are necessary in order to satisfy NASA demands, mainly because the equipment controlled by N-USOC is not regarded as a potential threat to ISS safety. Because of this, the reporting of human errors alongside the technical errors is something of a recent initiative at CIRiS. Surveying a total of 36 experienced USOC operators – about a third of the total number of experienced operators – as part of a larger effort to develop a model of human dependability in space flight, Ophof et al. (2012) found a number of significant causes of human error among USOC operators (Ophof et al., 2012):

1. Parallel tasks
2. Simple, repetitious tasks
3. Lack of domain knowledge on other systems
4. Long hours
5. Teleconferences on console
6. Lack of team support

One of the more surprising conclusions of this survey is the decision that cross-cultural factors are not a valid source of human error for USOC operators. This is surprising because, as previously mentioned, this has been established as a source of error for ESA ground crew in general, and has a solid theoretical foundation (Hofstede, 1983; Sandal & Manzey, 2009). Also, some differences in communication between NASA and ESA team members were reported by N-USOC operators, the NASA operators being labeled as both more hierarchical and more problem solving than their ESA counterparts. One explanation for this discrepancy could be that the number of involved operators in USOC operations is small enough that these differences are leveled out by a higher level of personal relations between the operators. Also, the ESA ground crew surveyed in Sandal and Manzey's (2009) study collaborated with the Russian, Chinese and Japanese space agencies as well as European and American operators, something that would have had an impact on the conclusion (Sandal & Manzey, 2009).

While not all of the sources validated by the survey are within the scope of CRM training, there are a number of ways in which CRM training could mitigate these sources of error. The workload management module could have beneficial effects on the high/low workload-related issues of point 1 and 2, and though the lack of team support in point 6, in this study, was discussed as an administrative issue of having support at all available on console, the communication CRM module would typically encourage and increase mutual performance monitoring and backup behaviors, increasing the likelihood of colleagues recognizing situations that could lead to an increased need of support.

## 3.4 Mitigating circumstances

### 3.4.1 The voice link GUI

The graphical user interface of the voice link system lets the operators monitor the general communication between virtual team members, giving a good overview, and preventing workload problems through informing on whether team members are occupied at any given point. Also, it is reported to be a useful tool when two operators are on console at the same time, giving one operator the option of glancing over at the colleague's screen to check availability before communicating. This kind of awareness technology is regarded as a very useful tool in virtual teamwork (Hinds & Bailey, 2003), mitigating threats to good CRM in a number of ways. Generally, it increases situational awareness on every level, alleviating some of the challenges posed by the complexity of the USOC interfacing. Also, it helps avoid the cross-talk that was identified as a major distraction by USOC crew (Ophof et al., 2012), and allows for mutual performance monitoring and backup behaviors.

### 3.4.2 Personal relations

The small number of N-USOC operators, taken together with the, perhaps typically Scandinavian, flat and informal structure means that the operators are well equipped to develop good personal relations, something that is helpful both in collocated teamwork and the handover phases. The challenges would thus be expected to be mostly in the virtual part of the team collaboration.

One of the major threats of virtual teamwork is the impersonality of communication that does not involve face-to-face contact. This threat is dependent on the 'degree of virtuality', or the lack of richness of the virtual teamwork. The ad-hoc structure and low richness of the N-USOC virtual interfaces are not, in this capacity, especially conducive to good teamwork. However, for experienced operators, the number of people involved is not so great as to preclude the possibility of regular contact with recurring team members. While fresh operators may find other NASA or ESA operators a bit curt or strict – possibly simply due to communication standard operating procedures (SOPs) – they soon build personal relations with their virtual counterparts, leading to some personal communication over the voice link. This, and the opportunity to meet other operators face to face at courses and meetings, does a lot to avoid unhelpful task and affective conflict in the virtual teamwork. These reports from operators are in line with theoretical findings in virtual teamwork, and serve to underline the potential gains by simply gathering USOC, technical support, COL-CC and POIC operators for regular face-to-face contact.

### 3.4.3 Procedures

Despite the difference between central NASA and ESA standards and the standards expected from payload developers like the USOCs, the space flight domain in general remains highly proceduralized, with strict standard operating procedures surrounding virtually every part of the team collaborations. These SOPs and the use of shared tools and systems help build a shared context that helps team members share mental models and coordinate their efforts in a predictable way. Also, work taking place at the ISS is structured after the local circadian rhythm at the space station, and the recurring loss of signal periods, which are visualized on the user interface for all operators everywhere. Relating to a shared time frame helps mitigate teamwork challenges posed by different geographical locations and circadian rhythms (Hinds & Bailey, 2003). On a local level, the sharing of responsibility and rotating of the coordination tasks helps the N-USOC operators increase their shared knowledge of their colleagues' workload, helping their workload management, mutual performance monitoring and backup behaviors as a team.

# Chapter 4: Preliminary recommendations for CRM training in N-USOC

## 4.1 Course content

### 4.1.1 Theoretical perspective

From a theoretical perspective, the definition and organization of the team gives us some relevant pointers. While general teamwork literature, not surprisingly, provides support for including the entire set of CRM modules, the N-USOC's mostly ad-hoc and virtual interfaces mean that research on these aspects of teamwork can give priority to some CRM modules over others. Firstly, the main overarching threat to virtual teamwork is the level and impact of task, procedural and affective conflict due to its specific attributes, and handling this kind of conflict should be addressed in CRM training.

The geographical dispersion associated with virtual teams mainly threatens the quality of virtual teamwork through a lack of shared context; different cultures, unfamiliar co-workers, different circadian rhythms and different technology. These circumstances, however, are quite well mitigated through the limited size, standardized technology and shared time-frame of the relevant interfaces of N-USOC. Still, the number of possible permutations of the ad-hoc virtual team in any given situation, and the importance of developing a common understanding of situations that arise, gives some weight to the situational awareness topic of CRM training. Also, face to face meetings through regular training sessions helps build mutual trust in the virtual team, which affects all aspects of virtual teamwork.

Technological mediation of virtual teams threatens teamwork by hindering the understanding and synchronicity of communication. Low richness of data limits the amount of subtextual information transferred, and transfer speeds and circadian differences may mean information is not equally available to all team members, leading to team members being 'in the dark' or out of the information loop. Synchronous communication between N-USOC and its interfaces is mainly by voice, which yields quite low richness, but limits the challenges caused by lack of synchronicity. Asynchronous reporting, on the other hand, could be a source of information shortage, depending on when and how reports are written and read, especially when relevant interfaces are not manned 24 hours. Taken together, these circumstances suggest that CRM topics related to communication behaviors, team coordination and standard operating procedures connected to asynchronous communication should be weighted.

Cross-cultural issues affecting teamwork are connected to a lack of understanding and agreement between operators, both word for word and regarding motives, hierarchical matters and methodological preferences. These issues are not reported to be a major challenge in this specific context at this point; again, the size and scope of N-USOC operations, and the standard communication procedures used possibly cancels out the potential challenges posed by cross-cultural issues. However, should circumstances arise that complicate this area, e.g. by including other, unfamiliar actors in an operation, experience from similar work shows that it could potentially become an issue, and so it should not be excluded from CRM training, although not made a special priority.

Summarizing, then, from a theoretical perspective many CRM topics could be relevant for this virtual team context. Comparing with the list of CRM topics presented in 1.3.2, many of the detailed topics are covered, and one (Coordination) is added in the 'Leadership' module based on the theoretical findings.

TABLE 2: THE THEORETICAL PERSPECTIVE

| **Core CRM modules** | **Detailed topics** |
|---|---|
| Team work | Teamwork & Support |
| | Culture: National, Professional, Organizational |
| Leadership | Leadership |
| | Conflict management |
| | Risk management |
| | Coordination |
| | Standard operating procedures |
| Situational awareness | Situational awareness |
| | Cognition-memory |
| Decision making | Decision making |
| | Judgment |
| Communication | Communication |
| | Assertiveness |
| Personal limitations | Workload management |
| | Distractions |
| | Automation |

#### 4.1.2 Empirical perspective

From a data-driven perspective, the general virtual, ad hoc teamwork situation is at the root of the theoretically based recommendations, and so only serves to ground the importance of those in empirical data. There are, however, some specific attributes of N-USOC's working context that warrant additional attention.

In a one operator situation, the main challenges of N-USOC control room work are connected to a multitude of information sources and parallel tasks, combined with and aggravated by a lack of available support on console. What this means is that the operator has a greater individual responsibility for monitoring and assessing the situation, which increases demands on situational awareness, judgment and decision making, and also makes good management of both high and low workloads crucial. The corresponding CRM topics should thus be covered in training.

In a two operator situation, some of the major challenges of the one operator situation are mitigated by the added support and shared workload, specifically, the individual aspects of situational awareness, judgment and decision making are not that crucial. However, the added collocated team member does mean an increased layer of communication, and increased risk of cross-talk and distractions. Also, assessing the situation, the two operators need to make sure that they share their views of the situations, in order to effectively make decisions. Thus, CRM training should cover communication aspects, shared situational awareness and managing distractions to effectively improve on this situation.

Empirical findings, then, point to several factors within the situational awareness, decision making, communication and personal limitations modules, many of which were not covered by the theoretical perspective. This is not to say that neither the theoretical nor the empirical findings are invalid, rather to underline that CRM training does need to be adapted to its specific context.

TABLE 3: THE EMPIRICAL PERSPECTIVE

| **Core CRM modules** | **Detailed topics** |
|---|---|
| Team work | Teamwork & Support |
| | Culture: National, Professional, Organizational |
| Leadership | Leadership |
| | Conflict management |
| | Risk management |
| | Coordination |
| | SOPs |
| Situational awareness | Situational awareness |
| | Cognition-memory |
| Decision making | Decision making |
| | Judgment |
| Communication | Communication |
| | Assertiveness |
| Personal limitations | Workload management |
| | Distractions |
| | Automation |

#### 4.1.3 CRM topics for N-USOC

Summed up, then, both theoretical and empirical findings point to situational awareness, communication and workload management as the most relevant CRM topics to be covered by a customized training course for N-USOC operators. This conclusion mirrors the findings in Ophof et al. (2012), and is also in line with the CRM topics that were initially identified as most interesting by CIRiS employees. However, preliminary findings point to training needs within all core modules of CRM, which is in line with general CRM recommendations and teamwork literature.

TABLE 4: EMERGING CRM TOPICS FOR N-USOC

| **Core CRM modules** | **Detailed CRM topics** |
|---|---|
| Teamwork | Teamwork and support |
| | Culture: National, Professional, Organizational |
| Leadership | Conflict Management |
| | Coordination |
| | Standard operating procedures |
| Situational awareness | Situational awareness |
| Decision making | Decision processes |
| | Judgement |
| Communication | Communication practices |
| Personal limitations | Workload management |
| | Distractions |

While these are the CRM topics that have emerged from this preliminary literature review and domain familiarization, this does not necessarily mean that they represent a comprehensive and prioritized list of what should be covered in CRM training. Specifically, from a 'best practice' perspective, the dimension of risk management is integral to the very idea of crew resource management, and as such, it should be an important part of any CRM training intervention.

While the objective of this report was to give a broad overview of relevant 'detailed' CRM topics within the core CRM modules, the content of an initial CRM training session needs to be developed and specified in even more detail, something that is without the scope of this report. Looking at a recent example from the related offshore industry, Maersk presented a CRM training program for team-based well control, specifying the relevant topics to domain-specific work areas, e.g. 'experts on shore' under 'Teamwork and support', 'asking/listening techniques' under 'Communication', and 'identifying weak signals' under 'Situational awareness' (Hviid, 2013). This is an example of the level of detail needed for a properly customized CRM training course, and it needs to rest on the specific needs of the crew and the job content involved.

## 4.2 Participants

From a theoretical perspective, gathering virtual team members physically on a regular basis has a number of healthy effects. In terms of crew resource management skills, gathering actual team members will provide the best and most realistic opportunities for learning, and so probably will yield the best results. However, there are added benefits of meeting face to face for virtual team members, most importantly inducing mutual trust, thus mitigating many of the negative and resource-consuming conflicts that hinder virtual teamwork. The positive impact of face-to-face meetings with distributed team members was also reported by operators, and is mirrored by the excellent current working relationship with technical support. Also, the recurrence of such sessions, perhaps connected to impending major projects, could help give rhythm to the virtual teamwork.

This is, of course, not to say that all involved parties need to be gathered for joint training sessions, rather that such training sessions should ideally involve personnel across the relevant interfaces for maximum effect. Given the ad-hoc nature of the team collaboration, N-USOC teams are very unlikely to achieve any temporal stability as a whole, at an organizational level however, increased shared context and understanding, along with generally improved personal relations, should have a substantial 'extra-curricular' effect.

## 4.3 Duration and repetition

As previously mentioned, continued support for CRM training by users and management both is important to the results of training, on every level. Thus, CRM training should be undertaken with a reasonably long time frame in mind, three to five years have been suggested (Heemstra, 2013; Wahlstrøm et al., 2013), taking the time to customize and adapt the training program to the context, delivering the initial training to all relevant personnel, and planning ahead for recurring refresher sessions. As for the extent of the initial and refresher training sessions, and the frequency of recurring refreshers, this is connected to the depth of CRM training that is deemed required. Initial training could last from one up to three full days, as could refresher training, although it is probably bound to be shorter and more practically oriented, and the frequency of refreshers could be from six to eighteen months, tentatively. A good practice would be to survey operators after the initial training session with a CMAQ-related instrument to assess the demand for refresher training (Heemstra, 2013; Wahlstrøm et al., 2013).

## 4.4 Evaluation

A common question with CRM training is how to evaluate the impact of the training, in terms of attitudes towards, and knowledge about, threat and error management, in terms of observable CRM behaviors, or in terms of a measurable decline in human errors causing incidents or accidents during operations. According to Salas (2001, 2006), evaluation should be done on all these levels, in order to have a complete picture of the effect of CRM training (Salas et al., 2001; Salas et al., 2006). Employing questionnaires, e.g. adaptations of the CMAQ, to assess the impact of training on CRM attitudes and consciousness, along with similar tools to evaluate the gain of CRM knowledge, is an important step in order to verify the usefulness of CRM training, and to adjust the content and delivery of initial training for refreshers and later courses.

While improved CRM knowledge and attitudes is, from experience, a quite certain outcome of well-supported CRM training, the effect on daily working behaviors is arguably a more interesting measure of the worthwhileness of CRM training. In order to achieve this, there is a need of a valid and reliable instrument for observing and quantifying the CRM behaviors of N-USOC operators. In the aviation and healthcare domains, especially, the NOTECHS scale is currently the preferred framework for assessing such behaviors. Revising and adapting the NOTECHS scale to be used in USOC operations does mean that research must be undertaken to uncover specifically which CRM skills are most relevant to operations, and how these skills are manifested through behavior both in normal operations and simulated scenarios. The upshot of conducting this research is not only, eventually, a valid and reliable way of assessing specific training needs, but also a body of domain-specific research, expanding and improving this limited preliminary work, that could help guide future CRM training for USOC operators.

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# INVITASJON

# Human Factors in Control

10.-11. april 2013

## Team dynamics in critical situations – Crew Resource Management (CRM) and other approaches

Kjære deltaker
Vi vil med dette invitere til møte i HFC-forum (Human Factors in Control). Møtet holdes onsdag 10. og torsdag 11.april 2013 i Bergen, hos Rica Hotel Bergen. Vi starter kl 11.00 onsdag med lunsj og avslutter etter lunsj på torsdag, med et praktisk kurs i hvordan innføre CRM trening.

Tema for møtet er " *Team dynamics in critical situations – Crew Resource Management (CRM) and other approaches* " hvor vi diskuterer team interaksjon og samspill i kritiske situasjoner. Hva gjøres innen olje og gass, hvilke erfaringer kan vi hente fra andre industrier? Innen luftfart er CRM obligatorisk trening. HSE i Storbritannia har laget en rapport om bruk av CRM – se www.hse.gov.uk/research/rrpdf/rr061.pdf International Oil and Gas Producers Association (OGP) vil nå anbefale bruk av CRM trening innen boring. Vi får også høre om hvordan ca. 30 installasjoner blir styrt fra land, hvorav tre er bemannet og har eget kontrollrom. Vi har lagt opp til en "workshop" på slutten av møtet med tema *"Implementing a CRM Course in your area of Operations".* Vi har innlegg fra USA/John Hopkins University, UiB, Vision Monitor Aviation, DnV/Kystverket, SINTEF, CHC Helikopter Service, ErgoS Ergonomics, Ship Modelling & Simulation Centre, Maersk Boring og Flight Training College/Emirates.

Vi har reservert rom på Rica Hotel Bergen, Christiesgt. 5-7, tlf: 55 36 29 00, kode 14200954. Frist for rombestilling er den 25/3. Vi kan også bestille rom for dere – kryss da av på siste side.

### Programmet i grove trekk

Foredrag holdes bl.a. av: M. Rosen (USA): "Managing team dynamics in routine and crisis situations: Evidence-based strategies"; Bjørn Sætrevik/UiB: "Shared knowledge in second-line emergency handling teams"; Ruud N. Pikaar: "HF Case studies - On-shore supervision of off-shore gas production"; Anne Wahlstrøm (DnV) og Kystverket: "Å utvikle et CRM-kurs: Erfaringer fra et prosjekt med Kystverket"; Morten Ydalus fra Vision Monitor Aviation, Stig Ole Johnsen fra SINTEF, Glenn Christiansen (CHC), Ship Modelling & Simulation Centre og Lars Bagger Hviid fra Maersk Boring.

### Visjon og hovedoppgave for HFC forumet

HFC visjon: "Kompetanseforum for bruk av HF innen samhandling, styring og overvåkning i olje og gass-virksomheten." HFC hovedoppgave: "Å være et forum for erfaringsoverføring som bidrar til å videreutvikle HF metoder til bruk ved design og vurdering av driftskonsepter." (Om HFC, se: www.hfc.sintef.no)
Vi vil også benytte anledningen til å minne om kurset "MTO-Human factors" ved UiS som går høsten 2013, og NTNU kurset "Introduksjon til Human Factors, metoder og teorier med eksempler fra integrerte operasjoner" som arrangeres våren 2013 - 5,6,7 februar; 11,12,13,14 mars; 9,10,11 april, se videre.ntnu.no, http://videre.ntnu.no/link/nv13119.

Vennlig hilsen
Arne Jarl Ringstad /Statoil, Andreas Bye /IFE, Mark Green /HCD, Koen van de Merwe /DNV og Stig Ole Johnsen /SINTEF.

**Vær vennlig og returner registreringen innen 25.mars 2013 til:**
Rigmor.Skjetne@sintef.no, SINTEF

# AGENDA

# HFC Møte

10. til 11. april 2013

## Team dynamics in critical situations – Crew Resource Management (CRM) and other approaches

Rica Hotel Bergen, Christiesgt. 5-7

| Dag 1 | Innlegg og diskusjon | Ansvar |
|---|---|---|
| 11.00-12.00 | Lunsj. | |
| 12.00-12.30 | Velkommen til seminaret og runde rundt bordet<br>(m/ Informasjon om OGP´s planer for CRM trening) | |
| 12.30-13.15 | Managing team dynamics in routine and crisis situations: Evidence-based strategies | M. Rosen/ JHMI |
| 13.15-13.30 | Diskusjon og pause | |
| 13.30-14.00 | Shared knowledge in second-line emergency handling teams | B. Sætrevik/ UiB |
| 14.00-14.30 | Diskusjon og pause | |
| 14.30-15.00 | Evolution of CRM in aviation | M. Ydalus/ Vision Monitor Aviation |
| 15.00-15.30 | Diskusjon og pause | |
| 15.30-16.00 | Å utvikle et CRM-kurs: Erfaringer fra et prosjekt med Kystverket | A. Wahlstrøm /DnV Kystverket |
| 16.00-16.15 | Diskusjon og pause | |
| 16.15-16.45 | CRIOP med CRM fra 2004 – bakgrunn og erfaringer fra bruk (Case: boring, integrerte operasjoner) | S.O. Johnsen/ SINTEF |
| 16.45-17.15 | Diskusjon og pause | |
| 17.15-17.45 | Crew communication in critical phases of flight | G. Christiansen/ CHC |
| 17.45-18.00 | Diskusjon og pause. | |
| 19.30- | Middag - | |

| Dag 2 | Innlegg og diskusjon | Ansvar |
|---|---|---|
| 08.30-09.00 | Kaffe og noe å bite i | |
| 09.00-09.45 | HF Case studies - On-shore supervision of off-shore gas production | R. Pikaar/ ErgoS. |
| 09.45-10.00 | Diskusjon og pause | |
| 10.00-10.30 | CRM brukt i skipshåndtering | S. Dahle/ SMSC |
| 10.30-10.45 | Diskusjon og pause. | |
| 10.45-11.15 | Bruk av CRM trening – praktiske erfaringer | L.B.Hviid/Maersk Boring |
| 11.15-12.00 | Diskusjon og pause. | |
| 12.00-12.30 | Introduksjon til Workshop – "Implementing a CRM Course in your area of Operations". | L. R. Heemstra/ Emirates Airline |
| 12.30-13.15 | Lunsj | |
| 13.15-15.00 | Workshop : Implementing a CRM Course in your area of Operations<br>(Discussing threats, errors and CRM issues - leadership, communication, team dynamics, risk assessment, decision making, situational awareness, fatigue..) | L. R. Heemstra/ Emirates Airline |

# REGISTRERING

# Human Factors in Control

10. til 11. april
2 0 1 3

## Team dynamics in critical situations – Crew Resource Management (CRM) and other approaches

Ja, jeg vil gjerne delta:

Navn: __ ____________________________________

Tittel / stilling: ____ _________________________________

Organisasjon: ___ __________________________________

Adresse: __ ____________________________________

Kryss av for:

__ Lunsj 10/4, __ Middag 11/4, __ HFC bestiller hotellrom for meg 10/4 __ Lunsj 11/4

Tlf. : __________

E-post: _______________

Hvem faktureres (PO-Nr/Bestillingsnr/Referansenr: )___________________

For å være med må man betale inn medlemsavgift eller møteavgift, som dekker lunsj, middag og kopi av presentasjonene som holdes samt annet relevant materiale.

Medlemsavgiften er pr år:

- 25.000 for bedrifter med mer enn 15 ansatte (dekker 3 deltakere på årets to møter)
- 12.500 for bedrifter med under 15 ansatte (dekker 2 deltakere på årets to møter)

Møteavgiften er pr møte:

- 6.500 kr pr møte for ikke-medlemmer (dekker 1 deltakere på ett møte)

Medlemsavtale, informasjon og publikasjoner om HFC kan finnes på WEB-siden:
http://www.hfc.sintef.no

**Vær vennlig og returner registreringen innen 25.mars 2013 til:**
Rigmor.Skjetne@sintef.no, SINTEF