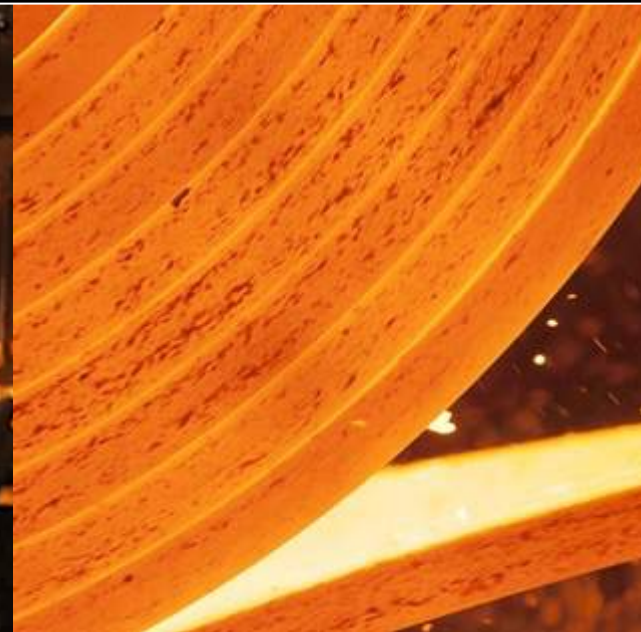


Automated Reduction of Surface Defects in Production of Ultra Low Carbon Grades for Automotive Exposed Applications Through AI

Dr. Falk-Florian Henrich, Founder & CEO of Smart Steel Technologies





AI IN STEEL

GENERAL APPROACH

AI IN STEEL

5-10% Performance Per Process

Large Additional Cross-Process Potential

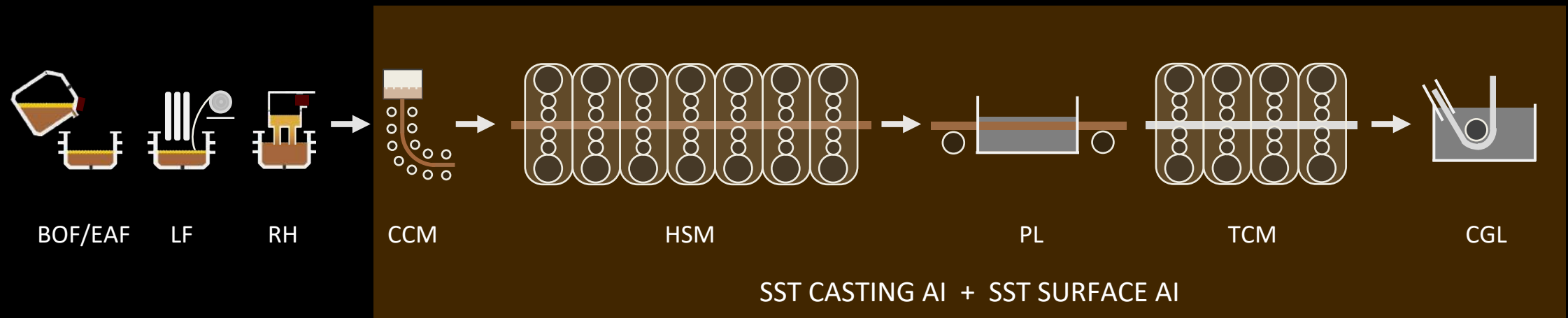
HELPING TRANSFORM THE STEEL INDUSTRY

Real-time AI-Based Production

Address CO₂ and Energy at Process Control Level

One Shop: Casting

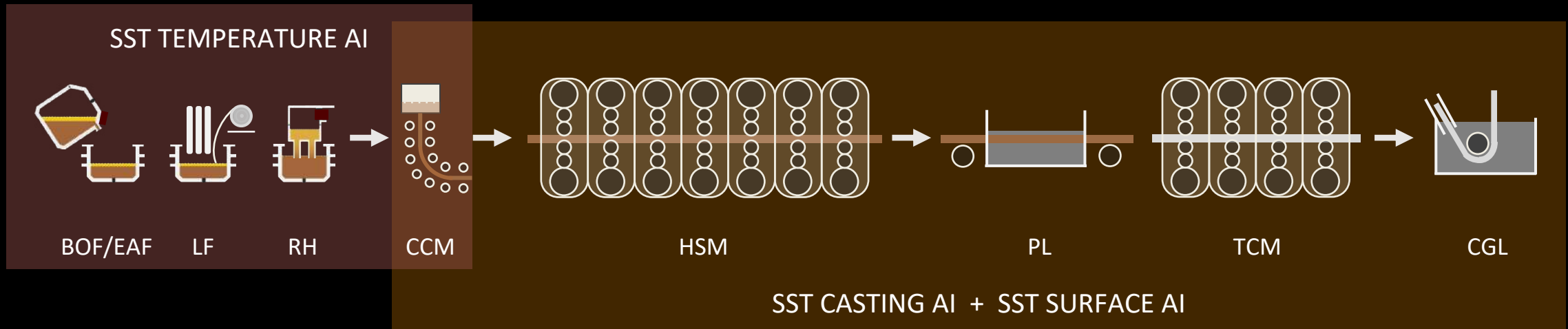
60% Surface Defect Reduction



RUNNING IN PRODUCTION SINCE 2020

Two Shops: Steelmaking + Casting

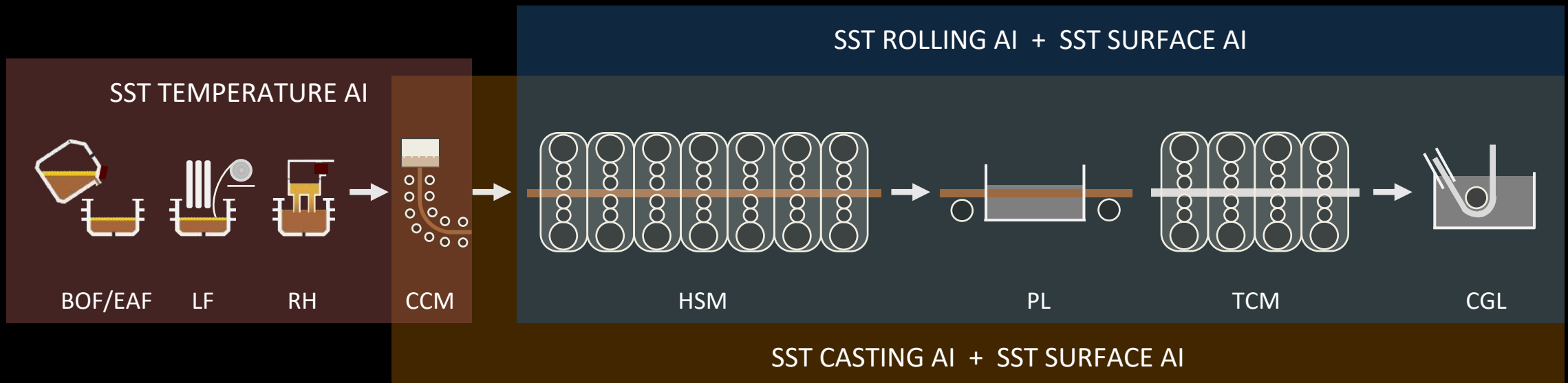
Energy, Cleanliness, Surface Quality



RUNNING IN PRODUCTION SINCE 2020

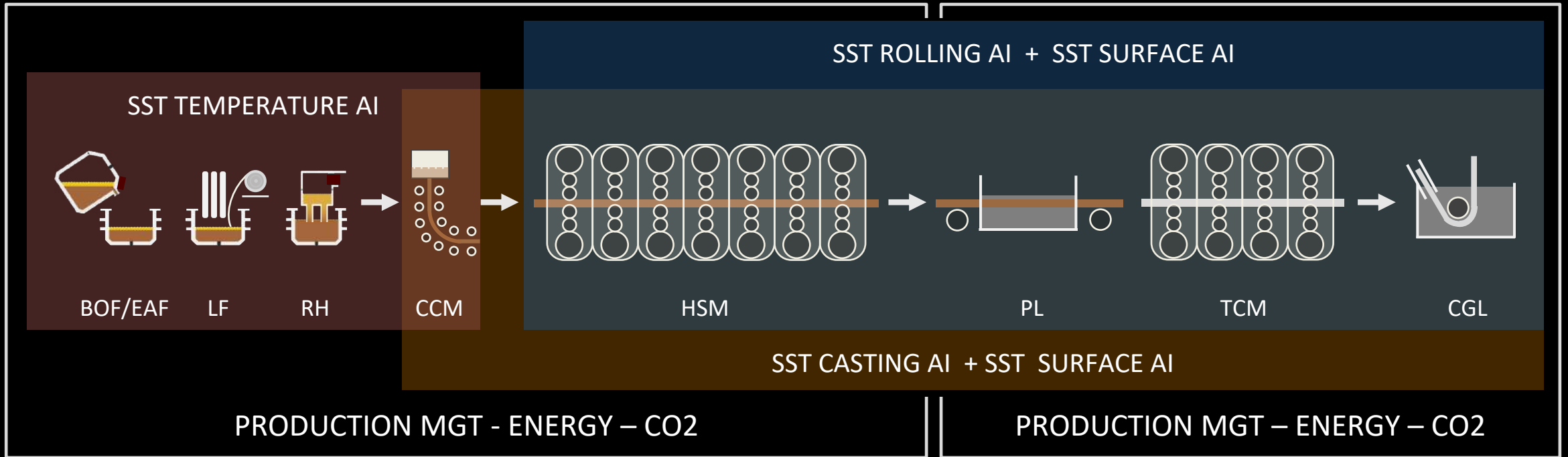
Three Shops: Steelmaking + Casting + Rolling

Energy, Cleanliness, Surface Quality, Flatness



RUNNING IN PRODUCTION SINCE 2021

From Rule-Based Production To Real-time AI-Based Production



COMING SOON

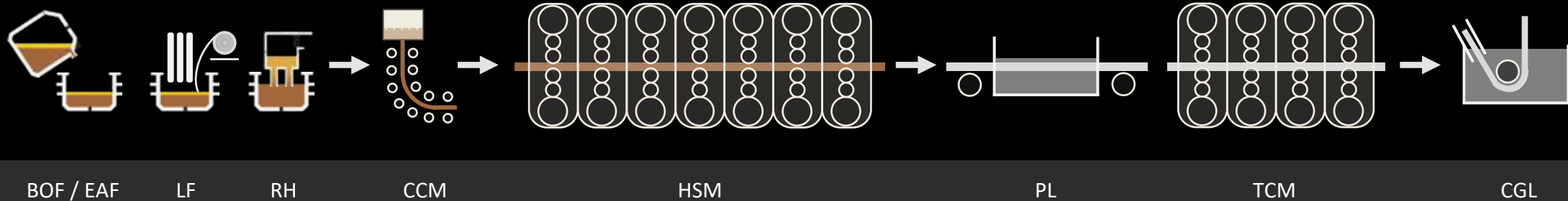


AI-BASED CASTING OPTIMIZATION

FLAT PRODUCTS

**REDUCING CASTING DEFECTS AND
DOWNGRADING BY 60 % AND MORE**

Economic Benefits of AI-Based Casting Optimization



CASTING OPTIMIZATION POTENTIALS

1. Quality / Slab and Coil Downgrades

- Defective slabs and coils have to be redirected to low quality orders
- Worst case: downgrading only after costly galvanizing process risks on-time delivery
- False positives: wrong downgrading of slabs / coils
- **FOCUS ON HIGH-QUALITY STEEL**

2. Energy / Hot Charging:

- Due to high level of casting defects slabs of certain steel grades are cooled down, inspected, repaired
- After reduction of casting defects additional steel grades can be hot charged to HSM
- Substantial energy savings

3. Production Throughput

- Start and tail out defects reduce yield
- Suboptimal caster operation reduces throughput
- Temperature deviations jeopardize stable casting speeds

4. Slab Repair Costs

- Frequent slab repairs indicate casting optimization potentials
- Slab repair increases production costs
- Slab repair increases logistics costs

EBITDA IMPACT: 8.4 million USD per year based on a typical 5 million ton / year steel plant

AI-Based Downgrading and Reallocation Savings for Automotive Exposed Steel

Focus on Galvanized Automotive Exposed, Highest Surface Quality

200,000 t

ANNUAL PRODUCTION VOLUME

Assuming a yearly production of 200 kt of galvanized automotive exposed steel, highest surface quality

20,000 t

DOWNGRADING / REALLOCATION

Assuming a downgrade / reallocation of 10 % of the annual production

12,000 t

DOWNGRADING REDUCTION BY SST

60 % reduction achievable through implementation of SST Casting Optimization AI

\$ 216 / t

DOWNGRADING / REALLOCATION COSTS

Assuming USD 216 / t downgrading costs



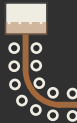


\$ 2,590,000 p.a.

YEARLY SAVINGS

Calculation: 12,000 t * \$ 216 = \$ 2,590,000



Data Platform for AI: Automated Feature Extraction and Cross-Process Data Matching

PROCESSES	LIVE DATA SOURCES	SST DATA QUALITY	SST DATA MATCHING	SST OPTIMIZATION CONTEXT
	<ul style="list-style-type: none"> ▪ L2 databases ▪ L1 time series ▪ Audio 	<ul style="list-style-type: none"> ▪ Validity checks ▪ Signal semantics ▪ Audio features 	<ul style="list-style-type: none"> ▪ Per heat ▪ Process time ▪ Process time 	<p>Complete description of process state and achieved quality per product</p> <p>„Product“ means: X cm cast strand or Y m hot strip Z m cold strip</p> 
	<ul style="list-style-type: none"> ▪ L2 databases ▪ L1 time series 	<ul style="list-style-type: none"> ▪ Validity checks ▪ Signal semantics 	<ul style="list-style-type: none"> ▪ Pos. on product ▪ Pos. on product 	
	<ul style="list-style-type: none"> ▪ L2 databases ▪ L1 time series ▪ Flatness 	<ul style="list-style-type: none"> ▪ Validity checks ▪ Signal semantics ▪ Diff Geo features 	<ul style="list-style-type: none"> ▪ Pos. on product ▪ Pos. on product ▪ Pos. on product 	
	<ul style="list-style-type: none"> ▪ Images ▪ Metadata ▪ Sensor values 	<ul style="list-style-type: none"> ▪ Image features ▪ Validity checks ▪ Signal semantics 	<ul style="list-style-type: none"> ▪ Pos. on product ▪ Pos. on product 	

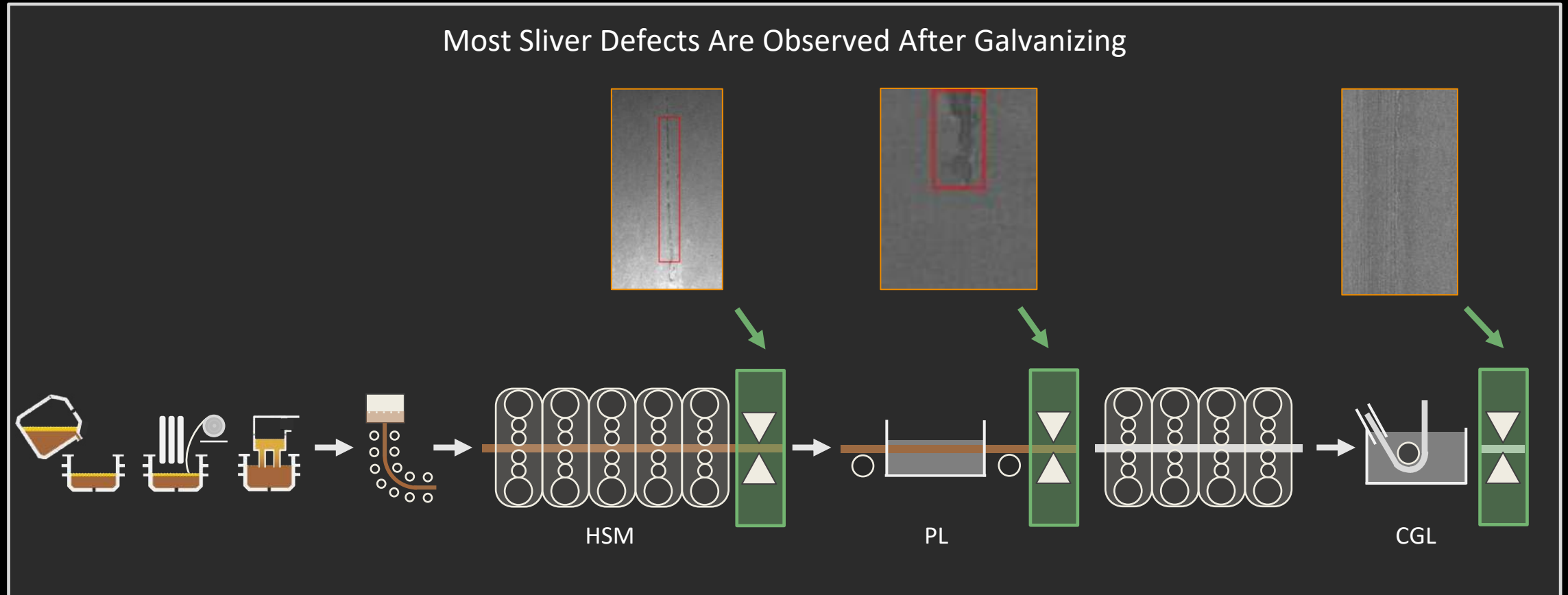


AI-BASED CASTING OPTIMIZATION

FLAT PRODUCTS

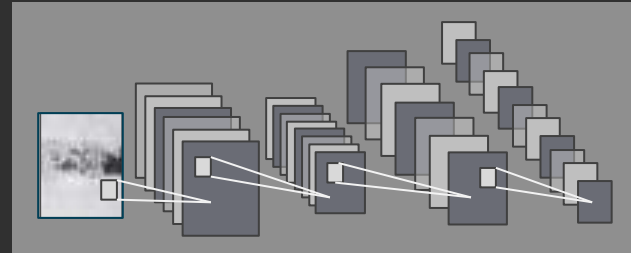
IMPLEMENTATION

Focus: Minimize Most Important Defect of Automotive Steel - Slivers



Theoretical mechanisms of sliver formation are well-known. Actual reduction of sliver defects is extremely hard

Install AI-Based Image Classifiers for Better Defect Classification



Scratch



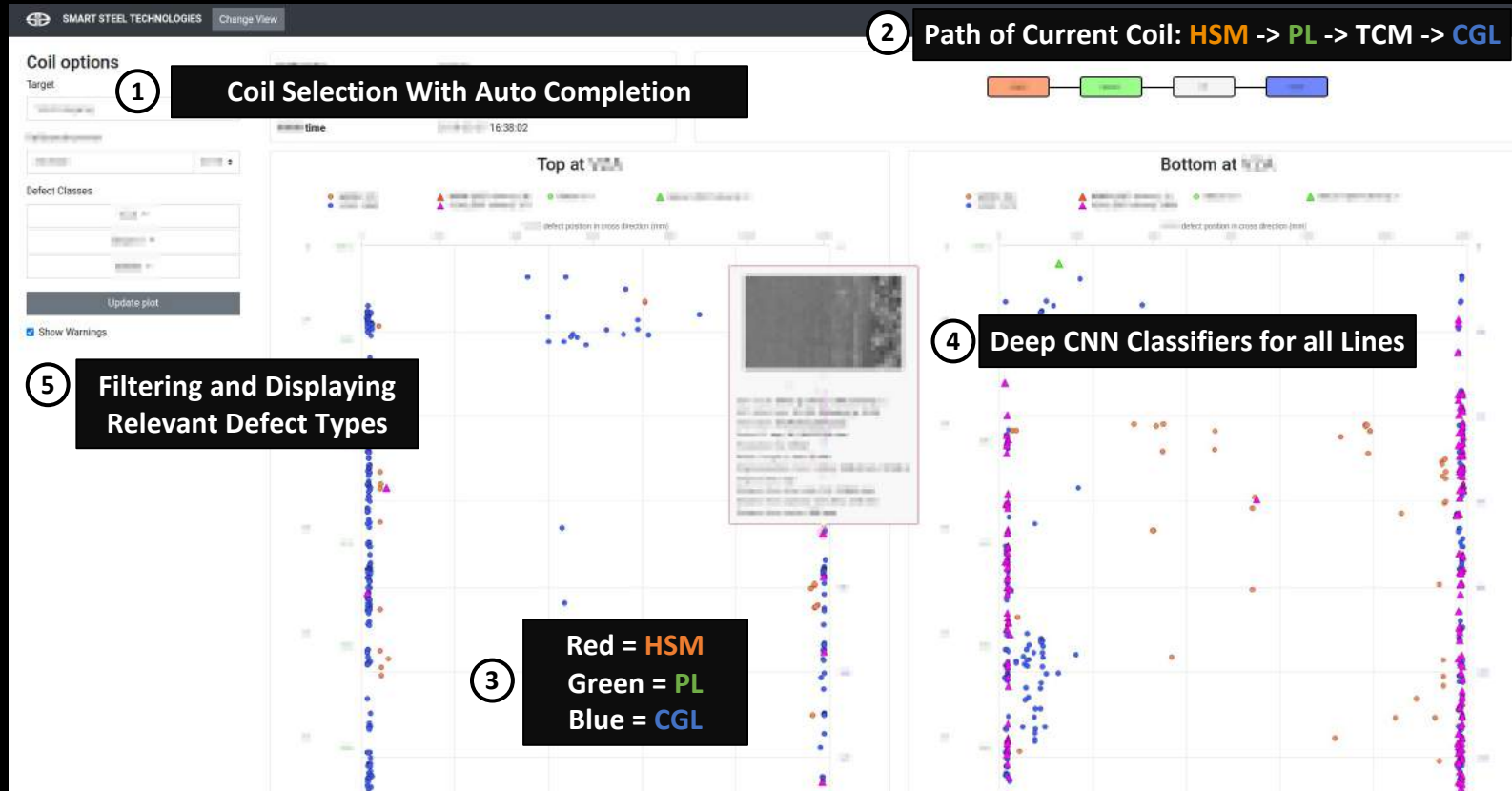
Sliver



- SST DIC_HSM: Deep CNN classifier for hot rolled strip - optional
- SST DIC_PL: Deep CNN classifier for pickled strip - optional
- **SST DIC_HDG: Deep CNN classifier for hot-dip galvanized strip - mandatory**

Outperforms all ASIS classifiers on all lines and on all defect types. Robust quality data for optimization

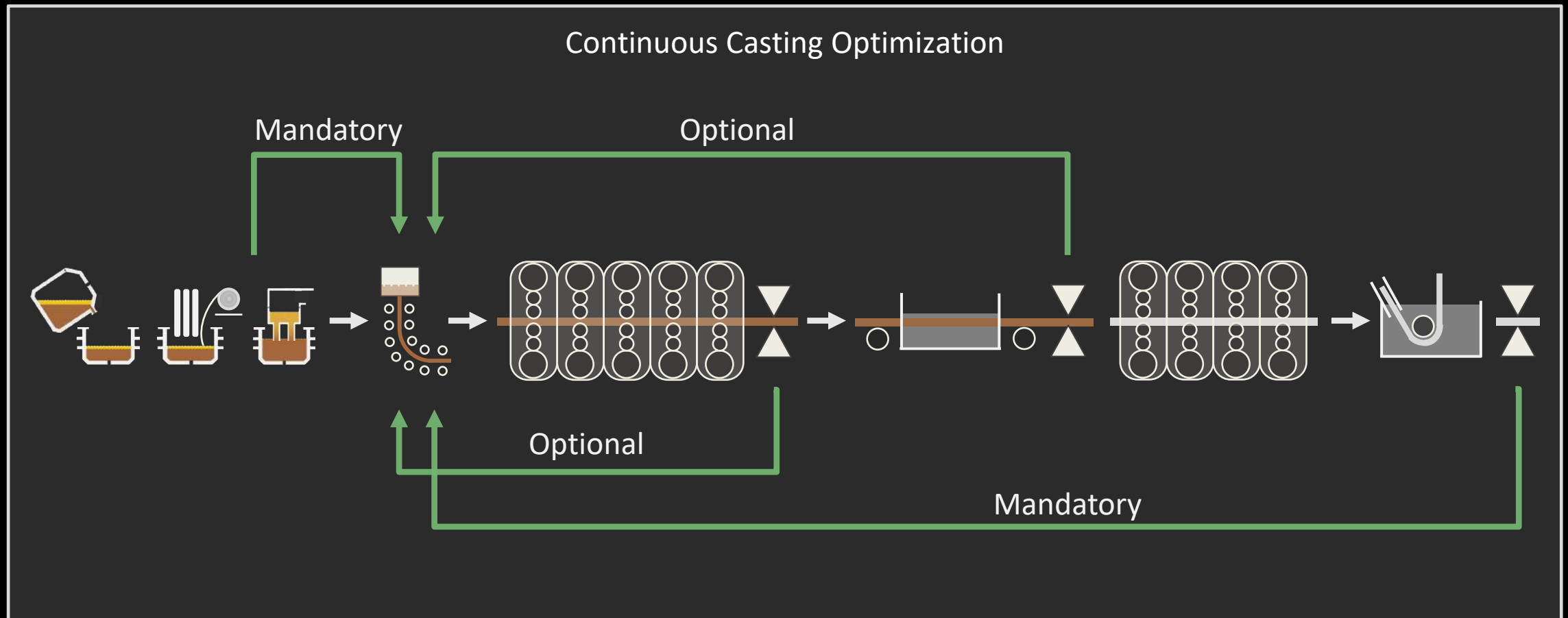
Set Up Precise Cross-Process Data Matching



- Precise matching of positions
- All production paths, including inspection lines
- Takes into account all strip manipulations
- HSM and PL ASIS can be considered in a later phase

Automated, position-based matching from casting to hot rolling to pickling to cold rolling to galvanizing

Automated Mapping of Data to Strand Position



Melt shop and caster Level 1 and Level 2 data as well as all surface inspection data is mapped to strand position

Inspect the Feature Space of the Caster Using Casting Analyzer



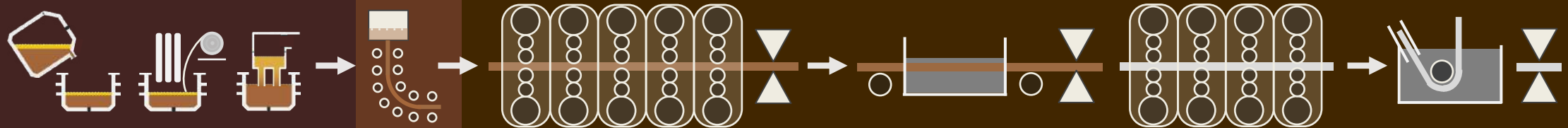
- Inspect influence of melt shop and casting parameters on surface quality
- Direct view from galvanizing line up to the melt shop !!!

Melt shop + casting data exactly matched to quality outcome described by surface inspection data

Fully Automated Optimization of Continuous Casting

AUTOMATED CONTINUOUS CASTING OPTIMIZATION THROUGH AI

LIVE TEMPERATURE GUIDANCE



DYNAMIC CASTING OPTIMIZATION + LIVE SURFACE DEFECT CLASSIFICATION

System dynamically computes optimal settings per slab/heat/sequence. Live modules provide operator support

Example of Dynamic Casting Optimization

SMART STEEL TECHNOLOGIES
SST Casting AI

	Start	Heat	Strand	Length	Width	Speed	RH Exit	SEN Min	SEN Max	MCW BSF	MCW BSL	SCW Z0	B Torque	UB Torque	Defect Red.
<div style="margin-bottom: 10px;"> Sequence Options View Mode Updated: Just Now <input checked="" type="checkbox"/> live </div> <div> Sequence ID Selection <input type="text"/> <input type="button" value="Search"/> </div> <div style="background-color: #333; color: white; padding: 5px; margin-top: 10px;"> Optimization Settings </div>	2021-03-06 23:11	9	1	788.8	1470	1.2	1.179	155	175	1400	1400	1367	76	83	97%
	2021-03-06 23:17	9	1	788.8	1470	1.2	1.179	155	175	1400	1400	1367	75	81	97%
	2021-03-06 23:24	9	1	1004.8	1470	1.2	1.181	145	175	1400	1400	1367	80	78	99%
	2021-03-06 23:34	10	1	1000	1470	1.2	1.181	145	175	1400	1400	1367	80	78	99%
	2021-03-06 23:43	10	1	1000	1400	1.2	1.181	145	175	1400	1400	1367	78	79	98%
	2021-03-06 23:52	10	1	1000	1400	1.2	1.181	145	175	1400	1400	1367	76	79	98%
	2021-03-07 00:01	10	1	1100	1400	1.2	1.181	145	175	1400	1400	1367	70	81	97%
	2021-03-07 00:12	10	1	1004.8	1350	1.2	1.184	155	175	1400	1400	1367	78	81	97%
	2021-03-07 00:20	11	1	1100	1350	1.2	1.184	155	175	1400	1400	1367	77	81	98%

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- Dynamic optimization of all settings, individually, for each slab / heat / sequence
- AI algorithm uses surface defect rates from hot rolling, pickling, galvanizing as target signals
- Live integration into production systems

Software Components for Dynamic Planning and Live Operation



SST PLANNING OPTIMIZER PRECISE PLANNING

Automatic Computation of Optimal Casting Parameters

For each individual heat and slab of each casting sequence:

- SST processes 100% of historic production data under consideration of steel grade, steel flow conditions in tundish and mold, position in sequence, and many more in combination with all quality inspection data
- SST automatically computes precise aim values for all casting parameters for each individual heat and slab in the current sequence to minimize casting defects
- SST automatically writes optimized aim values to production planning system



SST LIVE OPTIMIZER PRECISE OPERATION

Live Support for LF, RH, Caster Operators to Precisely Meet All Aim Values

- Live computation of optimal LF, RH exit temperatures under consideration of current TD temperatures
- Live tundish temperature prediction
- Live monitoring of process deviations



DIGITAL TRANSFORMATION FORUM FOR THE STEEL INDUSTRY



SMART STEEL
TECHNOLOGIES

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