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Cruise report
FFS „Walther Herwig III" Cruise WH487
25.03. to 16.04.2025

Test and training cruise for fishery and survey technology

Cruise leader: Dr. Andreas Hermann

1. Objectives

The main objectives of the cruise were to train and test new and modified technical equipment for fisheries and survey technology. During regular research cruises, there is often not enough time to test and evaluate new and modified technical equipment on research vessels. For complex equipment such as underwater vehicles (ROVs, ROTV, etc.), there is also a need for regular training for the operating personnel to ensure safe and effective use during regular research cruises.

The focus of this cruise was on testing and training the extensively modified ROTV Triaxus and its installed measurement technology. The aim was to determine the practical maximum undulation range (vertical deflection) and the optimal towing speed for this deployment. Additionally, the Sea Acceptance Test (SAT) was to be conducted according to the manufacturer's specifications, with representatives from the manufacturer MacArtney on board. Another goal was to collect measurement data on the ROTV in different operating conditions (cable lengths, towing speeds, and undulation limits) to determine the neutral depth and performance envelope in relation to these parameters.

Furthermore, underwater recordings of the IKMT with a modified MultiNet were made to validate the settings of the lines and the correct position in the underwater area, as well as recordings of new trawl doors in trawl operation to qualitatively assess their function. Imaging methods used included video recordings, as well as recordings from a 360° sonar and a sidescan sonar.

The depth range of the Triaxus covers depths of up to 400m, so suitable sea areas were targeted. The deep areas in the Skagerrak were used for this purpose. The port of Hirtshals was used for the ascent and descent of guest scientists and employees of the manufacturer, as well as for the reception of spare parts.

2. Overview

The "Walther Herwig III" set sail from Bremerhaven on 25.3.2025 towards the target area in the Skagerrak. On 26.3., additional scientists and representatives of the company MacArtney boarded the ship in Hirtshals. On 27.3., preparations began for the Sea Acceptance Test (SAT) in western winds of force 7. It was found that even in these conditions, the deployment and recovery of the equipment were possible on a windward course. However, the up and down movements of the towing ship in waves of over 2.5m had a significant impact on the towing forces. On 29.3., this led to a break of the Weak-Link and the associated loss of the vehicle at a depth of approximately 200m and at a cable length of 1200m. The vehicle was successfully recovered after an intensive search.

The SAT was conducted, and numerous data were recorded and presented in different operating conditions, as well as the planned investigations on two IKMT plankton nets with and without a MultiSampler. The plankton net tests were performed between the 3.4. and 6.4.2025. The cruise ended at the 7.4.2025 in Bremerhaven. All results will be presented in the report.

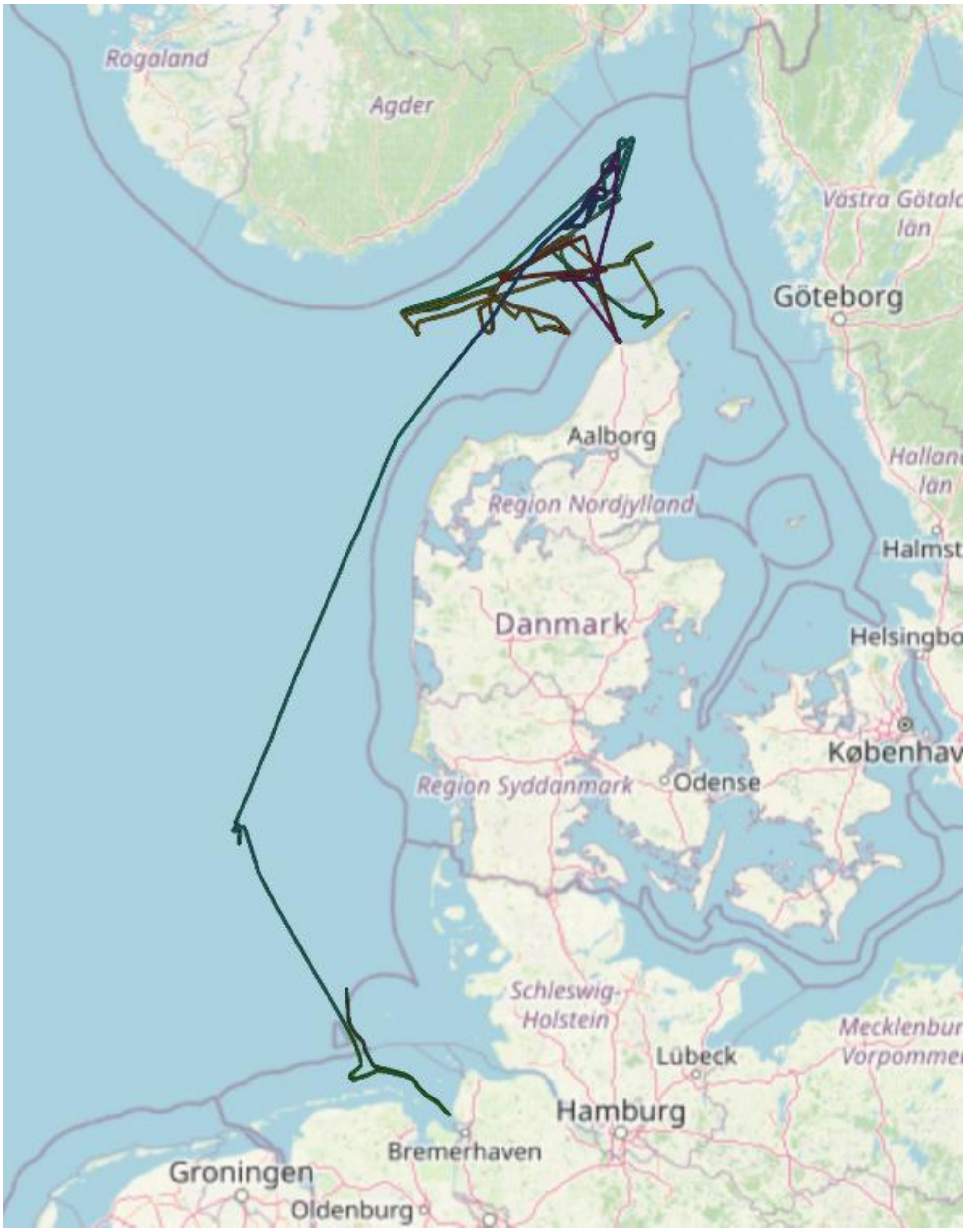

Figure 1: Overview WH487 deployment area and routes

3. Cruise Objectives and Work Areas

Overview of the main cruise objectives:

1. ROTV Triaxus
    a. Improvement of the procedure for deploying and recovering the ROTV. Revision of the pre- and post-dive checklists.

    b. Maneuver training for arming and disarming, maintenance, and repair of components.
    c. Determination of the dependence of the neutral depth of the towed vehicle on the parameters of towing speed and cable length.
    d. Determination of a performance envelope (maximum undulation range) in relation to towing speed and cable length.
2. Hydobios IKMT + Multinet
    a. Revision of rigging specifications (e.g. wire length) and validation of the correct positions of two IKMT nets with and without a HydroBios MultiNet unit.
3. New trawl doors
    a. Inspection of the position of new trawl doors and the revised fishery winches for bottom trawls in trawl operation.

Work areas:
1. Investigations 1 and 2 were conducted in the Skagerrak deployment area.
2. Investigation 3 and parts of investigation 2 were conducted in the German Bight.

3.1 ROTV Triaxus: Sea Acceptance Test (SAT)

3.1.1 Operating Conditions for SAT
The following operating conditions were specified for the Sea Acceptance Test:

1. Undulation 25m-350m depth at 8m/s towing speed and 1m/s vertical speed without active winch
2. Undulation 25m-350m depth at 8m/s towing speed and 1m/s vertical speed with active winch
3. Undulation 25m-400m depth at 10m/s towing speed and 1m/s vertical speed with active winch
4. Seabed following mode: At depths between 100-210m, the vehicle should be controlled to follow the seabed at a distance of 25m.

3.1.2 Result of SAT
The SAT was successfully completed, and all operating conditions were met, but with one limitation: towing speeds above 8 m/s should only be conducted in relatively calm seas. At wind speeds of 6-8 Bft and wave heights of 2-3m, the up and down movements of the ship in the waves caused strong load changes on the vehicle, leading to frequent interruptions of the undulation cycles and once to unstable behavior of the control algorithm, resulting in the break of the weak link of the towed vehicle. The vehicle was lost at a depth of approximately 200m and a cable length of 1200m. Although the recovery concept worked, and the vehicle surfaced as planned, the search was difficult, as the entire cable had to be reeled in before the ship could return to the location of the loss. Additionally, some damage occurred to the vehicle during the loss and recovery, which required a full day of repair.

Figure 2: Stations for ROTV-Triaxus SAT

3.2 Neutral Depths

The neutral depth is the depth to which the towed vehicle moves on its own when the flaps of the vehicle are set to neutral. This depends on both the speed and the length of the towing cable. This is important to know in order to determine the optimal operating conditions for the respective deployment goal. During undulating deployment, the speed and cable length should be chosen such that the neutral depth is as close as possible to the middle of the planned deployment depth range. **WARNING!** During deployment, **the neutral depth must be above the maximum water depth**, otherwise, there is a **risk of ground contact and damage to the vehicle** in case of communication loss. There are two safety settings in case of a communication loss. In one case the flaps set to neutral, the other sets them towards surface movement. When operating the ROTV with cable length beyond the neutral depth requirements the surface option should be chosen.

3.2.1 Neutral Depth over Cable Length

To select suitable cable lengths, the dependence of the neutral depth on the cable length was investigated for two fixed speeds, and the results are presented in diagrams. The behavior appears to be largely linear, so the equations of the linear regression lines are given.

Measurement results at a speed of 5.5kn:

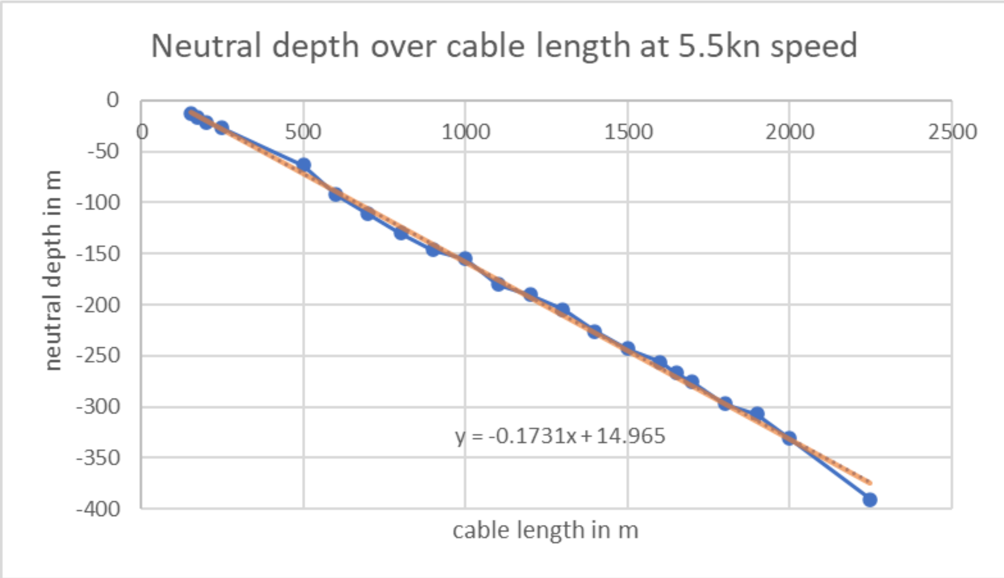

Figure 3: Neutral depth over cable length at 5.5kn speed

The following equation gives the formula of the regression line, which can be used to calculate the neutral depth $d_{neutral}$ for a given cable length l_{cable} at 5.5kn:

$$d_{neutral}(5{,}5kn) = -0{,}173 * l_{cable} + 15 \quad \forall \quad l_{cable} > 155\text{m}$$

The following equation gives the formula of the regression line, which can be used to calculate the required cable length l_{cable} for a desired neutral depth $d_{neutral}$ at 5.5kn:

$$l_{cable}(5{,}5kn) = -5.76 * d_{neutral} - 89 \quad \forall \quad d_{neutral} < -13\text{m}$$

Measurement results at a speed of 8kn:

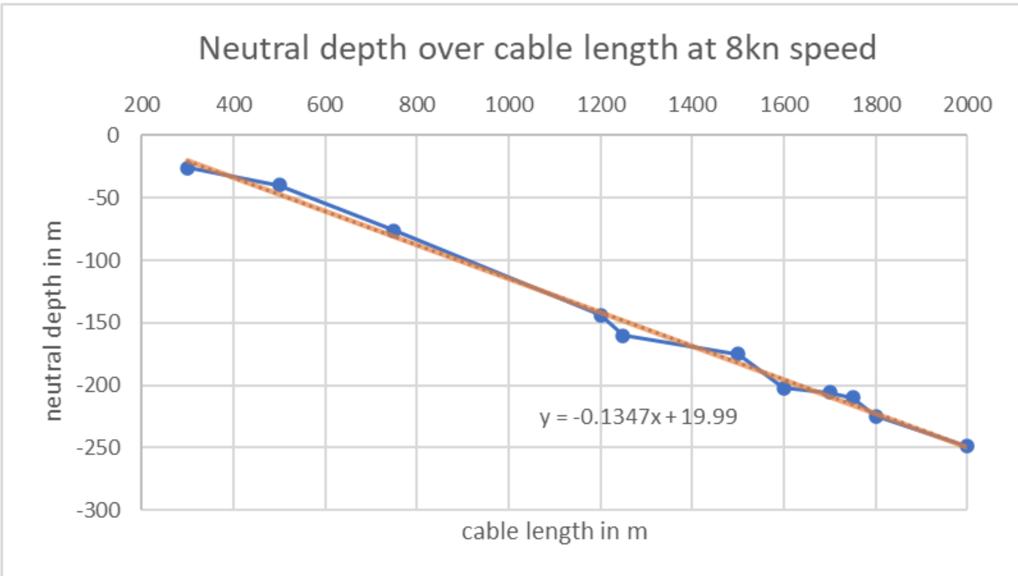

Figure 4: Neutral depth over cable length at 8kn speed

The following equation gives the formula of the regression line, which can be used to calculate the neutral depth d_neutral for a given cable length l_cable bei 8kn:

$$d_{neutral}(8kn) = -0.135 * l_{cable} + 20 \qquad \forall \quad l_{cable} > 250$$

The following equation gives the formula of the regression line, which can be used to calculate the required cable length l_{cable} for a desired neutral depth $d_{neutral}$ at 8kn:

$$l_{cable}(8kn) = -7.37 * d_{neutral} + 156 \qquad \forall \quad d_{neutral} > 25$$

3.2.2 Neutral Depth over Towing Speed

To select suitable cable lengths, the dependence of the neutral depth on the towing speed was investigated for a fixed cable length, and the results are presented in a diagram. The behavior appears to be largely linear, so the equation of the linear regression line is given.

<u>Measurement results at a cable length of 1200m:</u>

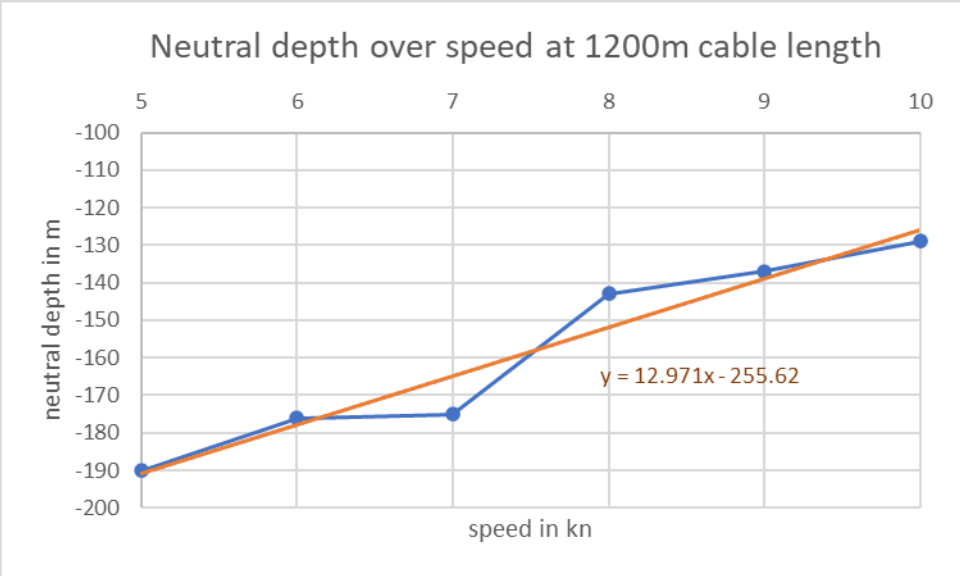

Figure 5: Neutral depth over speed at 1200m cable length

The following equation gives the formula of the regression line, which can be used to calculate the neutral depth $d_{neutral}$ for a given towing speed v_{towed} at 1200m cable length:

$$d_{neutral}(1200m) = 12.97\ \frac{m}{kn} * v_{towed} - 255.6\ \mathrm{m} \qquad \forall \quad v_{towed} > 5\mathrm{kn}$$

The following equation gives the formula of the regression line, which can be used to calculate the required towing speed v_{towed} for a desired neutral depth $d_{neutral}$ at 1200m cable length:

$$v_{towed}(1200m) = 0.0722\ \frac{kn}{m} * d_{neutral} - 18.93\ \mathrm{kn} \qquad \forall \quad d_{neutral} > 130\mathrm{m}$$

3.3 Performance Envelope

The performance envelope describes the maximum and minimum depths that can be reached at a given speed, depending on the cable length. The measured upper and lower turning points were determined for two speeds, and the results are presented in two diagrams. From these, the undulation amplitudes that can be achieved in the respective operating conditions can be determined.

3.3.1 Performance Envelope at 5.5 kn and 8 kn

At a speed of 5.5kn, cable lengths between 175m and 2250m were investigated, and at 8kn, cable lengths between 1250m and 2250m. The following graph shows the minimum and maximum reachable depths for both speeds. As a trend, it is clearly visible that with increasing speed, the reachable maximum depth decreases significantly for shorter cable lengths.

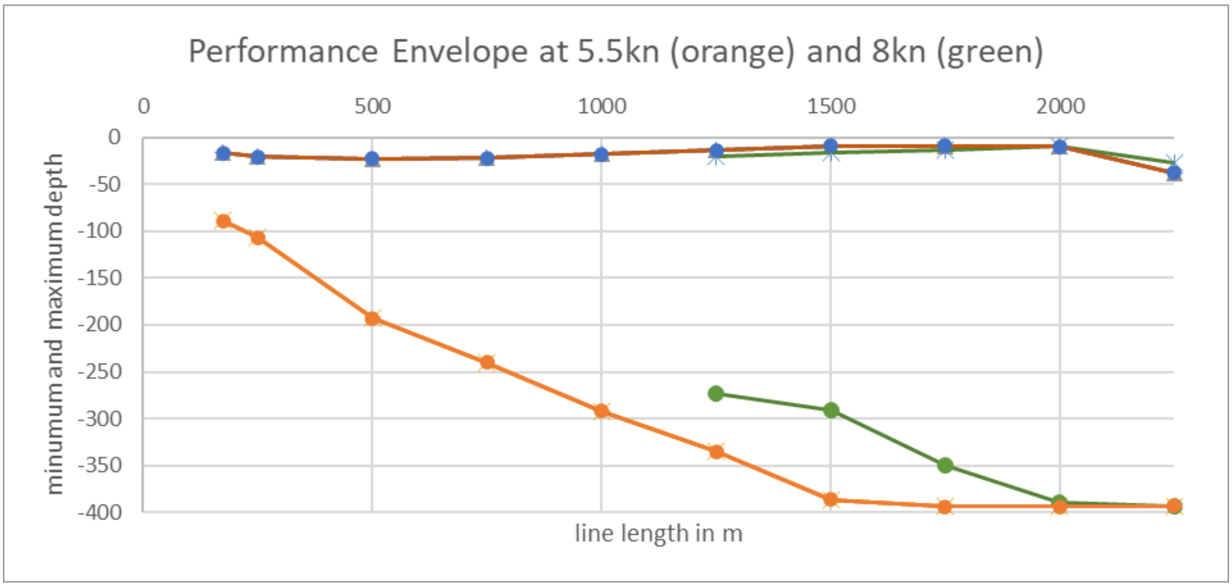

Figure 6: Performance Envelope at different speed (5.5kn=orange, 8 kn=green)

3.4 Investigations on Isaacs-Kidd midwater trawl (IKMT)

The Isaacs-Kidd midwater trawl (IKMT) is a plankton net with a net opening of approx. 6 m² and a mesh size of 500 µm. It filters comparatively large water masses and is therefore particularly suitable for collecting plankton organisms that occur in low densities and for studying plankton communities in oligotrophic regions. The device was manufactured by Hydro-Bios Apparatebau GmbH, Altenholz and is regularly used e.g. by the Thünen Institute of Fisheries Ecology to catch larvae of the European eel (*Anguilla anguilla*) in the Sargasso Sea. While the IKMT integrates over the entire sampled water column, its combination with a multiple codend would allow combining the unique characteristics of this large plankton net with the possibility of stratified sampling. Such a device would provide valuable information on vertical distribution and movements of planktonic organisms in oligotroph waters and, in case of the European eel, help to investigate the depth distribution and preferred environmental conditions of eel larvae in the spawning area, while at the same time increasing catch efficiency.

For this purpose, a MultiNet midi with five nets was modified by Hydro-Bios Apparatebau GmbH and mounted as an optional and easily removable codend on an IKMT (IKMT-MN). After construction, the IKMT-MN did undergo promising tests in a flume tank and was occasionally deployed at sea from Walter Herwig III. These tests of the IKMT-MN have shown that the gear is well suited to qualitatively compare plankton communities at different depth. However, due to length and shape of the IKMT and the comparatively low towing speed of approx. 2.5 kn, some material accumulated at the bottom of the net during towing, which prevents a quantitative assessment of single water layers. As this material is completely washed into the last net when the gear is lifted on board, the comparative analysis was limited to four strata. In order to further document and optimize its performance, the gear and the settings were extensively tested and improved during WH487.

3.4.1 Test of the IKMT in combination with a multiple plankton sampler

A total of five deployments of the IKMT-MN were carried out during WH487 and documented by several cameras mounted at the Triaxus and at the plankton gear itself. The performance of the device was observed at different depths (30m, 100m and 300m) and some modifications were made to improve it. On six additional hauls, two IKMTs without MultiNet codends were deployed and observed with cameras to document their performance and to measure the actual net opening during deployment.

The Triaxus camera was used to film the MultiNet from along the side (see figure 8). This recording was used to optimize the position of the buoyancy balls and the elimination of pockets in the IKMT in order to optimize the plankton flow. After the improvement process even at low towing speed there was no more material accumulated at the bottom of the net during towing and all five nets can be used for comparative and quantitative analysis.

Figure 7: Deployment of the IKMT (left, D. Stepputtis) and view into IKMT net opening (right, L. Marohn)

Figure 8: The MultiNet attached to the IKMT at a depth of approx. 30 m (Foto: A. Hermann)


Figure 9: The illuminated IKMT-MN at a depth of 100m (Foto: A. Hermann)

3.5 Investigations on trawl doors and revised fishery winches

One deployments of a bottom trawl were carried out with new trawl doors and the revised fishery winches. The results were documented by several cameras and the visual sonar mounted at the Triaxus. The performance of the device was observed at 30m depth.

The Triaxus camera was used to film the MultiNet from an angle above (see figure 10). This recording was used to evaluate the dynamic position of the trawl doors while trawling. The trawl doors are in optimal position and the tested fishery winches worked as expected.


Figure 10: Starboard trawl door in action (Foto: A. Hermann)

4. Cruise Participants

Name	Function	Institute
Andreas Hermann	Scientist (Cruise Leader)	Thünen-OF
Daniel Stepputtis	Scientist	Thünen-OF
Sebastian Mammitzsch	Scientist	Thünen-OF
Uwe Lichtenstein	Scientist	Fraunhofer SOT
Wolfram Pagel	Scientist	Fraunhofer SOT
Andreas Reikowski	Scientist	MacArtney Germany
Lasse Marohn	Scientist	Thünen-FI

5. Acknowledgments

We hereby thank all participants, the crew of Walther Herwig III and their captain Werner Stumpp for their outstanding cooperation and commitment.

Dr. Andreas Hermann (TI-OF)
(Scientist in charge)