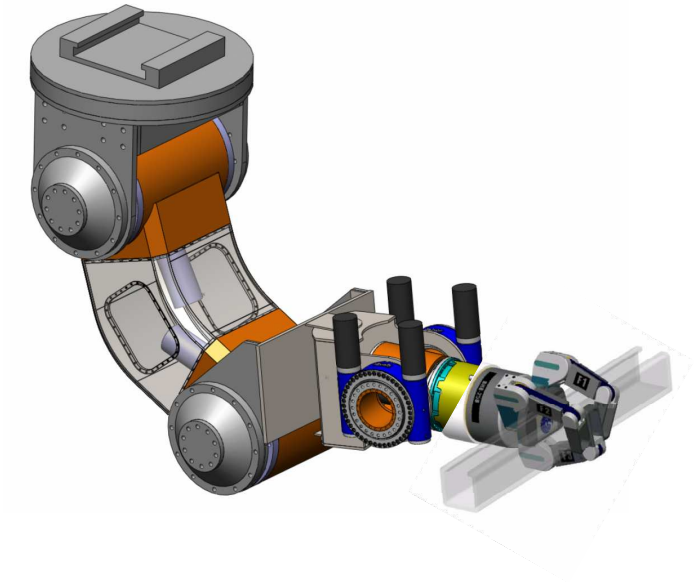
# *105 THH – Handy Hand*



| | | |
|---|---|---|
| | | |
| 02 | Updated with comments from meeting @ Stanford Nov 2009.<br>- Only requirements are updated<br>- Energid attended the meeting | 03 Nov 2009 |
| 01 | - Updated with comments from meeting between Stanford and Seabed Rig Dec 2008. Marked red<br>- New items marked red<br>- Restructure of document. Internal | 14 Jan 2009 |
| | Comments by Mark Cutkosky | 24 Nov 2008 |
| 00A | Draft – As working document for workshop | 11 Nov 2008 |
| **Rev** | **Reason for issue** | **Date** |

# Index

# 1 Introduction

## 1.1 Scope

This document specifies the functional requirements for the Handy Hand, a multipurpose subsea robot hand. This document presents some possible solutions but these should not be construed to limit the creativity of the developers.

The Handy Hand shall be a tool that the SBR robot is able to pick up from a known location and use to perform a number of operations, of which some may be predefined and others are unknown prior to task execution.

The Handy Hand's capability shall in general be as close to a human hand as possible giving the robot maximum flexibility in using the hand. The emphasis is on human hand function, not morphology.

**The Prototype**
As a first step, a prototype of the hand shall be designed and fabricated. This prototype should show the functional possibilities of a Handy Hand but is not expected to be ready for production. The prototype shall be presented for Approval of Concept (See chapter 5 Test & Approval).

The prototype may be a scaled down version in size/performance to make it possible for Stanford to design and produce the prototype within the Stanford facilities. Stanford will evaluate the best solution for this.

The prototype may be scaled down but the documentation for making a full scaled Handy Hand must be presented. It will be Seabed Rig's responsibility to produce the full scaled Handy Hand.

There will be 3 versions of the Handy Hand;

- V0.1 - 'Christmas' version - the first prototype for internal 'teaser' demo
- V0.2 - 'Easter' version – second prototype for internal full scale test
- V1.0 '4$^{th}$ of July' version - Release version for the ONS2010 exhibition

## 1.2 References

### 1.2.1 Definitions

| Expression | Explanation |
|---|---|
| Robot | Seabed Rig's handling robot located in the Robotic Drill Floor Module. |
| Handy Hand | Popular name for the tool to be attached on the robots tool interface (wrist) |
| Surveillance System | The Robotic Drill Floor Modules Surveillance system for measurement of the dynamic 3D environment. The system should be able to present shape and position information to any tool/equipment that may require so. |
| Stanford | Short for Stanford University |
| | |
| | |

### 1.2.2 Abbreviations

| Abbreviation | Explanation |
|---|---|
| SBR | Seabed Rig AS |
| | |

### 1.2.3 Reference documents

| Document id | Note |
|---|---|
| "Development of Seabed Drilling Rig, Cooperation with universities" | Document used between Stanford University and Seabed Rig to realize the cooperation. |
| SBR-100000 RQS – Seabed Rig | Requirement Specification for the complete Seabed Drilling Rig |
| SBR - Phase 2 schedule.mpp | The project schedule<br>X:\4 SBR Products\1 SBR Drilling rig\2 Plan & Reports\Plans |

### 1.2.4 Applicable standards

| Document id | Note |
|---|---|
| NORSOK, D-001 Drilling Facilities | |
| ATEX 95 equipment, Directive 94/4/EC - | (Equipment and protective systems intended for use in potentially explosive atmospheres )<br>For conventional rig version (in air) |
| | |
| | |

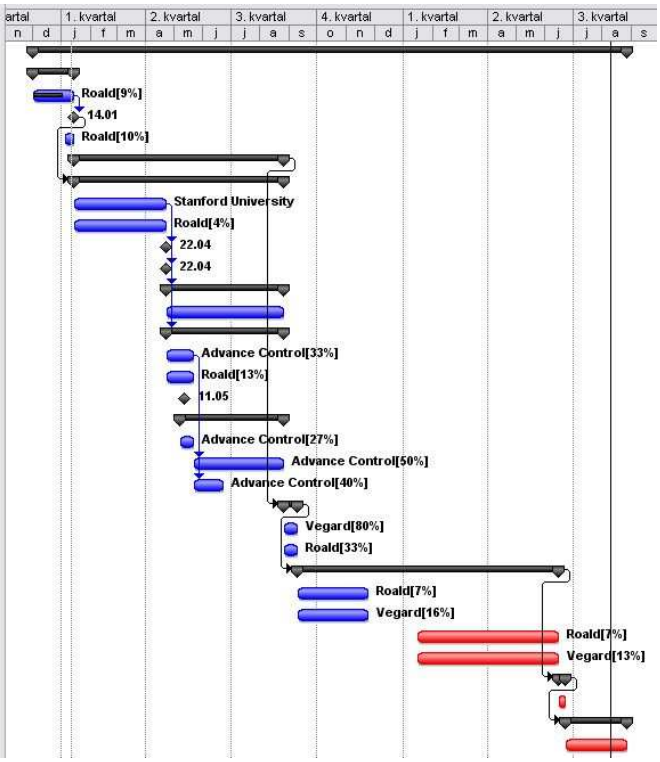
# 2 Administration

Please refer to document “Development of Seabed Drilling Rig, Cooperation with universities” for any administration issues other than the following;

## 2.1 Plan & Progress

The following guidelines are to be used (also see 1.2.3 Reference documents);

| Aktivitetsnavn | Start | Slutt |
|---|---|---|
| **105 THH - Tool Handy Hand** | **ma 01.12.08** | **fr 27.08.10** |
| **105 THH - Concept** | **ma 01.12.08** | **on 14.01.09** |
| 105 THH - Concept | ma 01.12.08 | on 14.01.09 |
| 105 THH - Design Freeze | on 14.01.09 | on 14.01.09 |
| 105 THH - Release - RQS Doc | ma 05.01.09 | on 14.01.09 |
| **105 THH - Engineering & Purchase/Production** | **on 14.01.09** | **ti 25.08.09** |
| **105 THH - Eng & Pur/Prod** | **on 14.01.09** | **ti 25.08.09** |
| 105 THH - Engineering | on 14.01.09 | on 22.04.09 |
| 105 THH - Engineering | on 14.01.09 | on 22.04.09 |
| 105 THH - Design Review - MEC | on 22.04.09 | on 22.04.09 |
| 105 THH - 3D Model data - Release | on 22.04.09 | on 22.04.09 |
| **Purchase/Production (P/P)** | **on 22.04.09** | **ti 25.08.09** |
| 105 THH - P/P - Component #1 | on 22.04.09 | ti 25.08.09 |
| **105 THH - SW - Eng & Programming** | **on 22.04.09** | **ti 25.08.09** |
| 105 THH - Engineering | on 22.04.09 | to 21.05.09 |
| 105 THH - Engineering | on 22.04.09 | to 21.05.09 |
| 105 THH - Design Review - SW | ma 11.05.09 | ma 11.05.09 |
| **Programming** | **to 07.05.09** | **ti 25.08.09** |
| 105 THH - PROG - Implement 3D mod | to 07.05.09 | to 21.05.09 |
| 105 THH - PROG - Component #2 | to 21.05.09 | ti 25.08.09 |
| 105 THH - FDS Doc completion | to 21.05.09 | ma 22.06.09 |
| **105 THH - Assembly @ SBR** | **ti 25.08.09** | **on 09.09.09** |
| 105 THH - Assembly | ti 25.08.09 | on 09.09.09 |
| 105 THH - Test doc | ti 25.08.09 | on 09.09.09 |
| **105 THH - Internal Tests & Tuning @ SBR** | **on 09.09.09** | **ti 15.06.10** |
| 105 THH - Internal Test & Tuning | on 09.09.09 | ma 23.11.09 |
| 105 THH - Internal Test & Tuning | on 09.09.09 | ma 23.11.09 |
| 105 THH - Internal Test & Tuning on Robot | fr 15.01.10 | ti 15.06.10 |
| 105 THH - Internal Test & Tuning on Robot | fr 15.01.10 | ti 15.06.10 |
| **105 THH - Demo/FAT @ SBR** | **ti 15.06.10** | **ti 22.06.10** |
| 105 THH - Demo/FAT | ti 15.06.10 | ti 22.06.10 |
| **105 THH - Release&Report @ SBR** | **ti 22.06.10** | **fr 27.08.10** |
| 105 THH - Release & Report | ti 22.06.10 | fr 27.08.10 |




## 2.2 Cost

Please refer to document “Development of Seabed Drilling Rig, Cooperation with universities” for Cost issues.

## 2.3 Resources

The following resources have been appointed to join the project from idea through design, building and testing of the prototype;

- Seabed Rig. Overall project management
- Stanford University. Main responsible for the Handy Hand development including design, mechanical, electrical and software.
- Advanced Control. Responsible for the Seabed rig control system and robot software. Will be responsible for the software/communication towards the Handy Hand.
- Innova. Responsible for the physical interface towards the Handy Hand.

# 3 General Design Requirements

## 3.1 Temperature

| Situation | Temp. range °C | Status |
|---|---|---|
| Storage | -40°C to 40°C | |
| Transportation | -40°C to 40°C | |
| Operation - in water | -1.5°C to 20°C | |
| Operation - in air | -20°C to 40°C | |

## 3.2 Pressure

| Situation | Pres. range bar | Status |
|---|---|---|
| Static Pressure (Operation mode)<br>- 500m water depth | 0 to 50bar | Prototype = 1-2bar |
| Dynamic Pressure (Operation mode)<br>- Simulating water current speed | Static pressure +/- 10% | |
| | | |

## 3.3 Chemical Exposures

| Situation | Pres. range bar | Status |
|---|---|---|
| Water salinity | Max 50 ppt | D091103 RV: freshwater for prototype |
| Add particle sizes (sandblasting effects?) | | |

## 3.4 Design and Safety Factors

| Load Case - LC | Design Factor – DF |
|---|---|
| Tension | TBN |
| Torque | TBN |
| Burst Strength | TBN |
| Collapse Strength | TBN |
| Hydraulic Control line Pressure | TBN |
| Bending | TBN |
| Compression | TBN |

# 4 Requirements

## 4.1 Function Description

The following list describes but does not limit the requirements for the Handy Hand.

## 4.2 Performance Requirements

### 4.2.1 Operations

| Id | Requirement | Status |
|---|---|---|
| A1 | The Handy Hand shall perform but not be limited to predefined operations when attached to the robot. Unknown operations should be a learning input to give the Handy Hand even more predefined operations. | D091103 RV: v1.0 release. The requirement is a requirement for the robots as well. |
| A2 | The Handy Hand may be used by either of the two robots located in the Robotic Drill Floor Module | SW<br>D091103 RV: v0.2 release. RFID may be an alternative solution |
| A3 | The Handy Hand shall be able to operate in potentially explosive atmospheres | Not for prototype |

### 4.2.2 Functions

| Id | Requirement | Status |
|---|---|---|
| B1 | The Handy Hand shall be able to evaluate and make decisions for the next action without dependences from the robot controller. | SW<br>D091103 RV: v0.1 release. The THH and the RO will share the responsibility and functions. This requirement will therefore be partly true only. |
| B2 | The Handy Hand may request the robot controller for information to be used in the decision making process. | SW<br>D091103 RV: v0.1 release. The THH and the RO will share the responsibility and functions. This requirement will therefore be partly true only. |
| B3 | The Handy Hand may request the robot controller to alternate the robot controller's next action. | SW. Weak requirement<br>D091103 RV: v0.1 release. The THH and the RO will share the responsibility and functions. This requirement will therefore be partly true only. |
| B4 | The Handy Hand may request the surveillance system for information to be used in the decision making process. | SW<br>D091103 RV: v1.0 release. The decision making process will be handled by the THH and the RO. |
| | The Handy Hand shall be able to grip and handle objects with the following shapes and characteristics; | |
| B5 | Minimum grip area size is h: 40mm, w: 40mm and d: 40mm or cylinder shapes with diameter ø 40mm. | D091103 RV: v0.1 release. Prototype requirements are decided prior to v0.1 release |

| | | |
|---|---|---|
| B6 | Maximum grip area size is h: 400mm, w: 400mm and d: 400mm or cylinder shapes with diameter ø 400mm | D091103 RV: v0.1 release. Prototype requirements are decided prior to v0.1 release |
| B7 | Minimum weight is 4kg (in air) | D091103 RV: v0.1 release. Prototype requirements are decided prior to v0.1 release |
| B8 | Maximum weight is 200kg (in air) | D091103 RV: v0.1 release. Prototype requirements are decided prior to v0.1 release |
| B9 | The objects structure may be fragile. The gripper shall be able to grip the following without making physical deformations (visual check);<br>- Mento Hydraulic hose type 421SN-20 (http://www.mento.no) | D091103 RV: v0.1 release. Prototype requirements are decided prior to v0.1 release |
| B10 | The object may be round like a ball, a cone, cylindrical or have flat edges like a box | D091103 RV: v0.1 release. |
| B11 | The Handy Hand must be able to evaluate and decide how to grip any objects. The Handy Hand may require help from the operator as a last outcome of an challenge | SW<br>D091103 RV: v0.2 release. This shall not be used in ONS2010 demo. |
| B12 | The Handy Hand must be able to evaluate if the grip is accepted with regards to the possibility to lose control of the object due to weight and the center of gravity or due to a slippery surface | SW<br>D091103 RV: v0.2 release. |
| B13 | The Handy Hand should be able to pick up and use general toolbox tools or adapter(s) for these such as wrenches, screwdrivers, Allen keys, hexagonal keys, file and lubrication cans. | Low priority requirement. Most probably a separate tool for this.<br>D091103 RV: Not applicable for the project. |
| B14 | The Handy Hand should be able to sense forces to determine obstacles (outside sensing) or confirming the location of known objects (inside sensing) | D091103 RV: v0.2 release for the inside sensing and v1.0 release for the outside sensing |

## 4.3 Design Requirements

### 4.3.1 Robot interface (robot wrist)

Innova will be the responsible for designing the robot tool interface (located on the robot). Innova will make the interface by involving Stanford to secure correct design.

| Id | Requirement | Status |
|---|---|---|
| C1 | The Handy Hand shall be picked up by the robot from a known location at a dedicated tool handler/park station.<br>The handy Hand shall be designed to easy storing in handler/park station | D091103 RV: v0.2 release. SBR responsibility as SBR will make tool handler for different tools. |
| C2 | The robot tool interface will include mechanical guidance pins or similar to simplify the docking sequence between the robot and the Handy Hand<br>The Handy hand interface shall be designed to comply with the robot tool interface | D091103 RV: v0.1 release. Already included. |

| | | |
|---|---|---|
| C3 | The robot tool interface will include locking mechanism for securing the Handy Hand from falling of the robot while in use<br><br>The Handy hand interface shall be designed to comply with the robot tool interface | D091103 RV: v0.1 release. Already included. |
| C4 | The robot tool interface will include electrical power supply with the following data:<br>- 24VDC +/-5%<br>- Max 5A<br>- Short Circuit safe<br><br>The Handy hand interface shall be designed to comply with the robot tool interface | May change during 2009.<br><br>D091103 RV: v0.1 release. |
| C5 | The robot tool interface will include hydraulic power supply with the following data;<br>- Minimum 5l/min @ 200bar<br><br>The Handy hand interface shall be designed to comply with the robot tool interface if hydraulic power is required | This is out. Replaced by rotating shaft.<br><br>D091103 RV: v0.1 release. Rotating shaft power; 5kW motor max 3000RPM |
| C6 | Electronics in tool shall be galvanic isolated | D091103 RV: v0.1 release. |
| C7 | Material interfacing the robot tool interface shall be of XXX type. | D091103 RV: v0.1 release. Will only be exposed to freshwater |
| C8 | There must be a method to keep the tool interface clean. Method to be presented.<br>- Cap or flushing... | D091103 RV: v1.0 release. SBR responsibility |

### 4.3.2 Communication

| Id | Requirement | Status |
|---|---|---|
| D1 | The Handy Hand should preferably communicate with the robot and other systems like the surveillance system by use of wireless communication<br><br>NB: Prototype will have other interface. Fibre or on power cables | Not applicable |
| D2 | The communication protocol will be ProfiNET CBA | Not Applicable. See D3 |
| D3 | The communication will be max 120kbps | D091103 RV: v0.1 release. Communication over the inductive coupler shall be the included ethernet communication (10Mbit). Stanford may convert the ethernet to USB or CAN. |

### 4.3.3 Handy Hand shape

| Id | Requirement | Status |
|---|---|---|
| E1 | The Handy Hand should be as small as possible | D091103 RV: v0.1 release. |
| E2 | A 3D model of the Handy Hand shall be presented Seabed Rig as soon as possible no later than start of | D091103 RV: v0.1 release. |

| | | |
|---|---|---|
| | internal testing at Stanford University to be used in Seabed Rigs complete rig simulator. | |

### 4.3.4 Thoughts and ideas

These are inputs to possible solutions and not hard requirements.

| Id | Thoughts and ideas | Status |
|---|---|---|
| | If the Handy Hand will have some sort of fingers; | |
| F1 | Would it be possible to put an electromagnet on one of the fingers for picking up small objects? | |
| F2 | Could one of the fingers be used for handling of the toolbox tools mentioned in 2.b? | |
| F3 | Could one of the fingers have a build in camera for visual use? | |
| F4 | Suction pad for picking up objects? Water pump? | |
| F5 | Local clean water jet for use together with a camera? | |

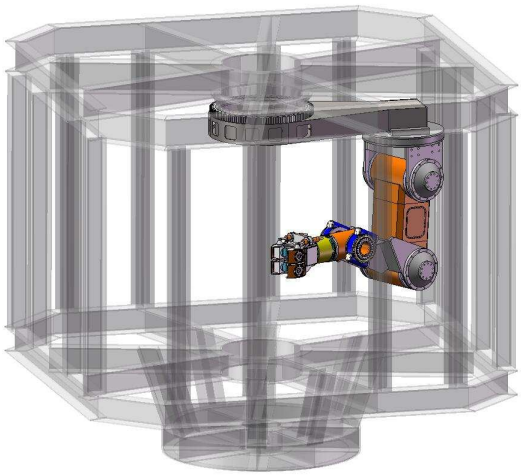
# 5 Test & Approval

Prototype Approval of Concept test criteria

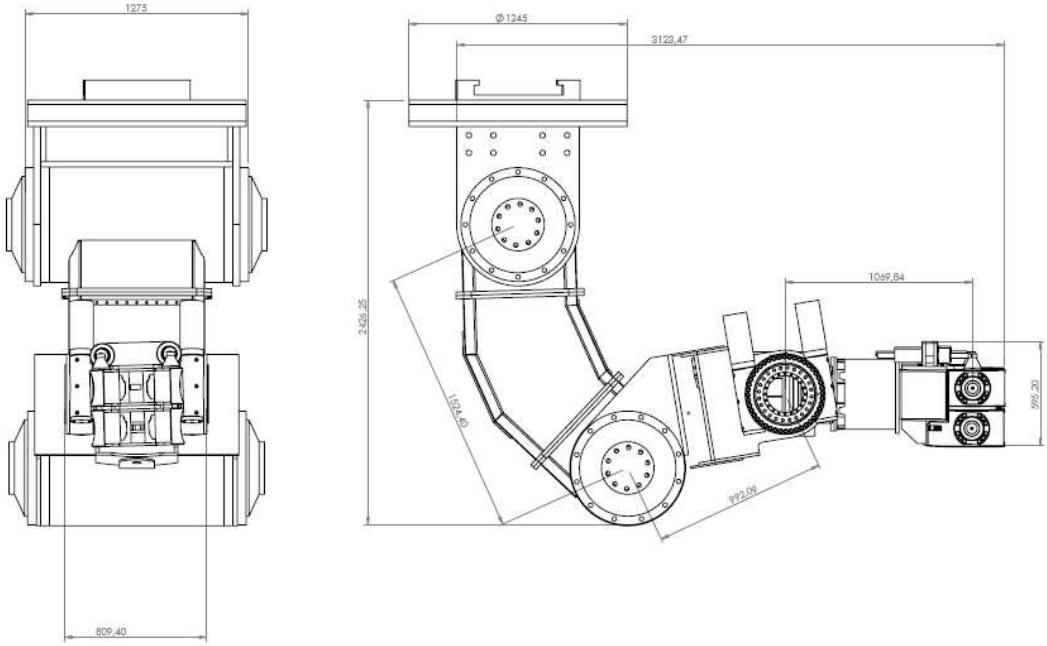
| Id | Test | Acceptance criteria |
|---|---|---|
| G1 | The prototype test will be performed in Stavanger (Norway) whereas Seabed Rig is responsible for the planning and execution of the test. There will be three tests;<br>1. V0.1 release. 'Christmas' version. Jan 2010.<br>2. V0.2 release. 'Easter' version. Apr/may 2010.<br>3. V1.0 release. '4th of July' version. July/Aug 2010.<br>4. | D091103 RV: Change in requirement |
| | The following test sequence shall be used for each of the mentioned object tests;<br>1. Robot with the Handy Hand shall be activated and in stand-by mode/position.<br>2. An object will be identified, at random position and orientation within the robots working range, by use of camera system (or similar)<br>3. The Handy Hand with the robot shall pick up the object and place the object at an instructed location<br>4. Return to stand-by mode/position | D091103 RV: v0.2 release. For v0.1 release the test sequence will be focusing on the THH grasping allowing the robot to follow a pre programmed path to a known and repeatable location |
| G2 | Test object #1: 1,5 meter of a 5" drill pipe (App 60kg) | Place the object at the instructed location<br>D091103 RV: v0.1 release. Weight and length to be decided prior to v0.1 release. |
| G3 | Test object #2: Metal ball placed in a small tank of fresh water. Weight between 5 and 10kg. | Place the object at the instructed location<br>D091103 RV: v0.2 release. v0.1 release will pick up a ball without the tank. The weight of ball to be decided prior to v0.1 release |
| G4 | Test object #3: Metal ball. Size 40mm in diameter<br>NB: Weight might be under minimum requirement | D091103 RV: v0.1 release. The size and weight of ball to be decided prior to v0.1 release |
| G5 | Test object #4: 3m of Mento Hydraulic hose type 421SN-20.<br>NB: Weight might be under minimum requirement | Being able to grip, lift and move gently without physical damages (visual check).<br>No position requirement as the hose is flexible.<br>D091103 RV: v0.2 release. Requires that the RO operates satisfactory |

# 6 References

The reference figures are only presented to show an overview of how the Handy Hand could be used. The figures will be updated as soon as the details have been settled.



**6-1 Working Envelope Overview**




**6-2 Robot Layout**