Linear Translation Stage Guide

*by **pmd**technologies*

Abstract

This document describes how to choose and how to setup a linear translation stage to calibrate prototype or low-volume camera modules.

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1. Introduction

A setup with a linear translation stage is required to evaluate and characterize the performance of **pmd** time-of-flight systems in a comparable, reproducible manner. It is also required for low-volume or prototype calibration, or calibration of uncommon devices, i.e. in scenarios where bringing up specially tailored calibration boxes is not reasonable. It is currently also the only setup to calibrate multi-illumination systems. Last, it is used to bring up golden devices for the box calibration.

In this section the basic operation principle and the requirements are explained. General resources concerning the **pmd** fundamental working principles can be found in references [1, 2].

1.1. Basic Operation Principle

A linear translation stage setup actually comprises the following elements:

- Actual linear stage
- Homogeneous target
- Suitable protection against reflected and ambient light
- Eye-safety precautions

The setup is shown in Figure 1. The linear stage positions the camera module to pre-defined positions relative to a well-defined target[1].

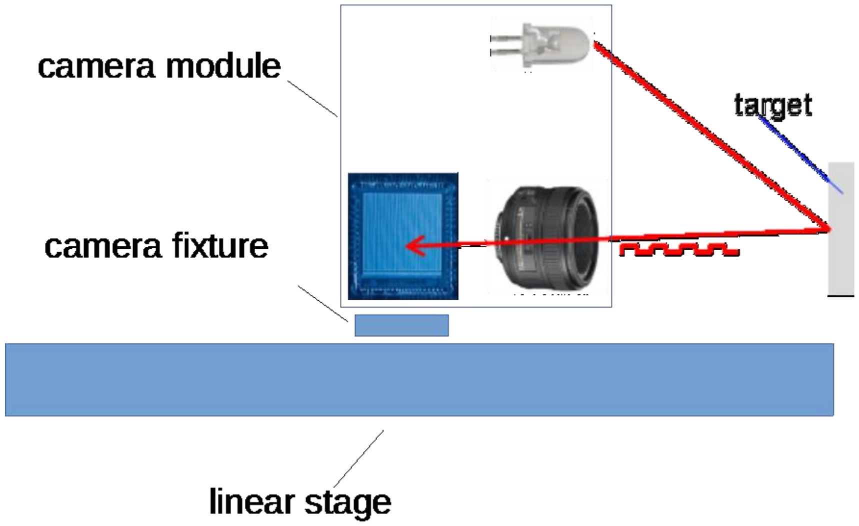

Figure 1: Basic stage setup

1.2. LTS Requirements

A linear stage must meet the following requirements to allow calibrating **pmd** ToF modules:

- Position accuracy <±1mm
- Shock-free movements, setup should not oscillate after abrupt stops
- Controller programmable by PC via standard interface (USB / Ethernet / RS232 / RS435)
- Range: see chapter 2
- Speed: for prototype calibration, it is commonly acceptable to have a measurement time of 10 to 15min per device. Thus no particular speed requirements need to be mentioned.
- Environment: protection against ambient light and reflections from the setup itself: see chapter 2
- Eye-safety precautions: see section 3

[1] By the way, typically, it is much easier to move the camera module, but in terms of data processing, the target could be moved as well.

2. Setup

Figure 2 shows how to proceeding choosing the components of a linear stage setup. A lab version of such a system can be seen in Figure 3.

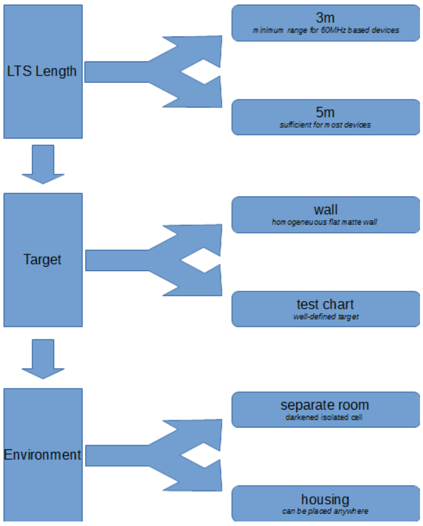

Figure 2: Choose Setup

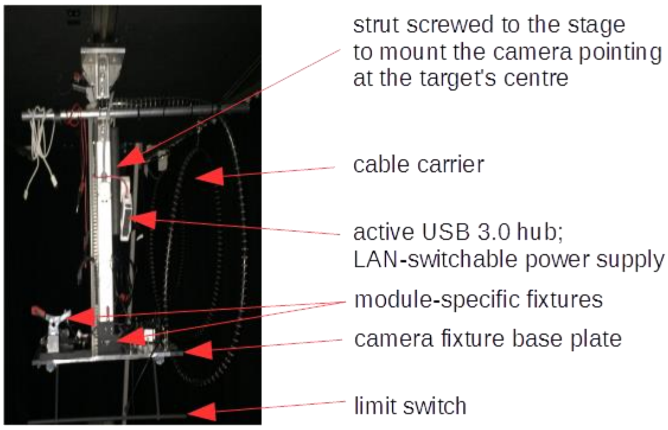

Figure 3: stage, carrier and fixtures

The <u>length of the linear stage</u> must minimally cover the unambiguous range of the lowest modulation frequency used plus a safety margin. For typical pmd 80/60MHz camera modules, this results in a minimum range of 3m. To allow the characterization of the camera beyond the calibrated range, and to have a certain flexibility to work with high-power camera modules, it is advisable to extend the range to 5m. Beyond this limit, shipping the linear stage gets more complicated, and the prices tend to increase more than over proportional.

The <u>target</u> should cover a reasonable part of the field of view. For a typical opening angle of 60°x45° (HxV), a target of 4mx3m is sufficient. For larger opening angles, this “reasonable part” must be a compromise between invest, disposable space and intended evaluation. For instance, the calibration itself uses only a centre area; it would not benefit from a larger target. On the other hand, analysing corner effects might be feasible only then. Depending on the circumstances, the following two types of targets can be used:

- Room wall: flat surface (ideally <1mm height deviations), homogeneous matte grey painting (**pmd** has made good experience with [4])
- Special test target: there are specialized suppliers being able to deliver flat matte grey targets with defined reflectivity, which can optionally be exchanged quickly. See section 0 for an example.

Regardless of the target being used, it is import to align the stage carefully perpendicular to the target. E.g. use a laser pointer on top of the axis and ensure that it always meets the same spot on the target.

Environment

In order to avoid reflections especially from metal surface like strut profiles or the stage itself, cover all such materials with cellular rubber (EPDM). Allow for a flexible camera holder capable of holding the module in a way that the field of view is not limited e.g. the stage; at the same time, the holder should not result in oscillations at abrupt stops of the stage. Use a rigid housing or at least dark absorbing curtains (→ Figure 4) to block ambient light from falling into the measurement area.

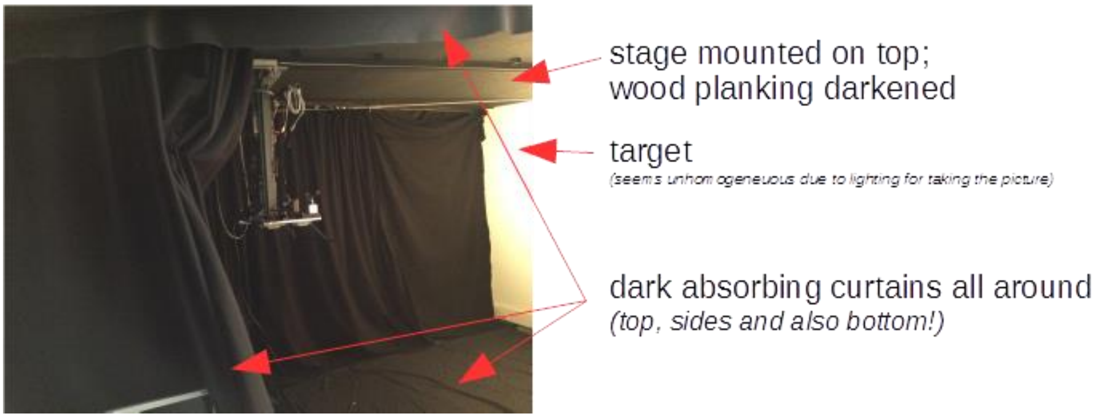

Figure 4: Photo of the stage in a lab environment

Software / PC Connection

The connection to the computer depends on the controller; typically this is some kind of serial interface. The computer is usually place outside the darkened area. Any suitable programming language can be used for data acquisition, e.g. Python or C++ or Matlab. For the supplier listed below, **pmd** can provide an interface to all these three languages mentioned.

3. Eye-Safety precautions

All legal eye-safety precautions must be applied. In particular, ensure that no human can enter the measurement area without laser protection glasses for devices which are not undoubtedly classified as LC1. An appropriate housing / drape must ensure that no person is exposed to danger due to direct light or reflections. Ensure that no specular surfaces are in the measurement area, or cover these with absorbing cellular rubber.

4. Supplier Image Engineering

pmd has evaluated a global supplier with experience in mass-production capable modular test stands. The supplier is called Image Engineering [see 3]; cf. Figure 5 for an example rig.

The supplier gives a modular offer with a 3m linear stage as the core. Optionally, it can be extended to 4m or 5m. There is an optional item to deliver an industrial-grade housing (allowing the stage to be integrated into a fab (cf. Figure 8), and there is another optional item for a lab-grade curtain-like shield to block ambient light. Furthermore, the supplier offers a magnetic test chart holder with a defined, grey, matte, homogeneous, robust foil, which was qualified by pmd.

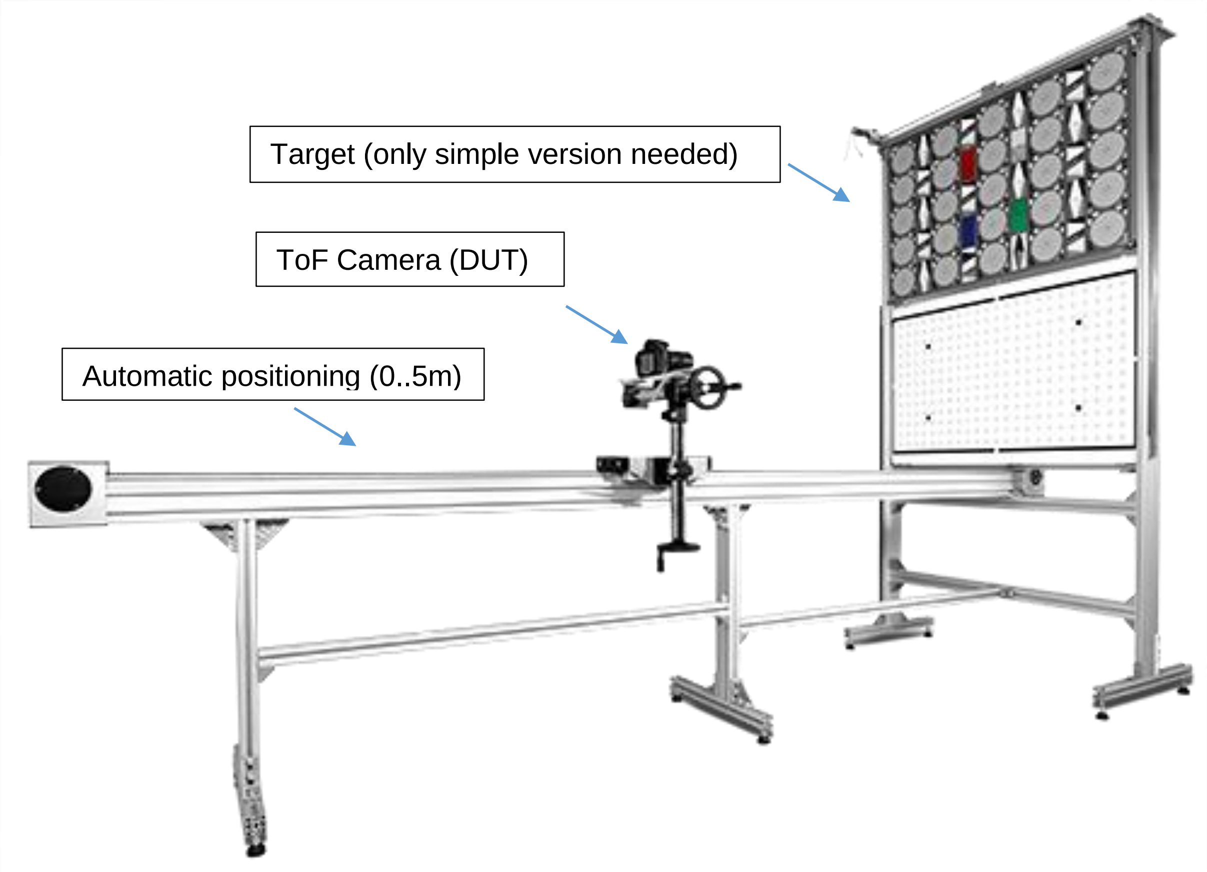

Figure 5: Image Engineering Calibration Rig

The supplier offers a common software API which can be used to connect to any of their motorized stages. It is written in C++ and **pmd** implemented a wrapper between this interface and the calibration software (Matlab).

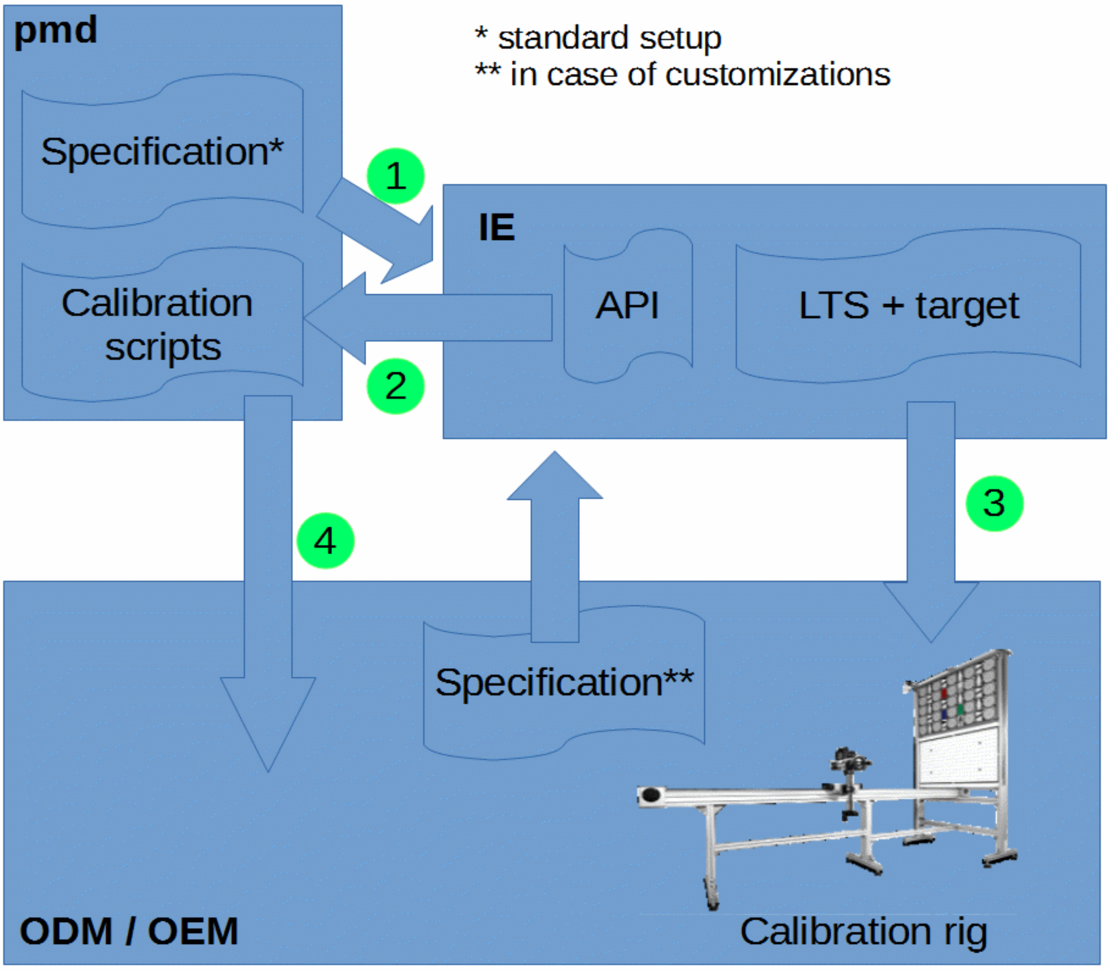

Figure 6: Standard Characterization and Calibration Rig

The supplier takes care of aligning the stage perpendicular to either an existing plane wall or to an ordered test chart. Furthermore, the supplier ensures that all parts, in particular all strut profiles, are covered by absorbing cellular rub material to avoid stray light / reflections. The supplier is responsible for shipping the stage, taking it into operation and support the customer in case of failures related to the system. Evidently, the supplier does not take any responsibility for the script operating on the basis of the API.

For a universal mounting system, an aluminium mounting plate is provided onto which the customer can fix the modules, see Figure 7.

Figure 7: Universal mounting plate

Figure 8: Optional housing

Literature

1. R. Lange, “3D Time-of-Flight distance measurement with custom solid-state image Sensors in CMOS/CCD-technology“ Siegen, 2000.
2. Z. Xu, Investigation of 3D-Imaging Systems Based on Modulated light and Optical RF-Interferometry (ORFI), Siegen, 1998.
3. Web link – internet presence of the company Image Engineering: https://www.image-engineering.de/products/solutions/modular-test-stand ; last status check on Feb 15th, 2016
4. Sigma Polymatt dispersion paint 3062 GE , see http://www.sigmacoatings.de/sigmacoatings/produkte/innenwand/sigma-polymatt

Document History

Document title: LTS-Guide – Cal-9-1-AN

Revision	Origin of Change	Submission Date	Description of Change
0	OLo	2016-02-17	New Application Note
1	OLo	2016-02-18	Added Photos
2	OLo	2016-05-02	Added Figures to section 4.

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