SiTrack:One

Precision and Flexibility

精确，灵活

Stuart Woods

HxGN Live China 2018, Beijing, China - China National Convention Center
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2018年海克斯康北京用户大会

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SiTrack:One

Application areas　　应用领域

Position Independent
Underground or above

无惧环境
地铁、露天铁路均可

Fast As-built Rail 3D Capture
Deliverables 100% in/from point cloud

快速获取竣工数据
成果100%源于点云

Safety
Designed to reduce foot traffic on rail, **no stop/go**

安全
基于减少步行的设计
无需走走停停

High Accuracy
onsite calibration, inertial systems at 1000 Hz, rail profiling by HD scanner

高精度
现场自检，
1000Hz 惯导系统，
高分辨轨道表面扫描仪

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Scanner-Option Leica P40　　徕卡P40三维激光扫描仪

- Customers in Europe, Asia and Latin America
- Leica P40 field of view : 330°
- Rotation frequency: 50Hz – 100Hz
- Recommended measurement speed: 1m/s

客户覆盖亚洲，欧洲，南美

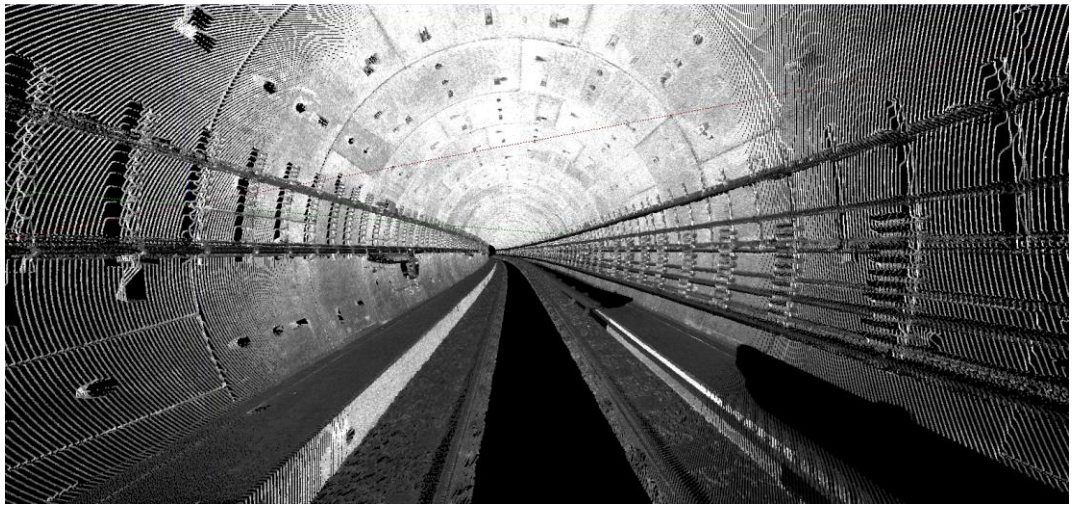
P40视场角：330°

扫描频率：50-100Hz

建议采集速度：1m/s

Measurement in UK

英国测量现场照片



Scan-Data from tunnel-measurement

隧道扫描点云数据

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Scanner-Option Profiler (ZF 9012)　断面仪配置版

- Customer intermetric GmbH in Germany　德国用户
- Recommended measurement speed: 1m/s　建议采集速度：1m/s
- Profiler 9012 field of view: 360°;　断面仪视场角：360°
- Rotation frequency: 50Hz – 200Hz　扫描频率：50-200Hz

Example Munich-underground - Station “Olympia shopping centre”
应用案例—慕尼黑奥林匹克购物中心地铁站

Example Munich-underground – Scan-Data
慕尼黑地铁站扫描点云图

Platform gauging　**站台测量**

Tunnel measurement　**隧道扫描**

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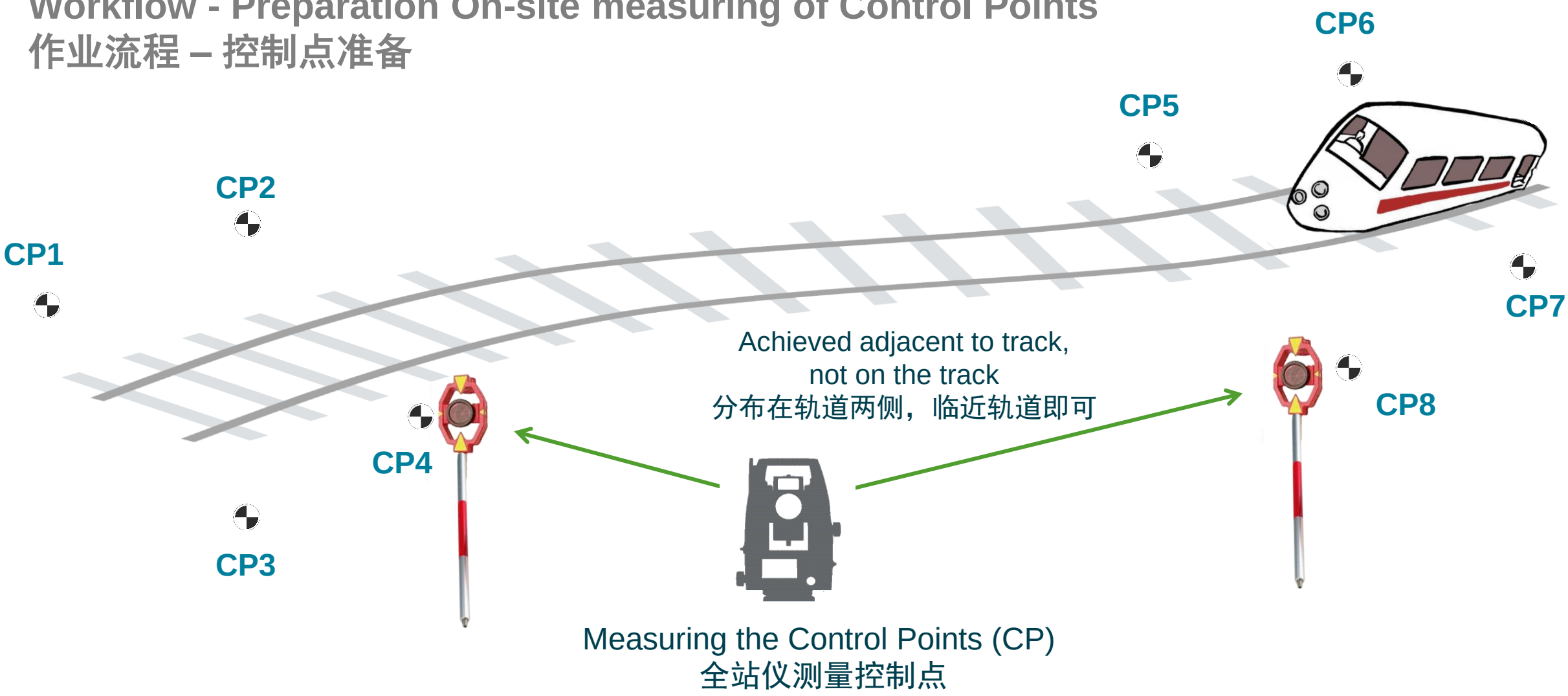
Workflow - Preparation On-site measuring of Control Points
作业流程 – 控制点准备



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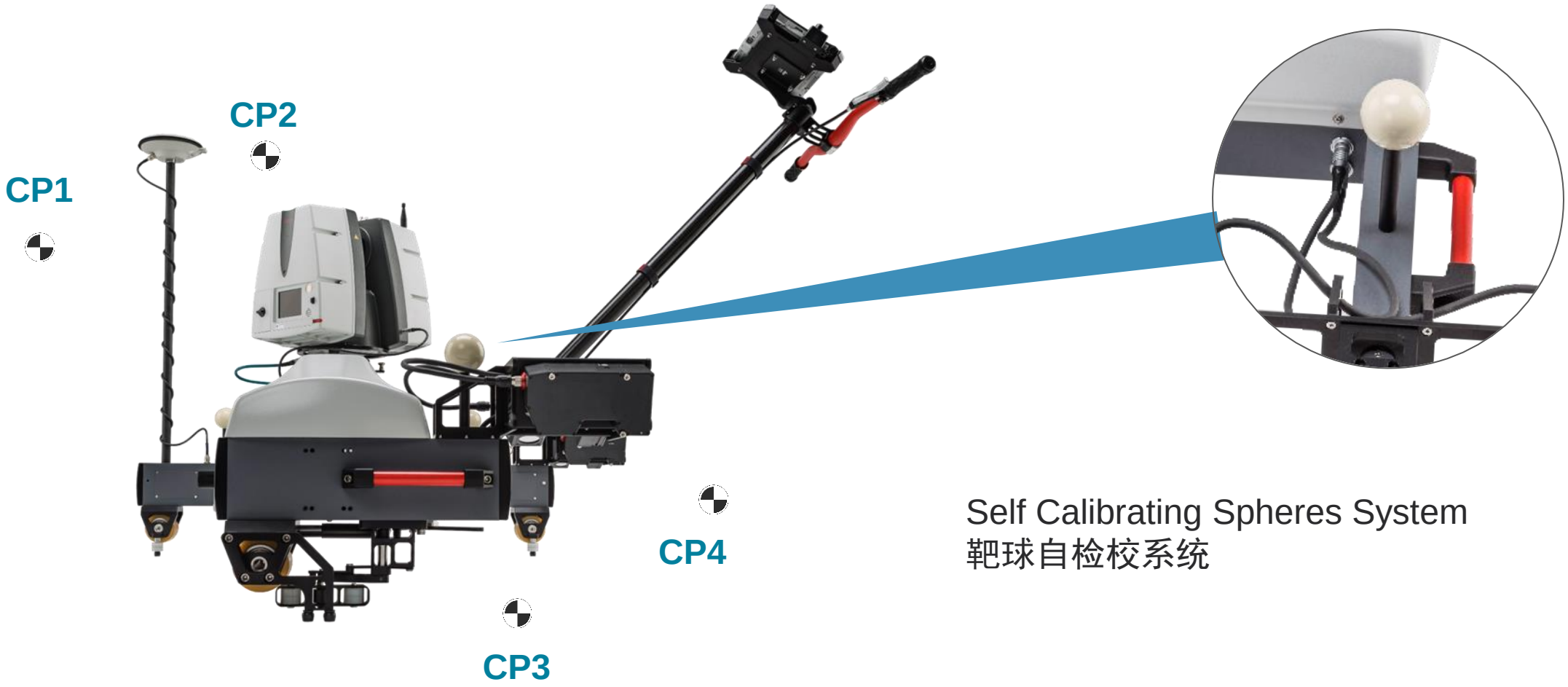
Workflow - On-site Calibration　　作业流程 – 现场自检校



Self Calibrating Spheres System
靶球自检校系统

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Types of measurement and processing　测量流程

- **4 different options of processing measurement data:**

  - With GCP for underground, tunnels and open sky
    - Constrained – 360° start/stop scan → Leica P40
    - Constrained – start/stop total station → Profiler 9012
    - Minimal constrained → P40 and 9012

  - Without GCP for open sky only
    - GPS based → P40 and 9012

- 4种不同的作业流程

- 有控制点，地铁隧道/露天铁路
  - 约束 – 起止点静态360°扫描法 – 徕卡P40扫描仪
  - 约束 – 起止点全站仪定位法 – 断面仪版
  - 最小约束法 – 徕卡P40扫描仪或断面仪

- 无控制点，露天铁路
  - 基于GNSS定位 – 徕卡P40扫描仪或断面仪

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Measuring options and their benefits　　测量方式与优势

- Constrained – 360° scan:
  - High accuracy from the very beginning of the movement to the stop → P40
  - Average accuracy for a GCP distance between 50m - 80m →Δ XY < 5mm; Δ Z < 5mm
  - Average accuracy for a GCP distance between 60m - 150m →Δ XY < 1cm; Δ Z < 1cm
- Constrained – total station:
  - High accuracy from the very beginning of the movement to the stop → Profiler 9012
  - Average accuracy for a GCP distance between 50m - 80m →Δ XY < 5mm; Δ Z < 5mm
  - Average accuracy for a GCP distance between 60m - 150m →Δ XY < 1cm; Δ Z < 1cm
- Minimal constrained:
  - High accuracy from the first GCP to the last GCP →P40 and Profiler 9012
  - For start/stop position no GCP-box or total station needed →Time saving
  - Needs calibration section before 1st GCP/ after last GCP →Calibration section: 10m - 30m
- GPS based:
  - GPS accuracy from very beginning of the movement to the stop →P40 and Profiler 9012
  - No total station needed / no GCP needed →Fast and easy

约束 – 起止点360°静态扫描法：

- 起止点之间精度高 – P40
- 每50-80米一个控制点的平均精度：ΔXY < 5mm; ΔZ < 5mm
- 每60-150米一个控制点的平均精度：ΔXY < 1cm; ΔZ < 1cm

约束 – 全站仪法：

- 起止点之间精度高 – 断面仪
- 每50-80米一个控制点的平均精度：ΔXY < 5mm; ΔZ < 5mm
- 每60-150米一个控制点的平均精度：ΔXY < 1cm; ΔZ < 1cm

最小约束法：

- 从第一个到最后一个控制点之间精度高 – P40和断面仪
- 起止位置无需控制点或全站仪 – 节省时间
- 在第一个控制点前、最后一个控制点后，需要10-30米检校距离

基于GNSS定位法：

- GNSS精度 – P40或断面仪
- 无需全站仪或控制点 – 快速简单

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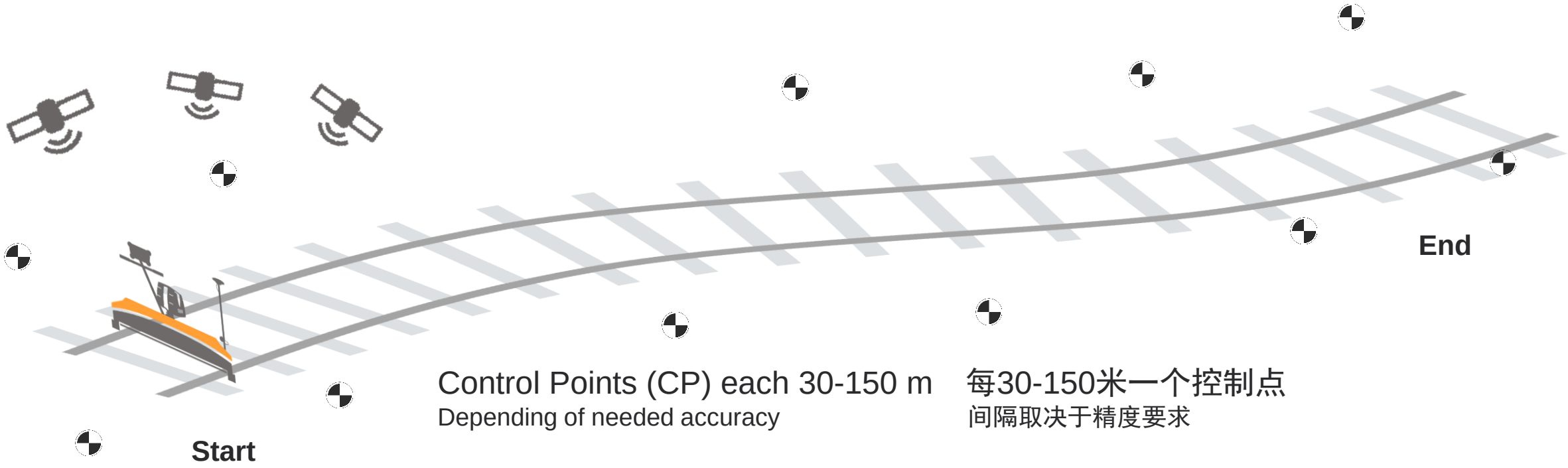
Workflow - 3D Capture - Using GNSS and/or Control Points
作业流程 – 采集 – 基于GNSS定位 或 控制点



Control Points (CP) each 30-150 m
Depending of needed accuracy

每30-150米一个控制点
间隔取决于精度要求

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SiSynchro - Synchronization of Scan-Data - Basic workflow　SiSynchro预处理软件

Start/Stop
起止点

Mechanization
融合解算

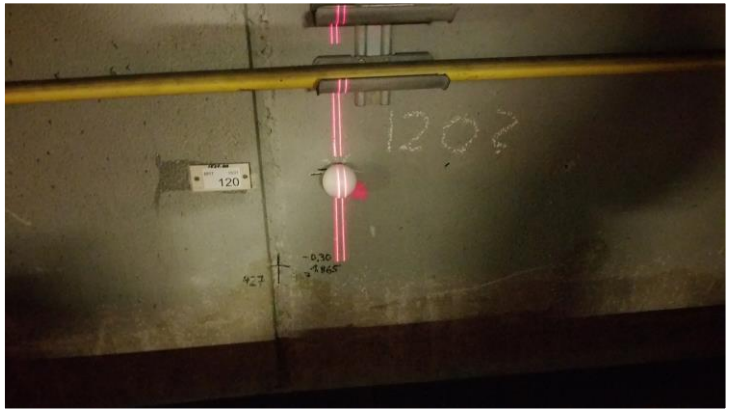
Linearize
线性化

Extract GCP
提取控制点

Calculating points
计算控制点

Create trajectory
解算轨迹

Synchronization
生成最终点云



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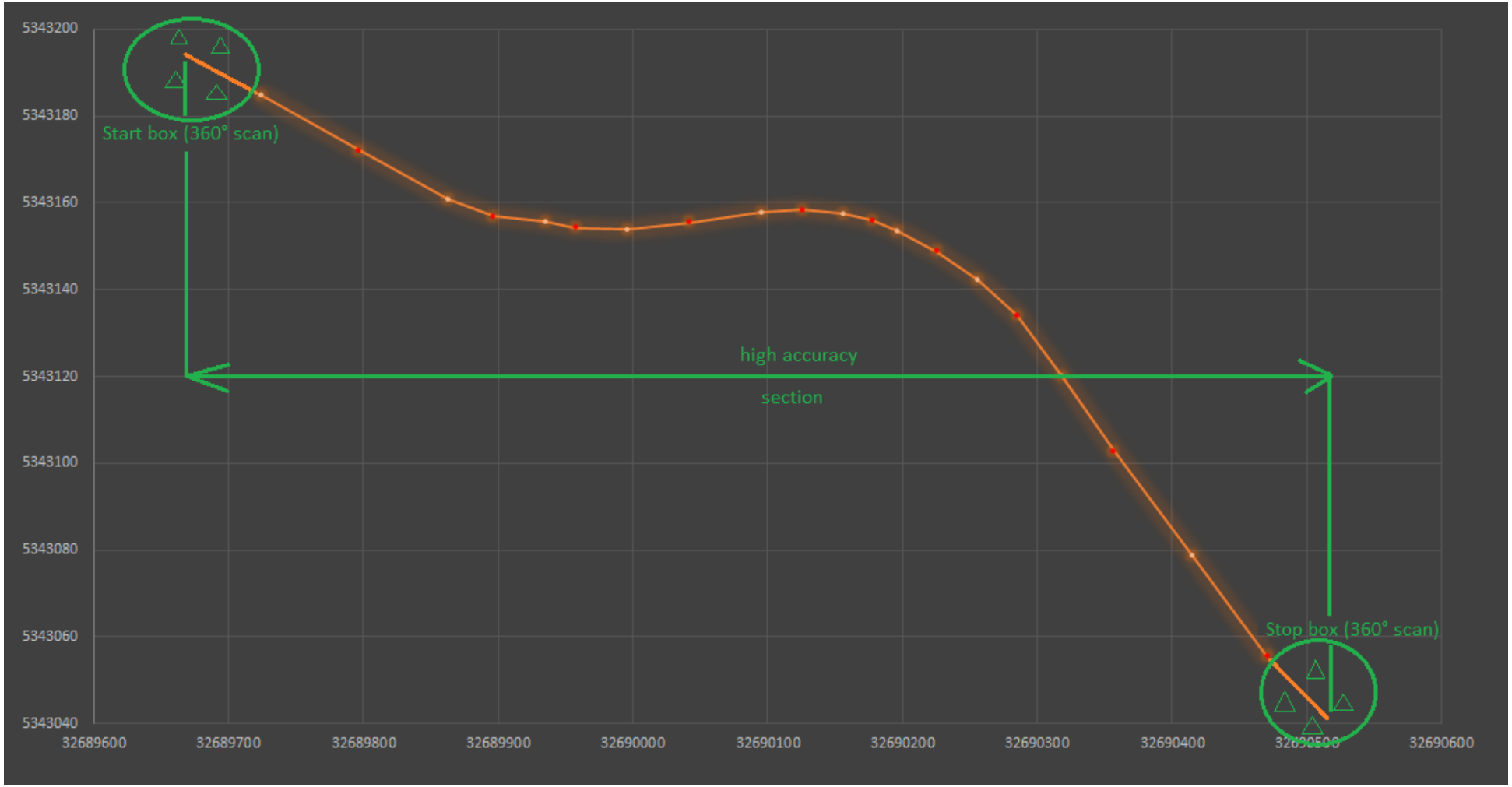
SiSynchro – Option constrained – 360° start/stop scan　SiSynchro起止点静态扫描约束法



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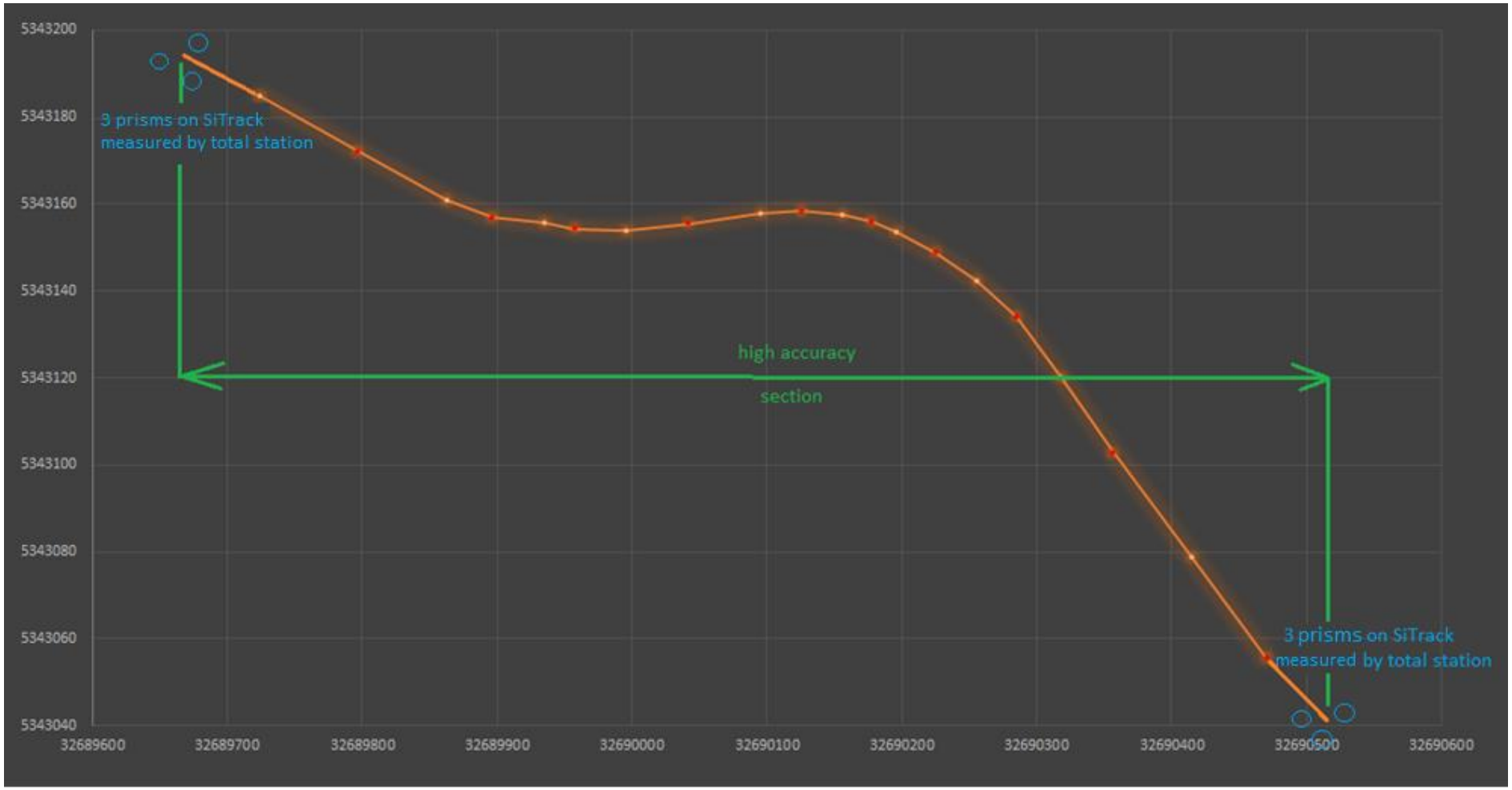
SiSynchro – Option constrained – total station SiSynchro起止点全站仪约束法



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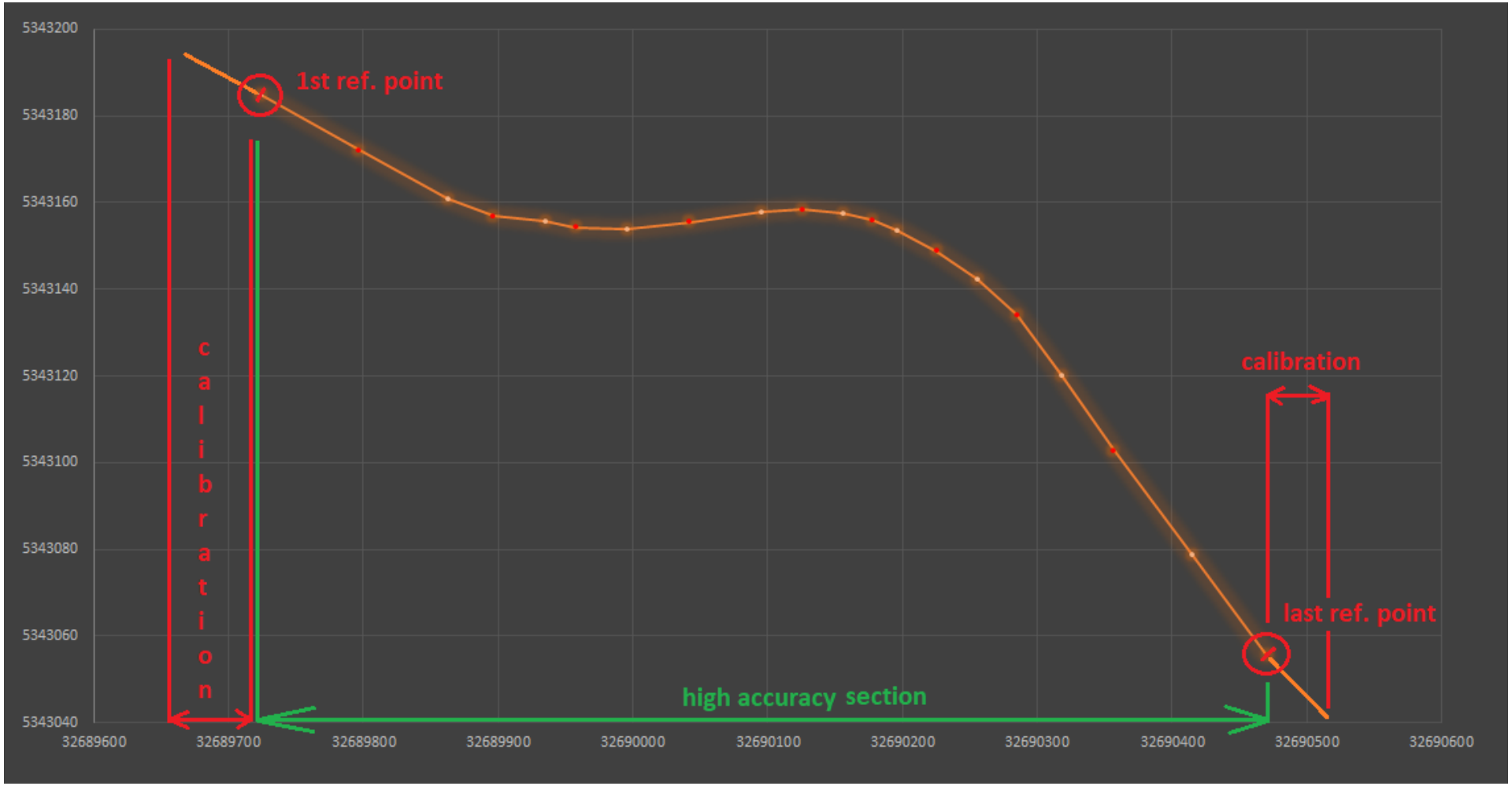
SiSynchro – Option minimal constrained 最小约束法



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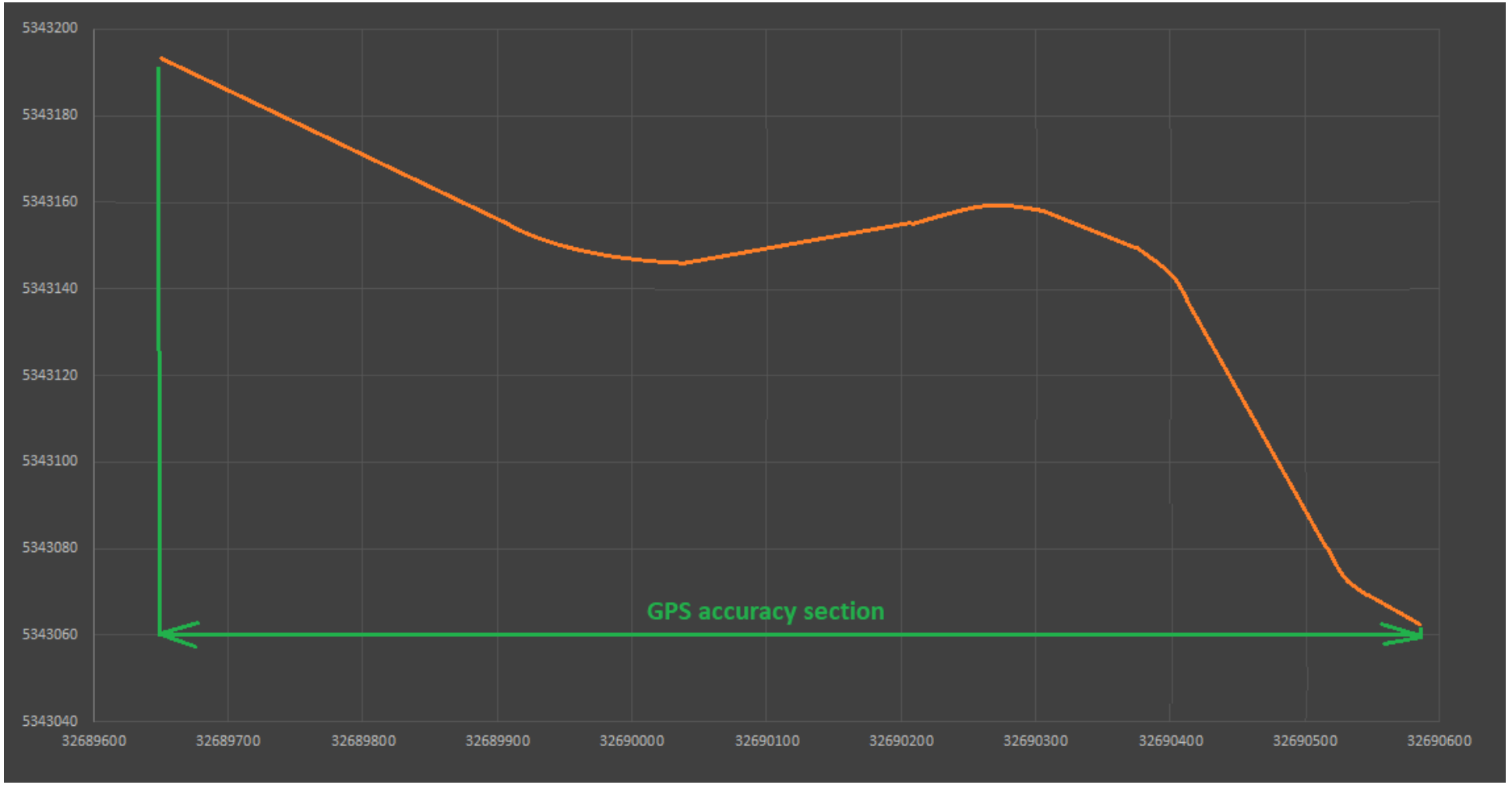
SiSynchro – Option GPS based (only open sky):　　基于GNSS定位法



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SiSynchro – Accuracy of control-points – GCP every 50m - 80m
控制点间隔：50-80米，精度

					Bsp.	<	5mm				
					Bsp.	<	1cm				
					Bsp.	<	2cm				
					Bsp.	>	2cm				
			GVP TARGET			Ref.Points (all used)			GVP ACTUAL		
Station:	Ref.Point Name:	Y	X	Z	ΔY	ΔX	ΔZ	Y	X	Z	
1	272.011	32690470.43	5343055.456	484.1362	0.0010	-0.0001	0.0019	32690470.43	5343055.456	484.13432	
61	272.009	32690414.58	5343078.741	484.1087	-0.0010	-0.0006	0.0002	32690414.59	5343078.742	484.1085	
123	272.007	32690357.07	5343102.785	484.1493	-0.0008	0.0004	0.0005	32690357.07	5343102.785	484.14884	
166	273.027	32690317.7	5343120.087	483.8043	0.0002	0.0010	-0.0001	32690317.7	5343120.086	483.80442	
202	273.025	32690285.08	5343134.012	483.9188	0.0011	-0.0016	0.0002	32690285.07	5343134.014	483.91859	
232	273.023	32690255.28	5343142.282	483.8796	-0.0010	0.0000	0.0025	32690255.28	5343142.282	483.87709	
262	273.021	32690225.61	5343148.753	483.7764	0.0019	0.0013	-0.0003	32690225.61	5343148.752	483.77667	
293	273.019	32690195.61	5343153.605	483.503	-0.0006	0.0006	0.0007	32690195.61	5343153.604	483.50231	
311	273.017	32690177.44	5343155.889	483.3448	-0.0015	0.0009	0.0001	32690177.44	5343155.888	483.3447	
333	273.015	32690155.6	5343157.45	483.1031	0.0017	0.0015	-0.0006	32690155.6	5343157.448	483.10365	
363	273.013	32690125.54	5343158.377	482.7753	-0.0008	0.0006	-0.0018	32690125.54	5343158.377	482.77706	
393	273.011	32690095.47	5343157.814	482.7618	0.0012	0.0029	-0.0016	32690095.47	5343157.811	482.76338	
446	273.009	32690042.39	5343155.419	483.3091	0.0005	0.0014	-0.0010	32690042.39	5343155.418	483.31009	
492	273.007	32689995.67	5343153.738	483.7977	-0.0024	0.0003	0.0003	32689995.67	5343153.738	483.7974	
531	273.005	32689957.7	5343154.307	483.9451	-0.0015	0.0004	-0.0011	32689957.7	5343154.307	483.94621	
553	273.003	32689935.34	5343155.631	483.9378	0.0011	0.0003	0.0006	32689935.34	5343155.63	483.9372	
592	273.001	32689896.45	5343156.801	484.094	0.0010	-0.0013	0.0006	32689896.44	5343156.802	484.0934	
626	274.011	32689863.07	5343161.029	484.1693	0.0003	-0.0009	0.0005	32689863.07	5343161.03	484.16876	
693	274.009	32689797.01	5343172.103	484.1111	0.0027	0.0012	0.0000	32689797.01	5343172.102	484.11107	
767	274.007	32689723.62	5343184.771	484.1368	-0.0010	0.0011	-0.0008	32689723.62	5343184.77	484.13764	
		StdErr (all used):			0.0013	0.0010	0.0010				

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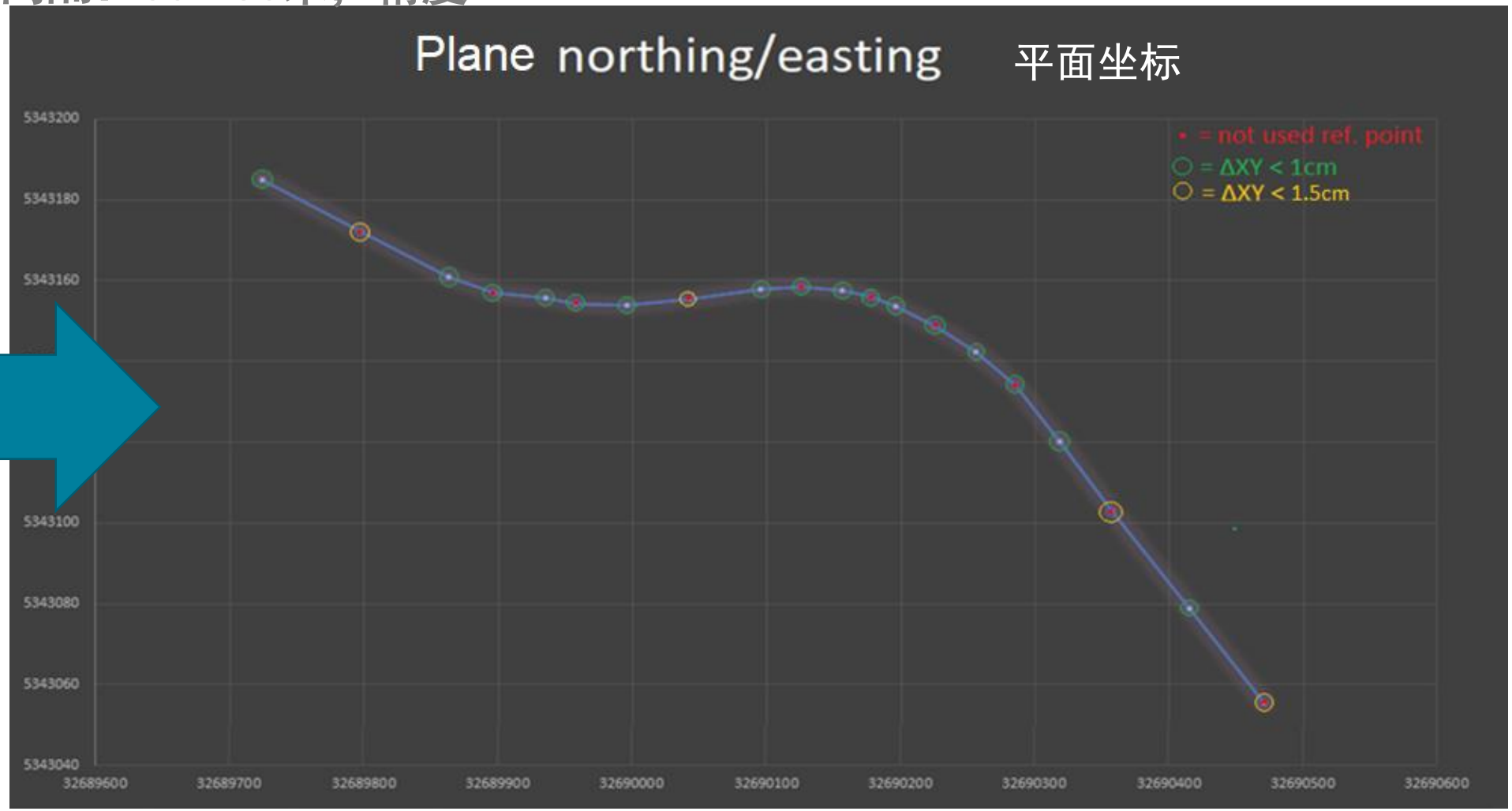
SiSynchro – Accuracy of control-points - GCP every 60m – 150m
控制点间隔：60-150米，精度



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SiTrack:One

SiSynchro - Accuracy of control-points - GCP every 60m - 150m
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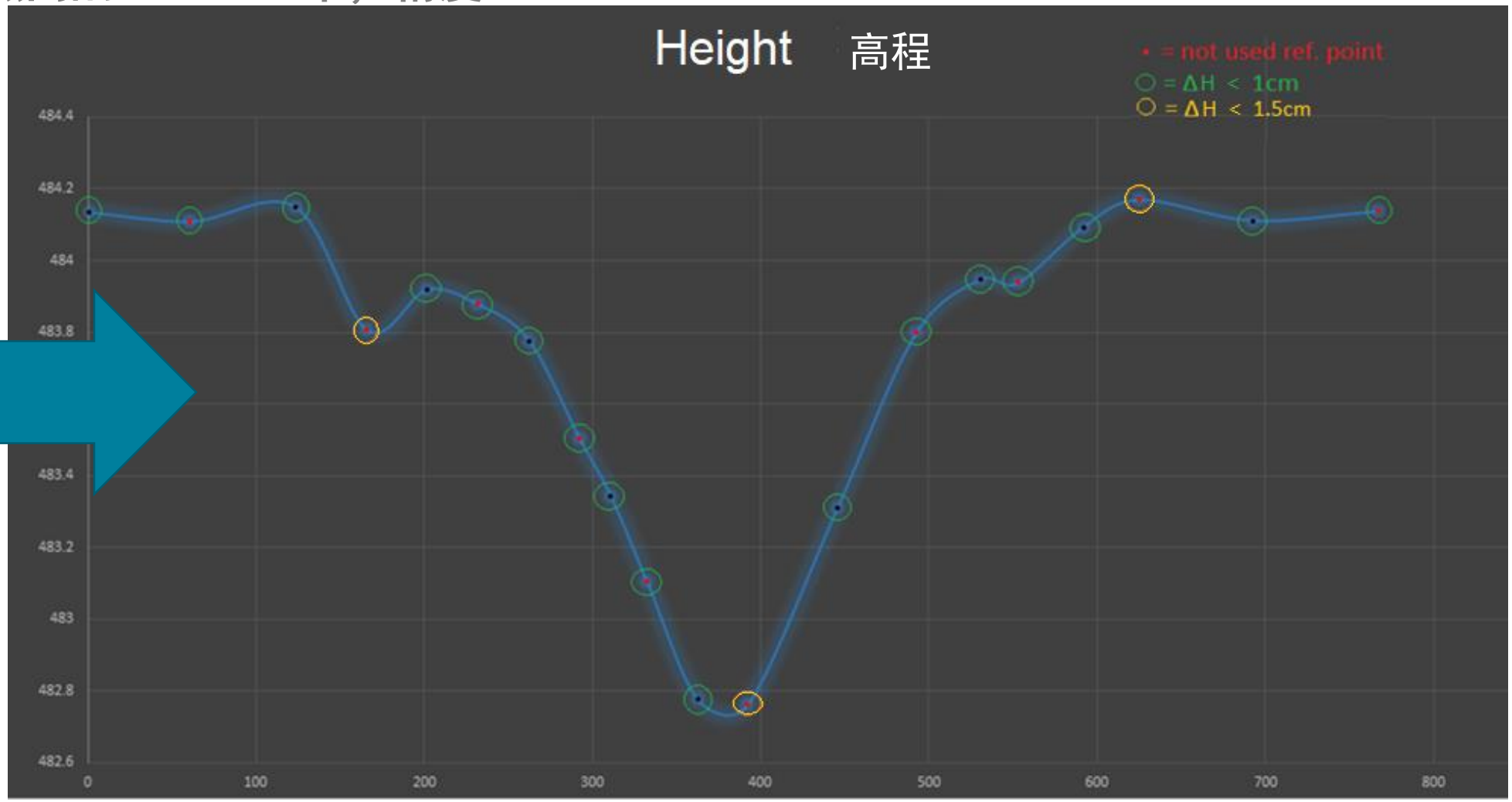

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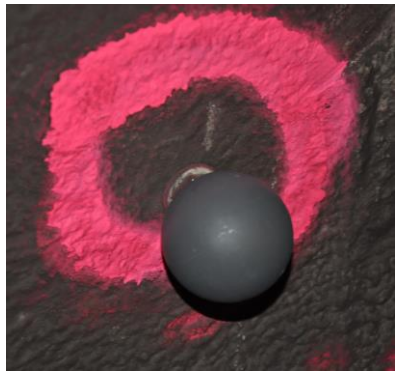
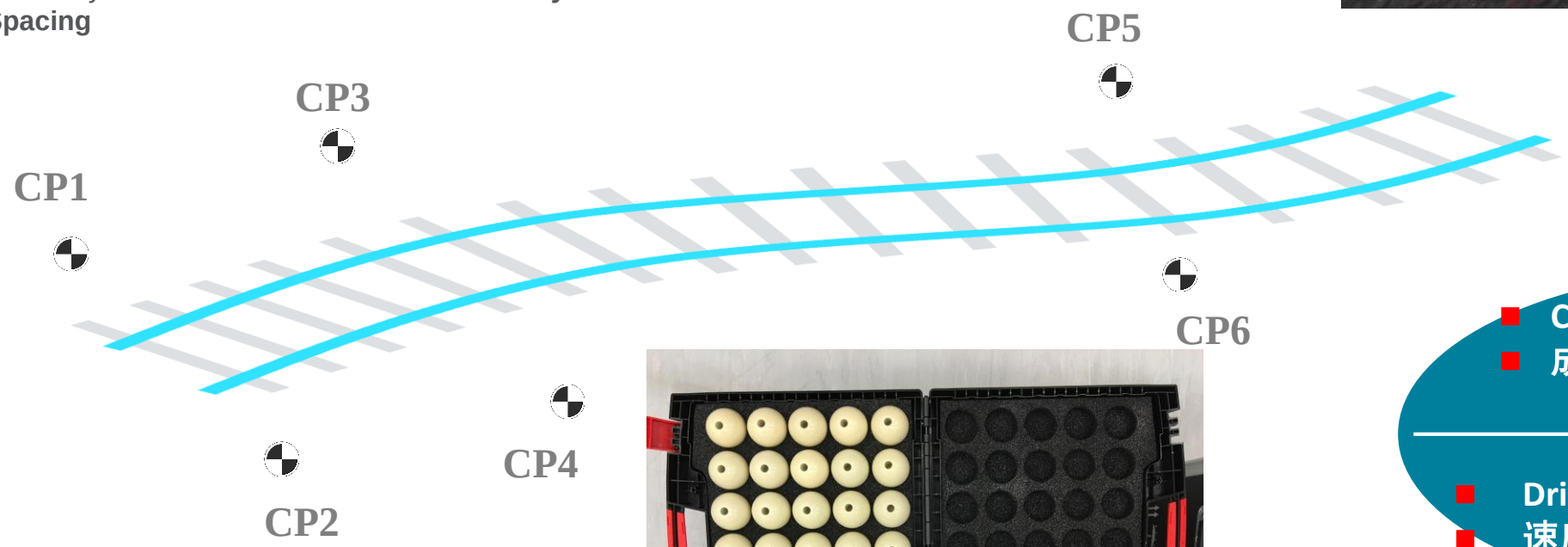
SiTrack:One

Railway Tasks - Boundary-Conditions
铁路检测任务

- To provide high absolute accuracy: Control-Points (CP) needed
- Boundary-Condition to reach desired absolute accuracy: **CP-Spacing**
- Boundary-Condition to **realize desired Railway-Task**: **CP-Spacing**

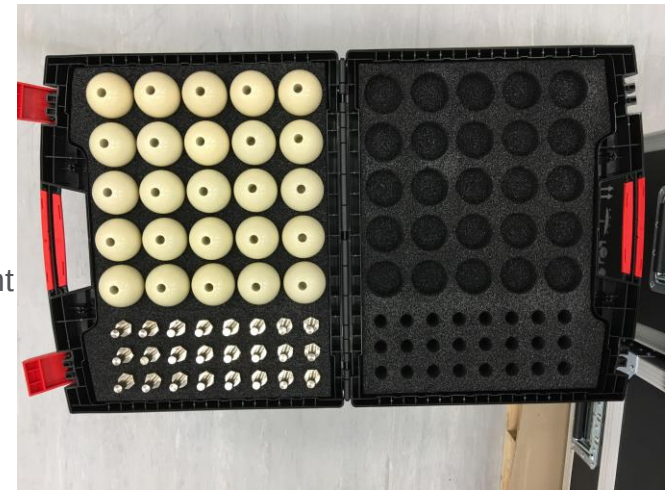
- 提供高精度绝对坐标：需要控制点
- 满足绝对精度要求：取决于控制点间距
- 实现任务要求：控制点间距

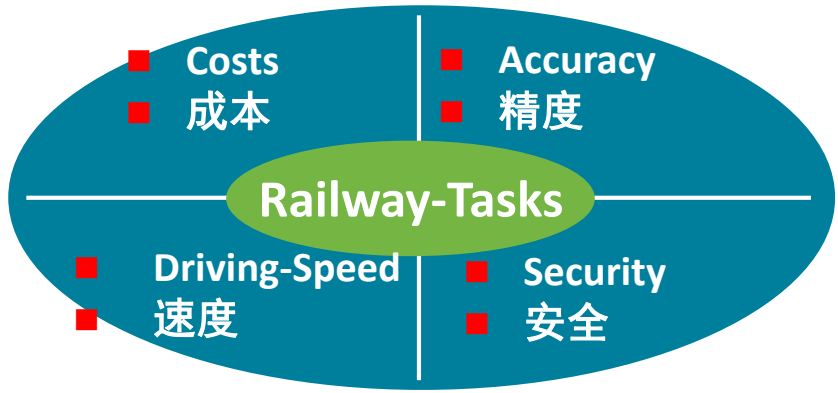




SiTrack:One: control point accessory box

SiTrackOne靶球附件箱





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Railway Tasks - Accuracy Table　　铁路检测任务 – 精度表

- Comparison of Usage-Cases　对比应用案例

	Rules DB-AG	Rules DB-AG	SiTrack:One	
railway task / usage case	Absolute accuracy 3D	Relative accuracy/10m	Possibility	CP* - Spacing
clearance typical (SNCF, DB-AG-LimezIII) - maintenance	25mm	<10mm	x	150-1000m
clearance new DB (new construction, f. ex. platforms)	5mm	3mm	x	30m
Distance to neighborhood/adjacent track	15mm	7mm	x	100m
Catenary/Electric wires	15mm	7mm	x	100m
Track geometry - maintenance	20mm	5mm	x	100m
Track gauge/cant from Pt CId** (maintenance)	15mm	2mm***	x	100m
Track gauge/cant from Pt CId** (new construction)	3mm	1mm***	x	30m
Track geometry - new construction highspeed (Acceptance meas.)	7mm	2mm	x	30m
Bridge-sleeper-replacement	4mm	2mm	x	20m
Rail-Wear-Calculation	-	1mm	x	-

clearance measurement
geodetic measurement
high accurate geodetic measurement

CP... Control Point

****baseline length between reference stations < 10km

*****depending on tunnel-length

*a priori absolute accuracy CP-points: Necessary absolute accuracy CP-points (from network adjustment) depends on railway-task

**Accuracy reachable by special post-processing algorithms

***SiTrack:One: Track gauge from additional gauge-measurement-system with relative accuracy up to 0.3mm possible

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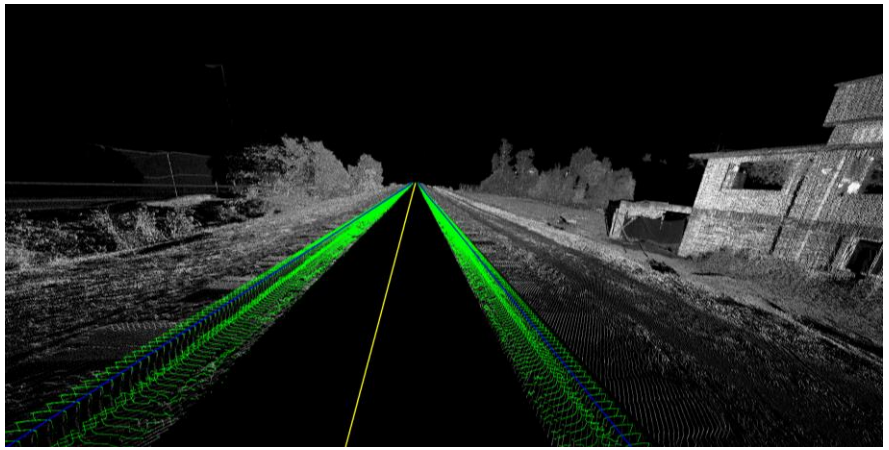
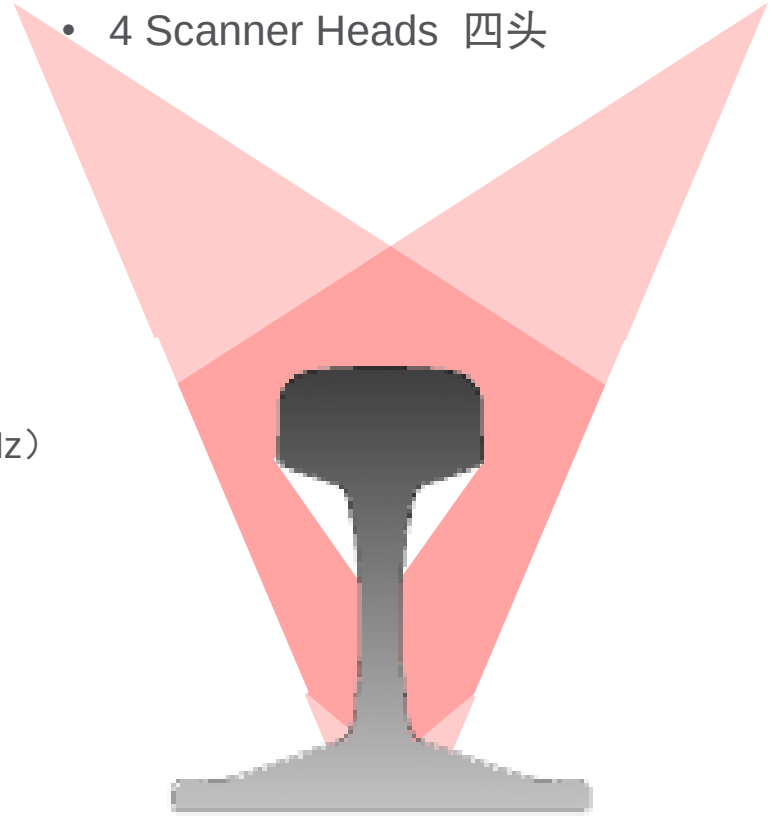
Railway Tasks – New Feature - Rail-Wear-Calculation　　铁路检测任务 – 计算轨面磨损



Configuration 配置:

- 2 Scanner Heads 双头
- 4 Scanner Heads 四头



- High frequency point cloud of rail
- Rail profile scanners – high-end technology (1000Hz)
- Automated export of rail informations

- 高频率扫描点云
- 轨道表面扫描仪：高端技术（1000Hz）
- 自动导出钢轨表面信息

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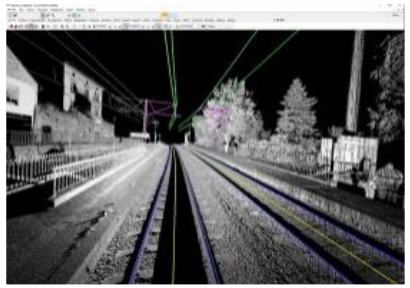
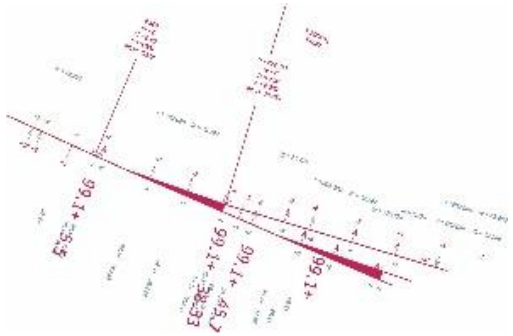
SiRail-Suite

Software Packages
配套软件包



SiRail Essential (Plus)



ATrack

Everyone		Professionals
Essential 必配版	**Essential Plus 高级版**	**Advanced 完整版**
SiRailScan ▪ Basic configuration ▪ Batch rail extraction ▪ Semi-auto rail ectraction ▪ Batch catenary detection ▪ Batch clearance static gauge	**SiRailScan** ▪ Basic configuration ▪ Batch rail extraction ▪ Semi-auto rail extraction ▪ Batch catenary detection ▪ Batch clearance static gauge ▪ Batch tunnel deformation ▪ Batch clearance dynamic gauge	**SiRailScan** ▪ Basic configuration ▪ Batch rail extraction ▪ Semi-auto Rail extraction ▪ Batch Catenary detection ▪ Batch Clearance Static Gauge ▪ Batch Tunnel Deformation ▪ Batch Clearance Dynamic Gauge **ATrack** ▪ Basic configuration ▪ Driving dynamics ▪ Trackplan ▪ Railway calculation

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SiRail-Suite

Standard Software Packages - Current Features　　配套软件包 – 现有功能

SiRailSuite后处理软件

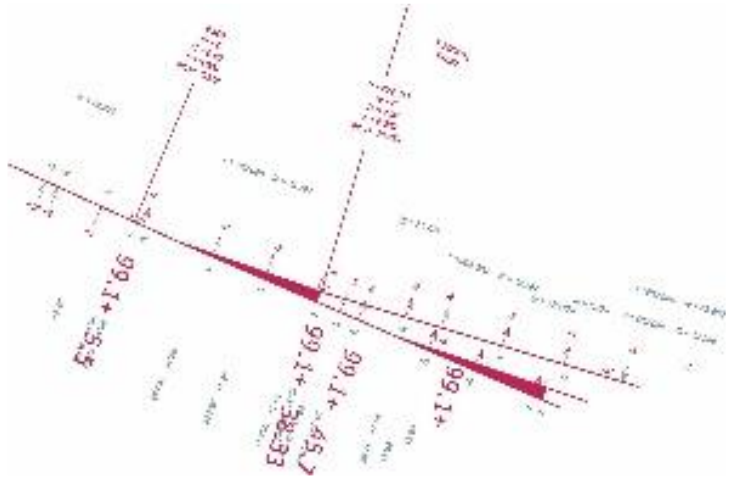
创新的软件解决方案，提高管理人员对铁路网络的监控管理，具有变形分析和计算功能。

SiRailSuite Essential(Plus)

The innovative software solutions contribute for the improvement in monitoring and control of the railway network conditions, for deformation analysis as well as for volume calculations.

ATrack

The Software solution created for track reverse engineering and optimization of algorithms, for railway design and planning, for as-built track geometry recovery and comparison between the designed and as-built track alignment.



ATrack后处理软件

轨道逆向工程与算法优化软件，具有铁路设计、计划，轨道几何要素计算等功能。

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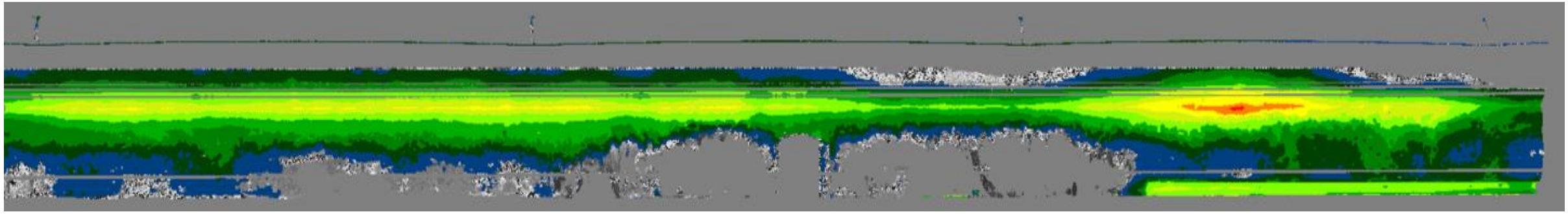
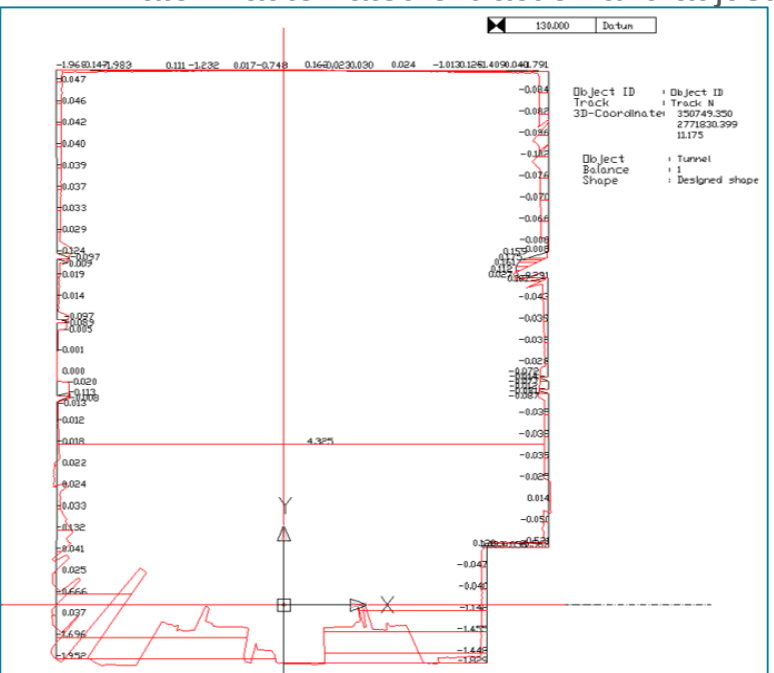
SiRail-Suite

SiRailSuite Essential(Plus) - Current Features SiRailSuite后处理软件 高级版 现有功能



- Batch - tunnel deformation analysis
- Automated calculation of differences “designed to as-built structure”
- Batch - automated extraction and adjustment of the as-built rails

- 批量处理：隧道变形分析
- 自动计算：设计与竣工差值
- 批量处理：提取轨道线

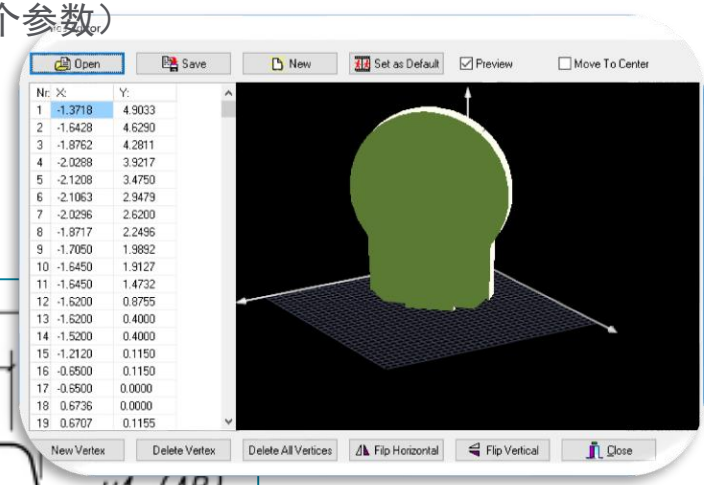


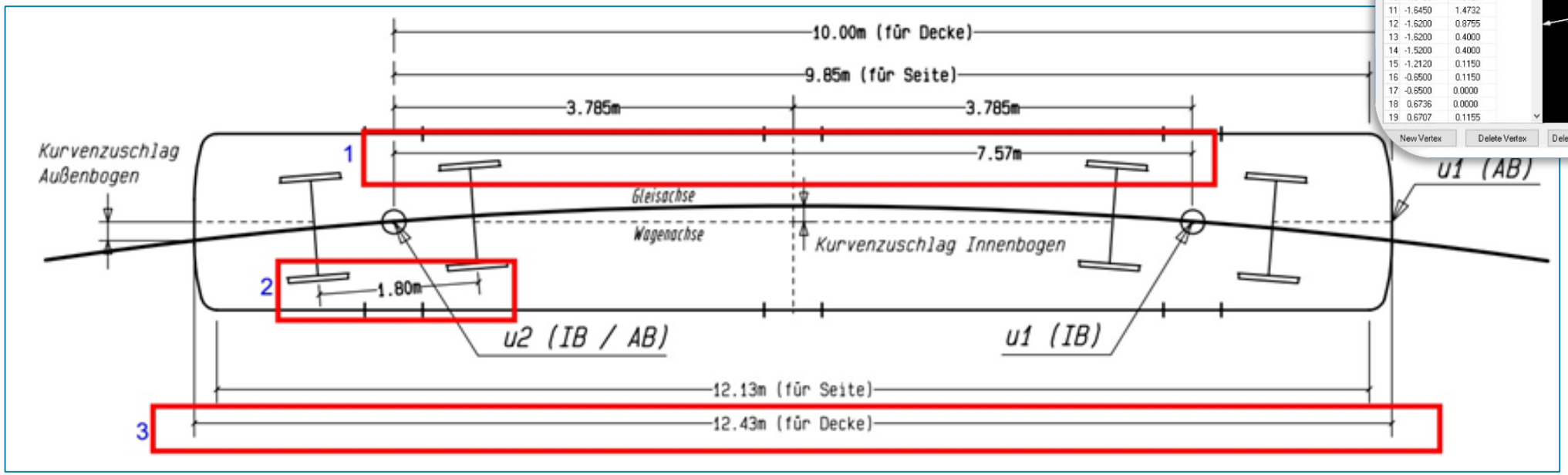
SiRail-Suite

SiRailSuite Essential(Plus) - Current Features – Collision Test/Clearance Analysis
后处理软件 高级版 – 现有功能 – 侵界检测、净空分析

- Definition of 2D Profile (for example import of *.DXF or *.XML-Safeload)
- Definition of 3D-Body (customized wagon profile) with 3 more parameters
  - (1) Distance between basepoints of the wheel
  - (2) Distance between the axis of the wheels
  - (3) Length of the wagon

- 定义二维断面、剖面（DXF或XML格式）
- 定义三维车体（基于下面三个参数）
  1. 轮体基准点间距
  2. 轮体轴线间距
  3. 车厢长度





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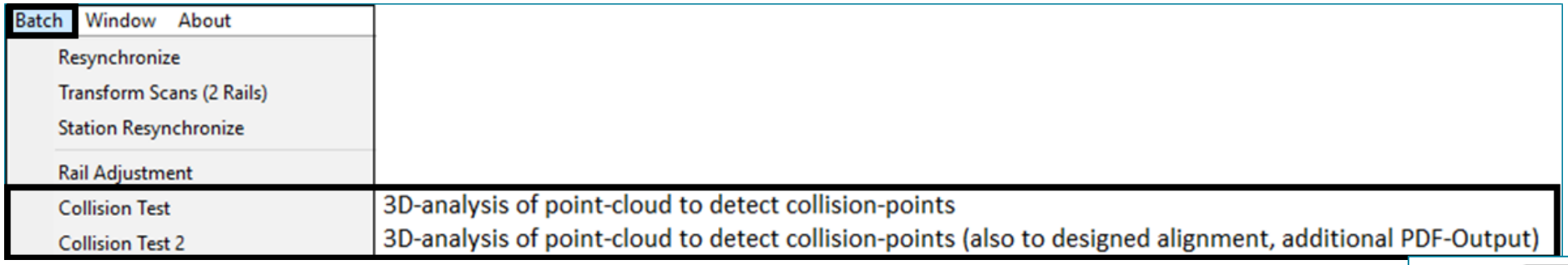
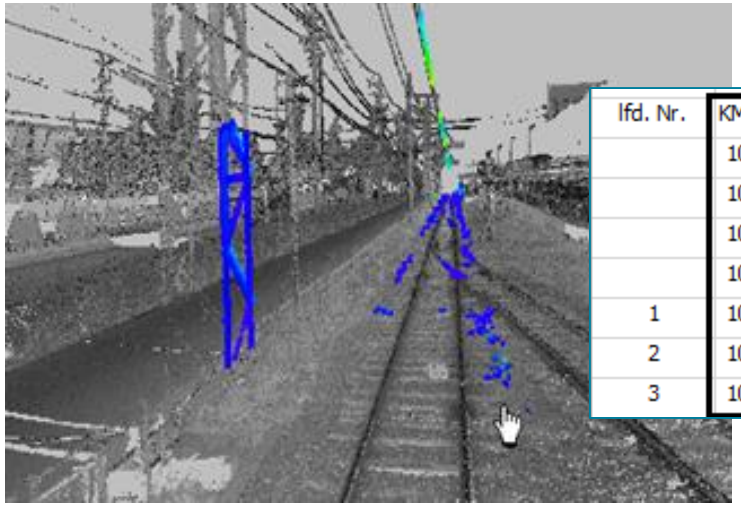
SiRail-Suite

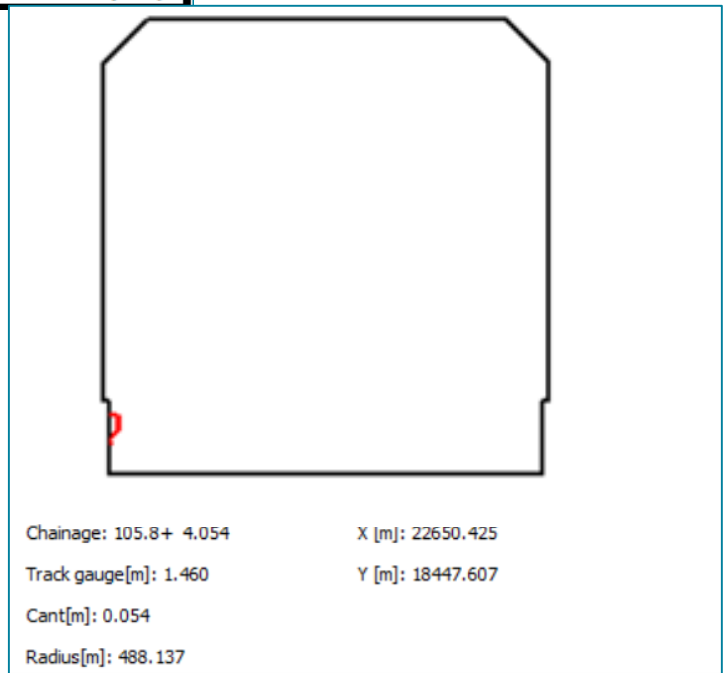
SiRailSuite Essential(Plus) - Current Features – Collision Test/Clearance Analysis
后处理软件 高级版 – 现有功能 – 侵界检测、净空分析

- **3D-Collision-Test:** Detection of problem-areas, **also Collison-Test to designed Track-Geometry**
- **三维侵界检测：基于设计轨道，检测侵界区域**





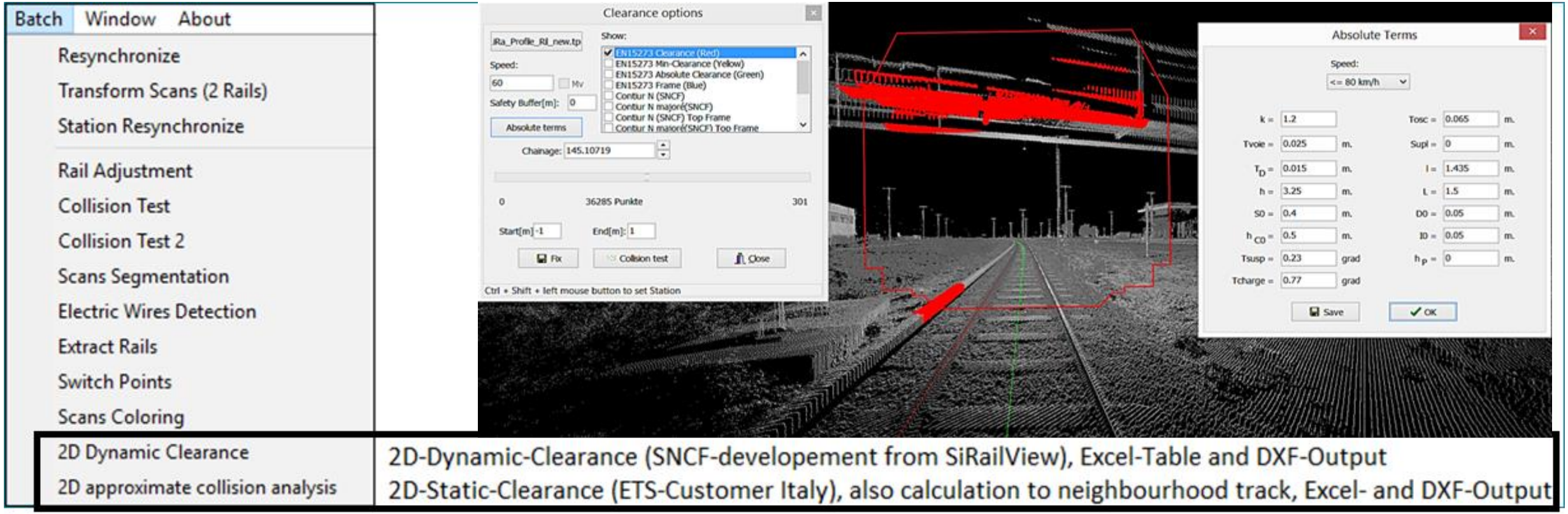
lfd. Nr.	KM-Station [m]	Points	Max. Einragung [m]	Lichtraumprofil
	105221.32	16	0.008	BVG-U-Bahn Großlichtraum - Bahnsteig
	105221.32	880	0.003	BVG-U-Bahn Großlichtraum - Bahnsteig
	105233.51	19	0.009	BVG-U-Bahn Großlichtraum - Bahnsteig
	105233.51	179	0.002	BVG-U-Bahn Großlichtraum - Bahnsteig
1	105416.90	1450	0,009	BVG-U-Bahn Großlichtraum - Bahnsteig
2	105424.90	1823	0,012	BVG-U-Bahn Großlichtraum - Bahnsteig
3	105430.89	2323	0,014	BVG-U-Bahn Großlichtraum - Bahnsteig



SiRail-Suite

SiRailSuite Essential(Plus) - Current Features – Collision Test/Clearance Analysis
后处理软件 高级版 – 现有功能 – 侵界检测、净空分析

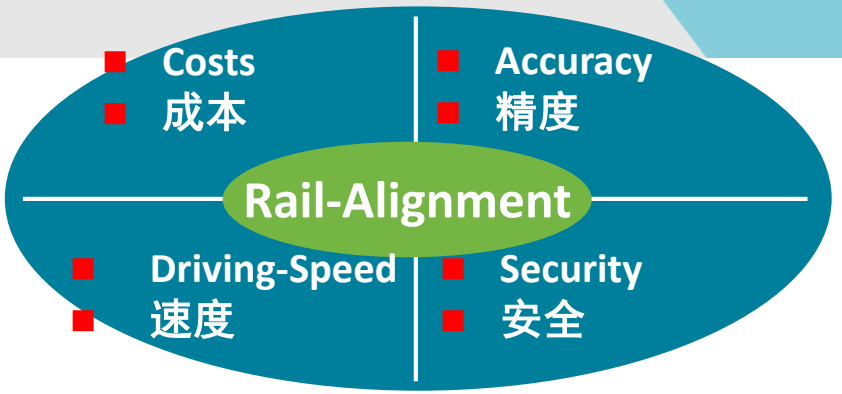
- **2D Clearance-analysis (static, dynamic):** Exact determination of clearance infringements
- Based on European rules and individual Formulas (for example for SNCF - National French Railway Company)
- Calculation of potential clashes also between neighborhood tracks
- 二维净空分析（静态、动态）：准确检测净空值
- 基于欧洲规定（比如法国国家铁路公司）
- 计算潜在的临近轨道发生的碰撞

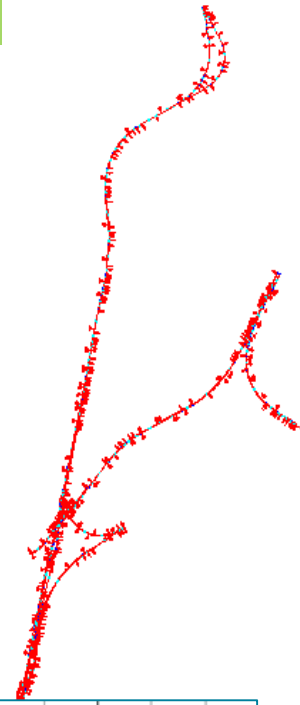


SiRail-Suite

ATrack - Current Features

ATrack软件 现有功能





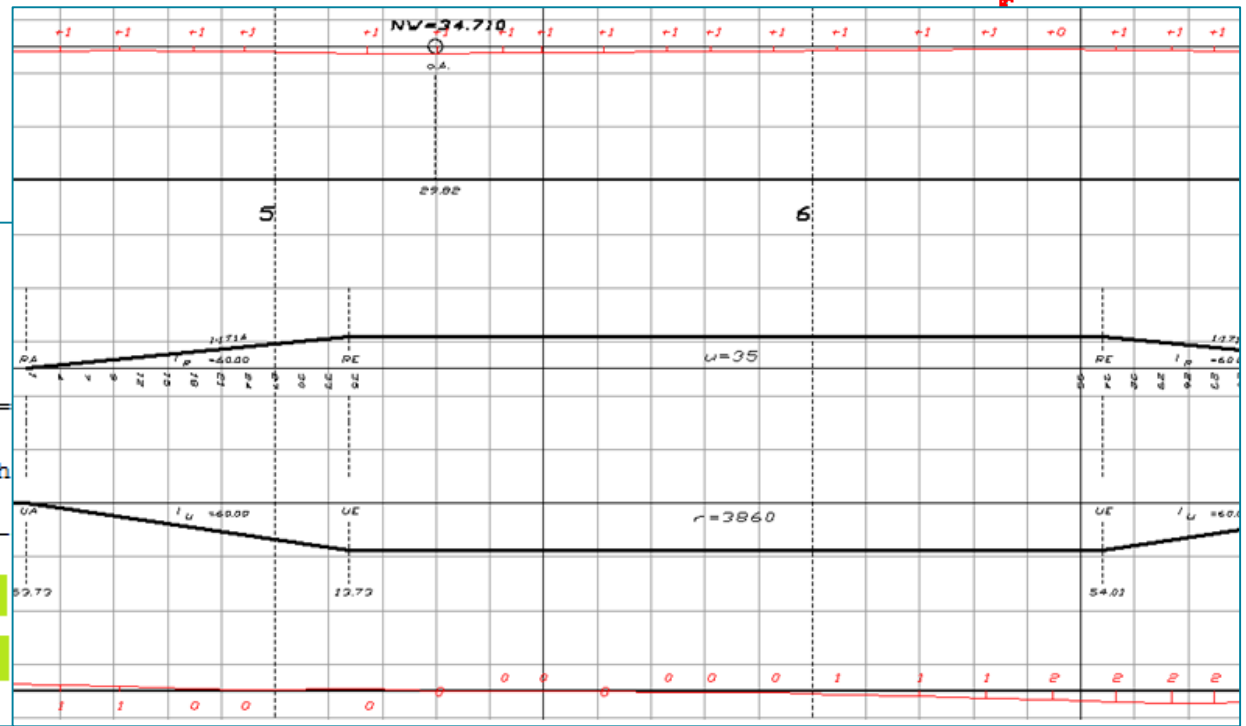
- **ATrack-Basic-Configuration:** Exact and automated determination of Track-Geometry (position, height)
- **ATrack-Railway-Calculation:** Railway-switches,single-points on the track,**Tamping-Machine-Export**
- **ATrack-Driving-Dynamics:** Calculation of possible speed along the track
- **ATrack-Track-Plan:** Final Product with result Track-Geometry
- ATrack基础配置：准确、自动的检测轨道几何元素，平面位置、高程
- ATrack铁路计算：轨道道岔、捣固机单点导出
- ATrack动态分析：计算列车行驶速度
- ATrack轨道计划：轨道几何结果报告

Trasse : High-Speed

DRIVING DYNAMICS TRACK: ANALYZED SPEED 200km/h

Route:SBW-ADM NB Area: Track: Processor:

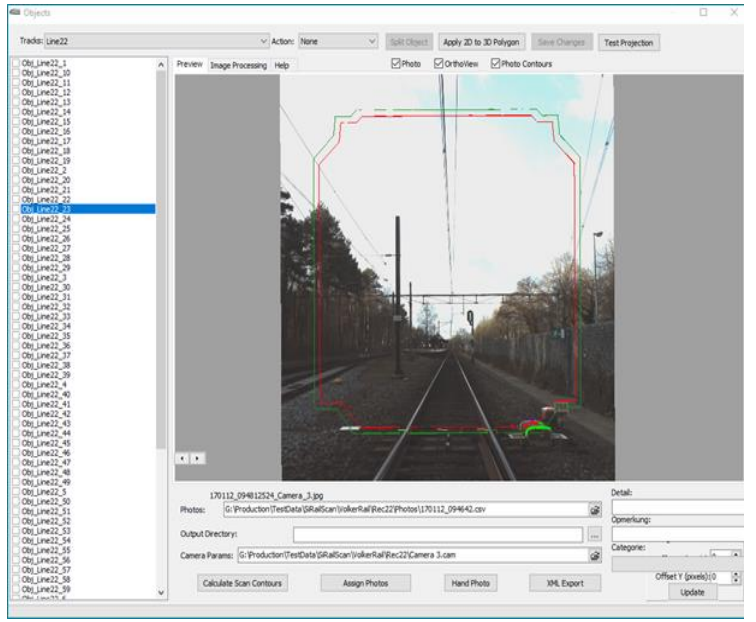
Advice restriction maxiumum Speed	El.Nr.	Station	Form	ve u/lu	max v km/h Ruck speed	cf-pos. ve	dcf o.	Track-elements R1	c1	length
	1	108.1+	95.00	SLINE	200	130		0	0	1449.9
	2	109.6+	44.85	CLOTH	200 200.5	130		0	0	65.0
	3	109.7+	9.85	ARC	200 237.6	130		-3917	40	138.4
	4	109.8+	48.28	CLOTH	200 200.5	130		-3917	40	65.0
	5	109.9+	13.28	SLINE	200	130		0	0	1412.1

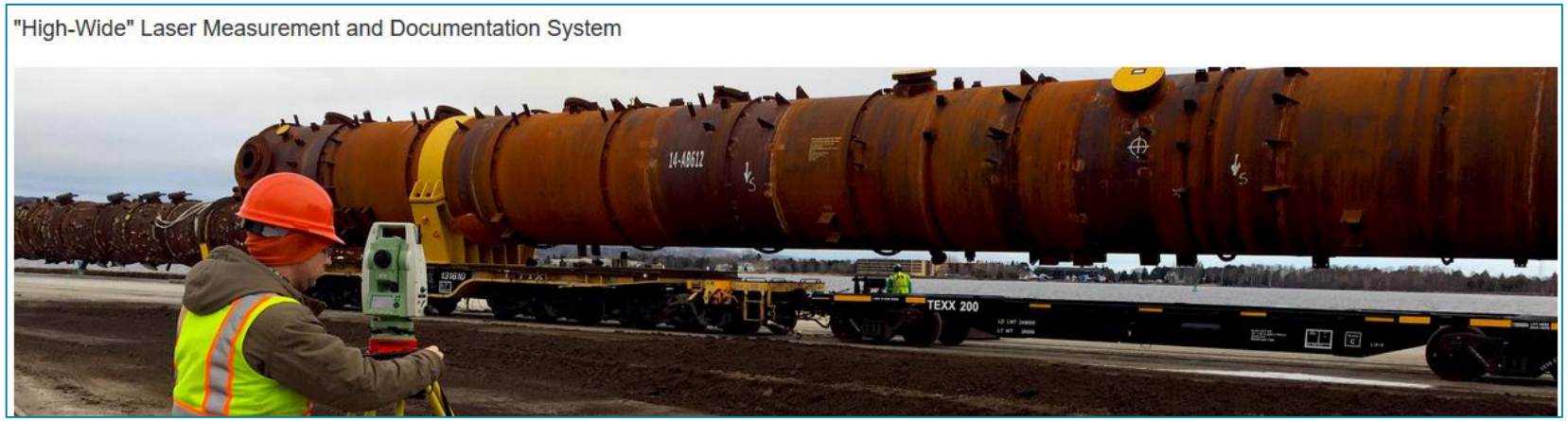


SiRail-Suite
New features 新功能

- Native Support of Pegasus Data (hpc) in SiRailSuite
- Leica Safeload-Integration in SiRailSuite

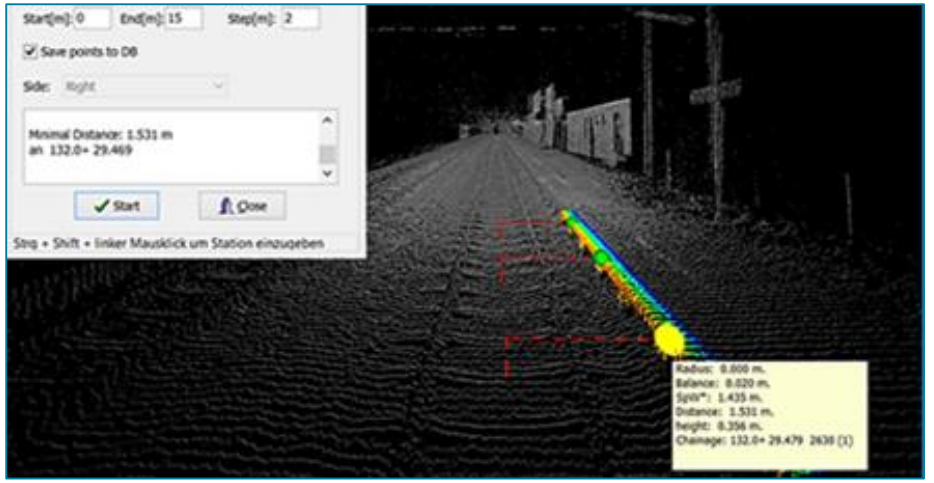
- 原生支持Pegasus产品点云数据
- 集成徕卡安全加密系统





- Specific new clearance-calculations, dependent on guidelines of railway-operators
- Individual templates for specific customers
- Automated platform detection in SiRailSuite

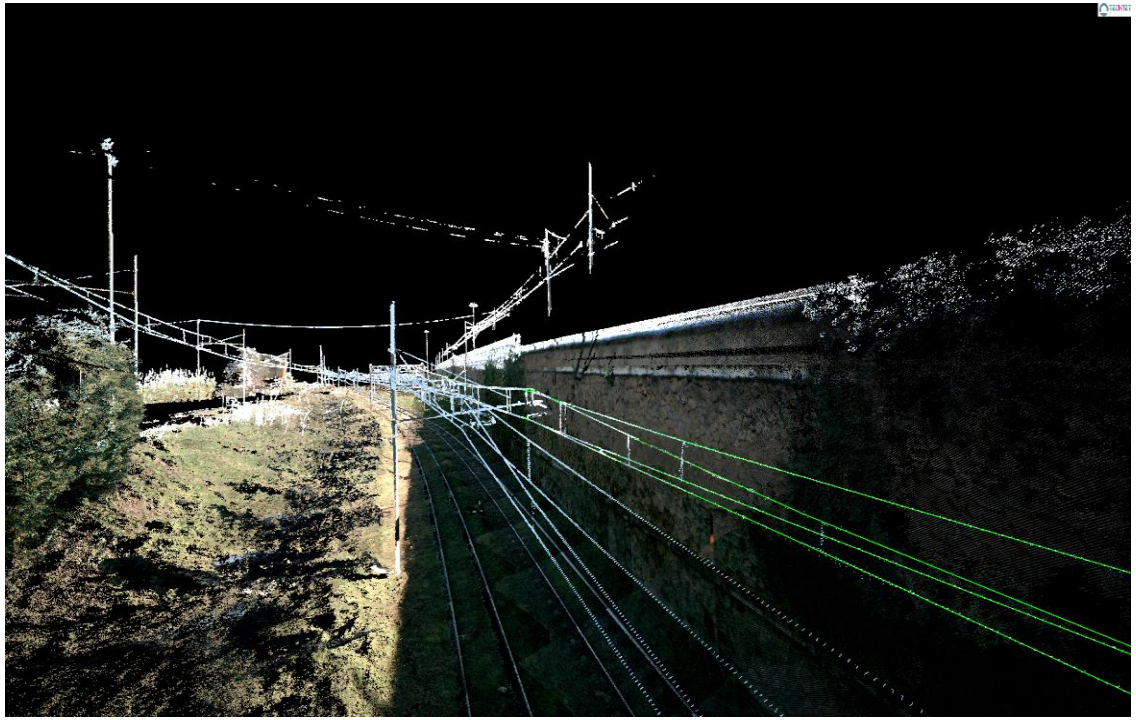
- 新的净空计算方法，基于铁路操作标准
- 为特定客户定制成果模板
- 自动轨面检测

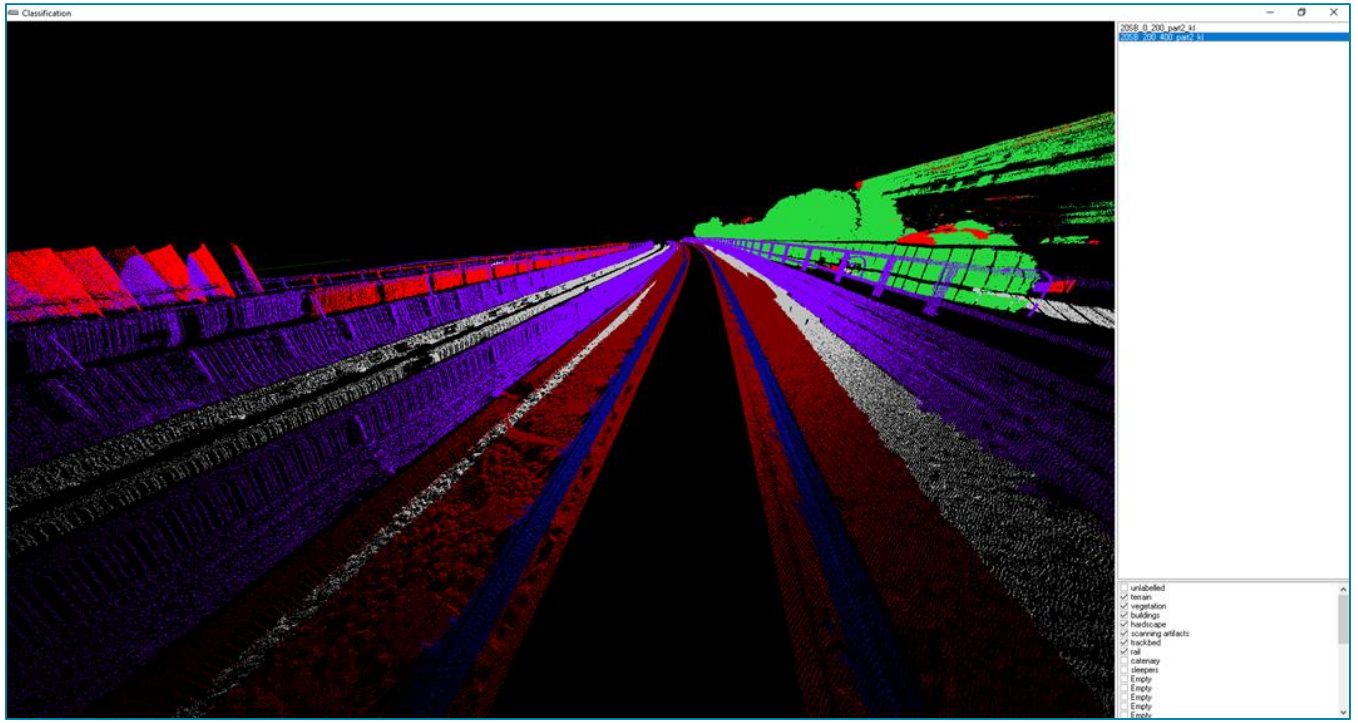


SiRail-Suite

New features　新功能

- Improvement of electric wire detection (precise detection of crossing wires above tracks)
- Classification of objects → Reduced processing time for calculations
- 提高接触网电力线检测准确性（精确检测交叉的电力线）
- 点云分类功能 -> 减少数据处理分析的时间





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SiRail-Suite

New features　新功能

- Significant reducing of processing time in SiRail-Software
- **Processing speed benchmark*:**

- 显著减少数据处理用时
- 处理速度评分：

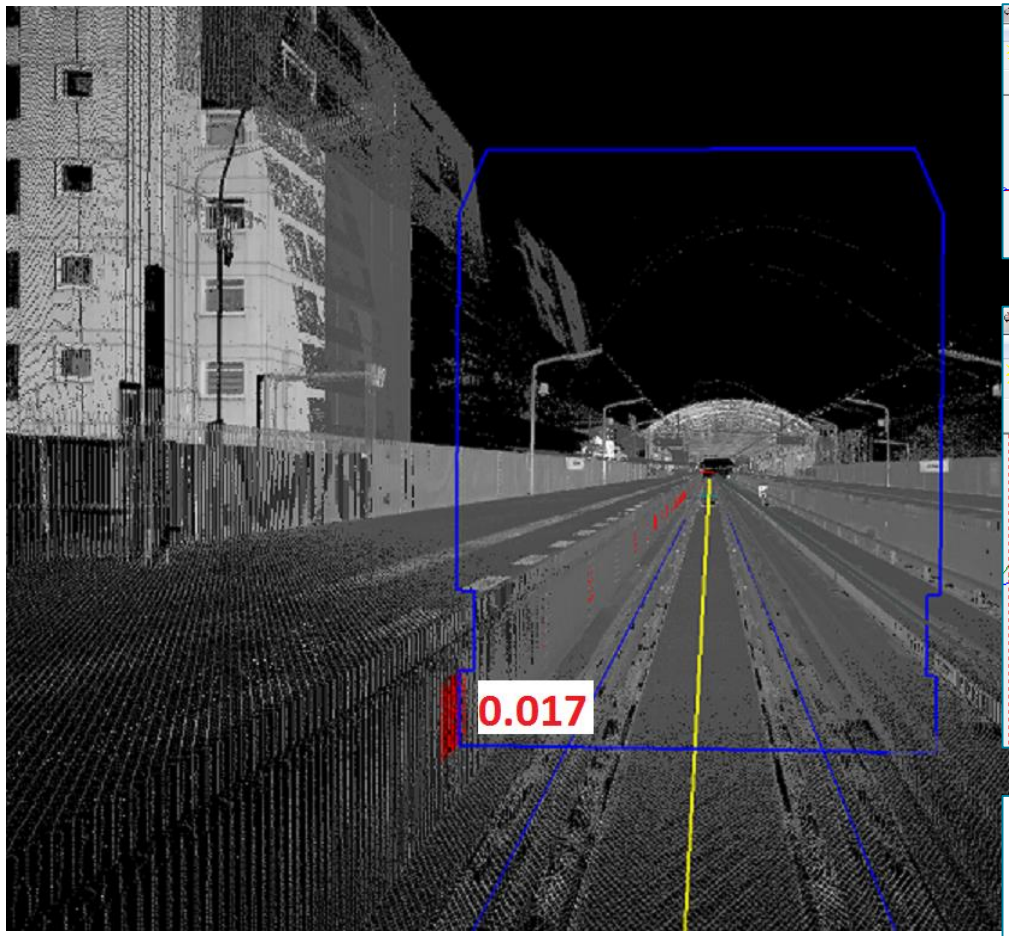
Feature Name 处理项目	SiRail 2018.1 [minutes 分钟]	SiRail 2018.2 [minutes 分钟]	Reduction 速度提升
Rails extraction 提取轨道线	32	7.5	4 times faster 4倍
Catenary wires extraction 提取接触网电力线	56	4	14 times faster 14倍
Cross-sections 提取断面	41	6	7 times faster 7倍
2d Clearance 净空分析	157	8	20 times faster 20倍
DTM (on trackbed)	107	< 1	☺

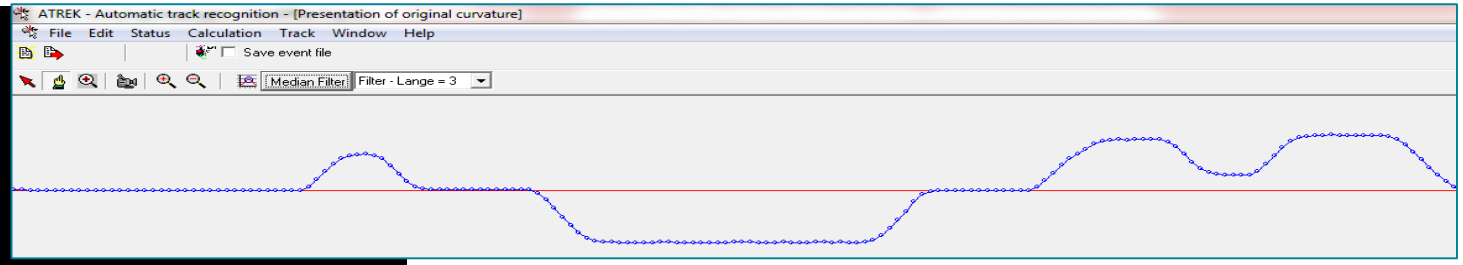
*Time measured on a 3 km tunnel dataset and processed on a quad-core laptop.
*测试条件：3公里隧道数据，搭载四核处理器的笔记本电脑。

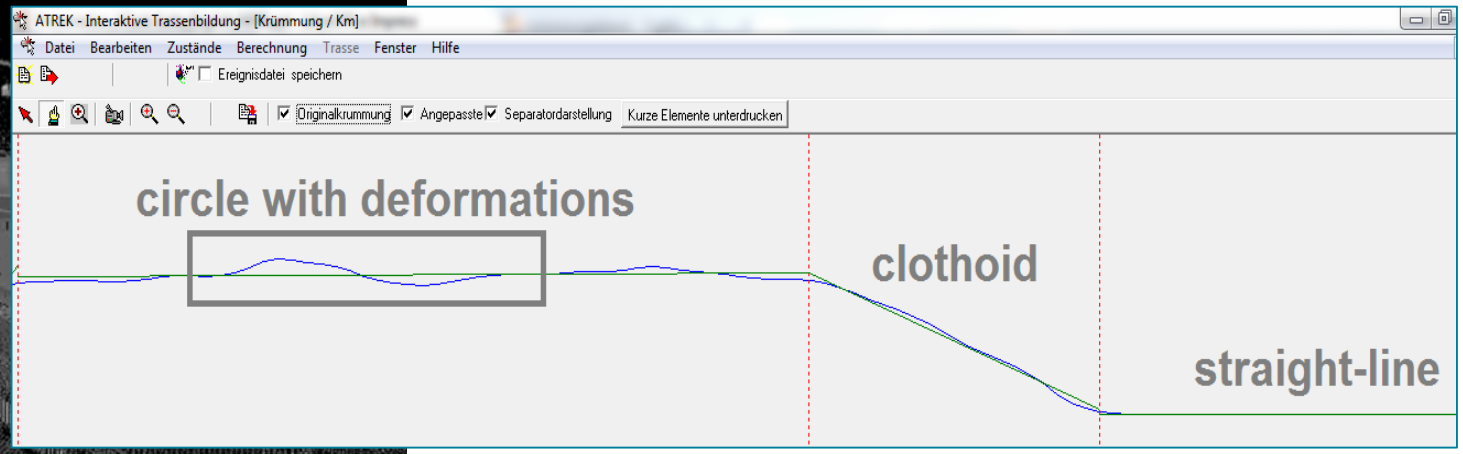
SiRail-Suite

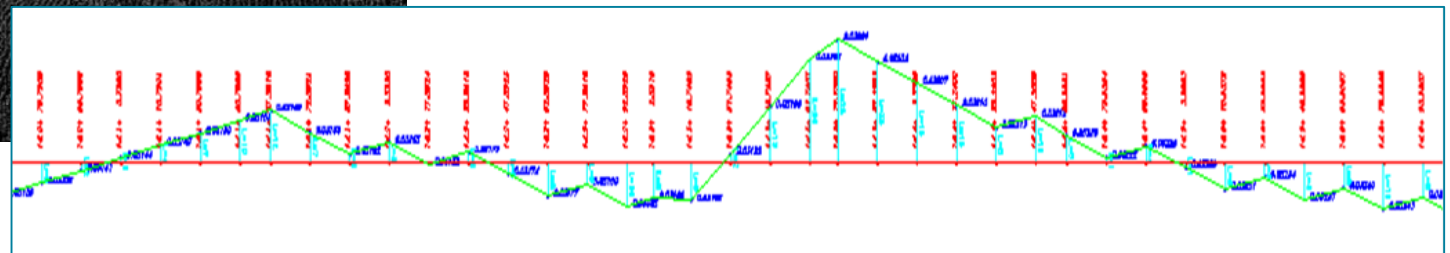
New Features　新功能

- Integration of ActiveX Plugin from ATrack (curvature-calculations, element-finding) into SiRailSuite Essential
- ATrack软件的曲线计算功能现在作为ActiveX插件集成到SiRailSuite Essential软件中了









SiRail-Suite

Current developements　发展现状

- **Calculation of Maximum Clearance Profile along a planned track**
- **Clearance-Analysis of every desired 3D-Object – example picture: wind blades transport north america**

- 计算沿线最大净空值
- 计算需要的三维物体的净空分析，图片为北美风扇叶片运输

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