Building Resilience Through Cross Industry Team Collaboration

Susanta Mandal (susanta@xlri.ac.in)  
XLRI School of Management  https://orcid.org/0000-0002-8859-1401

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Abstract

This paper addresses the key issues that go into the making of a heavy truck wherein steel made parts are used in the making of a chassis, so here the challenge for both for the bodyframe designer of the automobile industry and the sheet metal designer of the steel industry to come up with solutions that not only addresses problems relating to the lowering of the weight but also making it strong enough to bear enough loads taking into account changes in materials used, kinematics – differences in body angles that affects the velocity of the actions directed, how parts connected not only in the truck but also in the processes followed including changes in design and thereafter the prototypes to be tried out in the face of oncoming changes. A pentagonal framework that includes open cost modelling as well a business model that talks of creating a value streams in consonance with the changes for the uncertain future has been included.

Introduction

Building Resilience through Cross Industry Team Collaboration

Collaborating with Cross Industry teams other than that of your domain for innovating products has become very interesting with an approach that is “universal and easy to handle”.

In this paper the examples of two industries have been taken wherein Steel Company's Sheetmetal team works along with a Heavy Truck Manufacturing Company's team in developing the chassis of a truck.

Objective of the paper

1. Identify all the processes that can be taken as “indicators” that go into the development of the body frame of a truck using steel made parts
2. What are the “areas of dispersion” in the quest for innovation that can be investigated from the aspect of “productivity and influence”

Design of the study

1. First, this paper has been divided into four parts viz. a) Core Materials used that forms the genesis, b) Kinematics (motion of points, objects and systems of groups of objects) c) Connecting pieces (stacking up the things) d) Prototype Development
2. Secondly, an additional factor i.e. Open Cost Modelling has been used to understand where can we cognitively accommodate changes as we touch various exploratory endpoints.
3. Pentagonal Framework and a business model have been used to understand the changes that have the potential to succeed based on options and applications

Purpose of the Study

1. Think of ways to enhance the scope of your assets
2. Have an order that can be standardized as a process

Core Materials Used That Forms The Genesis

As the Chassis of a truck is the 2nd most expensive part of a truck next only after to the engine so coordination between a Steel Company and the Automobile Company becomes important.

Here we can have “Shared Storage Facilities” for both the “Sheet Metal Designer” of the Steel Company and the “Body Frame Designer” of the Automobile Company. Based on “Applications” both the companies will make investments.

The knowledge gathered and elaborated has to be stored within specific databases, encompassing all facets like the “design, redesign, assembly and the disassembly” times of target components and thereafter verifying their compliance with the target values.

Here both the companies need to map operations in terms of their criticalities i.e. high and low slopes to study “deformation, cleanliness, material type and coating/painting processes”.

Those working in different tiers of sheet metal design and testing can look for groups of products with similar characteristics to create “production batches that minimize the cost” of fulfilling production orders or negotiate with Body Frame Designers of Automobile companies and their associates like even their auto component manufacturers to go in for some adjustments in terms of shape, pattern, sturdiness.

Sheet Metal Designers can share data and have instant feedback with the Body Frame Designer Clients for studying product dimensions going out of tolerance limits highlighting the “Taguchi loss function” and how should they further design their experiments.

True earlier also even without this hyperconverged storage platform the executives of steel and automobile companies used to communicate but what difference this “Hyperconverged Storage Platform” will make. This so called platform will Help them Document new use cases, based on origin, scope, benefits and degree of complexity, create new schools of thought be it for “instance viewing of product, service and process innovations” as entirely different processes and the other viewing all three as essentially same processes
For instance both Sheet Metal designer and the Body Frame Designer can study data based on “the swiftness of the metal used in the making of the body frame a) ” like estimating the parameter of the forces that actually act upon the said structure , b) forces exactly “applicable on the said regions of control of the said structure created like chassis, suspension and bushings , c) what and how should the “different kinds of forces react against the layer that is coordinating the decision in moving of the steering and the axle “ andd) how should the “forces controlling ” get allocated/ distributed 8

Get Instant Feedback on the Milling Program

1 The Sheet Metal Designer of the Steel Company gets to know ” which continuous caster (CC) is to be involved ” what “kind of steel grade” is to be used “ number of predefined blocks ” whose latest finish time will actually precede the due date of the element being demanded by the Automobile Company 9

2. For instance develop table or indices for Heat affected Zones as to where to check the” hardening of the martensite islands that disrupt elastic/plastic flow” during loading , understand where to cut down on “martensite fraction” and where to “ increase the ferrite grain size” to decide on the strength of the Dual Phase Steel ( DP1000, DP1200) used for automotive products10

3. Get to discuss about the level of thickness and the hardness to be set , ”loss of standard rolling length of work rollers due to jumps,”and decide where to use Ant Colony Extended algorithm 11

Through Digital Twins both The ’Sheet metal designer” and The ”Body Frame Designer” can monitor and replicate physical plants, predict maintenance, increase the uptime where the equipment is operating at peak efficiency 12

Here bigger advantage will be from the development of “Numbered Point Clouds” where different kind of information can be stored from the Engineering side like – Specs, Drawings, Documents, Models, Analysis, Geotechnical information, Original Equipment Manufacture specifications 13

Both the steel and the truck manufacturer can have a dedicated cloud for cabin, cowling functions and ‘Local Business Logic” has to be used based on the problems faced in operations as a “part of the sequences that can be mapped” and structured . 13

Local connectivity in terms of providing the data to understand for both Automobile Body Frame Designer and the Steel Company’s Sheet Metal Designer , “what are the forces of reaction that act in separating a roll ”causing deformation forming stretch” and it is here that intelligence in the edge will help when it comes to deciding as to where should setting up of the position of the cylinder regulator merit ,share joint feedback about the function of the cooling bank , how much of water pressure jet be applied to remove the level of oxide layer to be applied on the slab as It can affect on the painting of the truck’s body or where should the ”looper be placed in fixing up of the strip tension”for reducing the thickness so as to bring down the weight of the truck if the speed of the truck has to be raised and the consumption of the fuel has to be brought down 14

Both be it the Sheet Metal Designer or the Body Frame Designer both despite having access to each other's data Graduation Intelligent Manufacturing System (DT-GiMS) processes15 will be there to ensure appropriate safeguards are in place through a “Distributed Grid Architecture” as ES ( Echo State POD) Kubernetes Operator - with “custom resource definitions” for providing User Access16

and set of “ controllers” working to analyse between two “States Of Queries” what is desirable and what is actually to be provided with three layers in place like , Input , Reservoir, Output ( Readout) Layer 17

Using Reservoir Computing principle. (a) A Recurrent Neural Network with fixed weights is used as a reservoir to encode information from a time-dependent input as well support the same with output weights trained with a linear regression. (b) Reservoir Computing flowchart. The successive reservoir states are first computed and thereafter used for training or validation.18

Even minute details like the use of lubricant to bring down gaps or anti peeling systems or using of the run out table for cooling or that of operating of the coffin schedule , every operation can be protected by tickets through Digital twins19

Sharing of data regarding “ influences of material properties “ the hardening exponent , the young modulus and the Yield Stress” and the parameters for forming “ feed amount per driving roll revolution and the level of friction coefficient “ to make the bumpers of the truck more sturdy and appear more lighter in terms of aerodynamic styling 19

Use Local AI toolkit ( a Raspberry Pi - the USB accelerator, to piece things together to form images to get projections on the roll force,20 the roll moment and growth rate of the ring diameter with the increase of hardening exponent or to measure deformations21

Innovations like The Self-organizing map (SOM) support vector machine (SVM) models , multilayer perceptron neural network (MLPNN where weights are assigned adjusted using backpropagation Update technique with area control error (ACE) to forecast day-ahead prices of electricity , arrival of raw materials to plan production schedules . Even Radial Basis Function Network ( is a type of feed forward neural network composed of three layers, namely the input layer, the hidden layer and the output layer.) can be used to study the tension on the material , thickness of the material, regulate the armature and field currents applied to the motors.22

Here through Digital Twins , Point Clouds , common Dashboards both Steel Industry and the Automobile industry executives can detect anomalies and cross check with each other firstly based on ongoing process phase, secondly using classifiers on the input data as “Expected”, “Warning”, or “Critical” and allowing
decision forests algorithm and decision jungle algorithms to decide. 23

With Additive Manufacturing coming in “complex structures using multiple materials without assembly or excessive waste” where even interferences in the form of vibrations matter or where “noise and high temperature” and communication over the range is a concern like where a furnace is used 24

Places where Authentication is required like the operations in Blast Furnace in the Steel Industry can be registered on the blockchain can be verified by the Body Frame Designers (Cab and Cowling) in the Automobile (Heavy Commercial Vehicles) and come from sources using their own private keys25

And jointly developing solutions for “charge program, raceway program, gas cleaning program, blowing program” and suggest where are the steps that need “a new string of manufacturing set-ups” or places / steps where the string of manufacturing set-ups needs to be reworked. In this way Given the cost of each block, an initial solution corresponding to a best combination of blocks is found by solving a shortest-path problem. 26

Even images from Real-world image Denoising (RID) dataset containing 200 pairs of high resolution images with diverse scene content - like picture taken from the angle where the ladle, slag drain, bosh is placed can be shared 27

Problems like heat loss, gas velocity in the tuyere or infrared thermography can be jointly discussed in how to reduce “the risk of burning” for the particular part of a would be body frame. 28

In this way we allow provider-to-provider (or B2B) business models to take shape that includes this kind of value co-creation [e.g., [29], [100]] between highly trained professionals 29

Kinematics

Let us divide Kinematics into areas like “Engine Block, Gear Box, Rear Axles, Propeller Shaft and Chassis Development”

First we have to understand as to what does Kinematics mean

It means handling “Changes in motion” through inputs like “changes in energy and momentum” and how can directions be influenced through continuous speed curves that can be used to link positions. We should also keep our eyes open to inverse kinetic measurements like “Smoothness of the motion and temporal coherency” “Concept of the space of Targets” and the extent to which the “End Effector” can reach.

Added to this the difference comes in from how robots are able to generate “velocities” that can span the complete tangent space where the inflexion is taking place. 30

So where can all Eight of these can make a difference - ( 1. Engine Block- Power Plant Designer, 2. Clutch , 3. Gear Box Designer, 4 ) U joint, 5 ) Propeller Shaft Designer, 6 ) Rear Axle Designer - from the automobile industry and 7 ) Sheet metal Designer and 8 ) Blast Furnace Operator from the Steel Industry can make a difference. 31

So serious thinking should get in the areas of “joints” and how they offer us some constraints, and “where is the target” being oriented and where it cannot be reached “distance between the (sub-)root and the target set; even if this distance is larger than the total sum of all the inter-joint distances even if target is located at a distance from the root, understand whether we can bend the kinetic chain to reach the target even if the distance is smaller be it inside the inner circle of the radius “or outside the outer circle of the radius.

Prediction Engines have to used to analyze “stride to stride time intervals”, Stride length and Step width fluctuations, Joint angles, Trunk Accelerations. Relation between discrete and continuous variables

Stride characteristic variables are “discrete variables” and the “joint angles and trunk acceleration” signals are continuous variables. 32

With this comes in the bigger issue as to how do we “decompose a rotation” through a reference coordinate system in a manner to avoid singularities. Where do we use the Jacobian matrix for the robot, which maps “joint velocities into task space velocities” and how do we calculate the “mass distributed” when it comes to “controlling the position of the centre of gravity” of the articulated chassis of the truck. 30

Should SDLS (Selectively Least Damped Squares) be used as it will cause the chassis of the truck to “oscillate less” during jerky movements, by calculating the relevant smallest singular values and their corresponding vectors through Cholesky decomposition where the damping factor works by adding rows and columns for the triangular matrix and its transpose. 30

We can use Multi-variate Gaussian distribution models (MGDMs) a using a ‘sport’ data set of “n” no of different sequences for as many DOFs (Degrees of Freedom) identified for the chassis and the Cabin Cowling system movement especially what happens in the joint space between the target and the end effectors. Here Augmented Reality (AR), Virtual Reality (VR) and Mixed Reality (MR) can be used to identify as many “no of frames of poses” (FOP) for Turning Radius Problems to calculate the Mean Square error during turning, the joint space “MSE in radians” and “target distance MSE” in metre. 33

The Question how should the Tools (spare parts) coordinate when the truck accelerates or deaccelerates, minimum “time feed rate” profile by intersecting all the constraints due to the drives in an iterative algorithm, where both “tangential jerk and axis jerk” are taken into consideration.

But what happens when angle profile is not that smooth and sharp corner of the said angle can consider “tangential value owning to singularity near the areas of connection”, create problems when the stage for acceleration and deacceleration varies. 34
Low-offset hypoid gearset (style of spiral bevel gear whose main variance is that the mating gears’ axes do not intersect).

Are rear beam axles to be replaced with “3-mount independent rear drive axle module” where in ultra-lightweight thin metallic carrier housing is used along with reducing load difficulties in a multi-drop work.

Warning if a truck is becoming unstable during tipping, what should be done to stop the front axle from being overloaded, what should we do to stop torque from the dashboard.

Load cells is also a wonderful idea as sensors will not work if the truck is going on and off a landfill site. Inclinometer can sound a warning if a truck is unstable, indicating a need for corrective action.

Having sensors to measure the suspension’s deflection as a load is imposed to that of having the front, rear axle weights and the gross weight, displayed on the dashboard.

Load cells can have functions like “neutral at stop,” that will reduce or eliminate the load on the engine when the said truck is stopped.

What if we break up truck duty cycle based on operations like for “refuse, distribution, transit bus, construction and dump truck operation” where varying load and terrain conditions for heavy-duty trucks.

Or should we look at ten-speed transmissions with “closer spacing between the gears” allowing the engine to operate in an optimal range at all times.

What if the gearbox does not have a clutch, and shifts are synchronized using the traction motor.

Or should we look at ten-speed transmissions with “closer spacing between the gears” allowing the engine to operate in an optimal range at all times with varying load and terrain conditions for heavy-duty trucks.

What if we break up truck duty cycle based on operations like for “refuse, distribution, transit bus, construction and dump truck operation” where software can have functions like “neutral at stop,” that will reduce or eliminate the load on the engine when the said truck is stopped. All what is required are “infinitely variable combination of shift points” supported with real-time operational data.

If controls can manage fuel injection so why not sense the load capacity that can either lift or lower the axle without relying on the driver, maximizing time with required combination of shift points.”

Say from 6-speed automatic transmission to 8-speed automatic transmission which there in cars but if tried out for trucks it will increase the ratio between the top gear and the lowest gear contributing to faster acceleration and climbing performance in low gears.

Just look at optional hydraulic impulse oil storage (HIS) opens up the possibility of the “start-stop function”, multiple power take-up elements including the torque converter, the hybrid drive, and the integrated power take-up element can really contribute.

Power take-up elements can be in the form of electric oil pump (EOP) and an algorithm controlling for the automatic transmission (AT) considering the flow rate and efficiency calculated according to the operating temperature of the AT fluid.

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If controls can manage fuel injection so why not sense the load capacity that can either lift or lower the axle without relying on the driver, maximizing time with a raised axle and enhancing traction.

Gaining traction when backing under trailers in soft soil or low traction conditions.

Improving maneuverability when the lift axle is raised.* Saving money on tolls where lift axles are not charged if lifted.

Having sensors to measure the suspension’s deflection as a load is imposed to that of having the front, rear axle weights and the gross weight, displayed on the dashboard.

Load cells is also a wonderful idea as sensors will not work if the truck is going on and off of a landfill site. Inclinometer can sound a warning if a truck is unstable during tipping. What should be done to stop the front axle from being overloaded, what should we do to stop torque up of the packing plate as too much rubbish is packed into the body as a result. Having “a blade to eject to distribute the load” if the axle is overloaded or do we diminish “load difficulties in a multi-drop work”.

Are rear beam axles to be replaced with “3-mount independent rear drive axle module” where in ultra-lightweight thin metallic carrier housing is used along a low-offset hypoid gearset (style of spiral bevel gear whose main variance is that the mating gears’ axes do not intersect).
Or let us even look at this way that instead of simply letting the trailer axles roll, cannot we think of integrating an electric machine there, with the e-axle, energy can be obtained when braking, which can be used to supply the units of the truck. Just think of refrigerated trailer, the savings can amount to 10,000 euros per year. If the cooling system is operated with the generated energy, this could save up to 9,000 liters of diesel fuel per year.  

Let us look at the concept of Command Area Network being fitted to the trucks of rear-axle drive with new set of chips allowing for decentralized over-the-air updates via the cloud to work. Additional interfaces such as CAN with flexible data rate (CAN FD) allowing for the eLSD (electronic limited slip differential) to be networked with the integrated brake system IBC (Integrated Brake Control) can work wonders.

Just think of Cold-formed rolled spline (cold rolled steel) being used to eliminate the need for machining, which can cause stress fractures and premature failures and look at "Extra-quiet gearing for diminished noise, vibration, and harshness (NVH); and a wide ratio range to cover a variety of straight truck applications.

Drive Axle with differential lock of higher ratios and better spread.

HEAD TO HEAD: Like many, Galaxy Insulation and Dry Lining prefers the extra capacity of 26-tonne 6x2s to simple 18-tonners, running two of the main contenders. But which is best?

Concern that extra weight can potentially increase tyre wear on the rearmost axle, even when the vehicle is unladen or should we also not look into the aspect of how to go about "improving traction and aiding of manouevrability "when the truck has to move into space that is confined and does "hydraulic steering rear-axle" certainly help in terms of improving "the turning circle" and reducing tyre scrub. How does additional overhang bother, so we not think of having an option that locks up the rear axle via a dash button to overcome this problem.

Other Considerations:

1. How can the air suspension distribute the additional load between the axles.
2. High capacity front axle is essential if the vehicle is to be used on multi-drop work with relatively heavy cargoes.
3. Does the truck operate without the forklift on the back. As this can change weight distribution and handling characteristics of the vehicle.

HEAD TO HEAD: Like many, Galaxy Insulation and Dry Lining prefers the extra capacity of 26-tonne 6x2s to simple 18-tonners, running two of the main contenders. But which is best?

4. Should we use Electric Turbochargers or Two Stage Sequential Turbochargers. In Electric Turbochargers an e-booster - separately forces air into the impeller of the smaller of the engine's turbochargers, This e-boost has to be powered by a separate 48v electrical subnet system.

Connecting Units

Different Units in factory how should they be connected.

Like Units (Hot Rolled, Cold Rolled, Blast Furnace) in a Steel Industry focus on Sheet Metal be connected with the units (Engine Block, Axles, Gearbox) in an Automobile (heavy vehicles) Industry focus on feasible and agile body frame of main and sub parts

Clarity: where are the "opportunities to integrate the platforms", "solutions to analyze real time activities carried out in processes throughout the logistical ecosystem", collect large information and process them regarding "location and changing physical parameters"

Discrete Finding: understand where to build "intelligent value streams" to fill the time gap between the occurrence of events and their corrective actions. Get the best out of speed, location and productivity of resources in real time.

foresee the value of technologies like Blockchain - where one can have access to the network to see what is happening at any given time or to follow any changes in real time.

Why Blockchain: It will make us have the benefit of "Decentralization" multi-centre collaborative authentication model is proposed

Each time stamp incorporates the information of the previous timestamp into its random hash value to enhance the previous timestamp information. Because of the uniqueness of the data, the "traditional trading mode" and "platform operation mode" cannot well protect the interests of both sides of the transaction and there are certain hidden dangers in the transaction process.

So what are the challenges, "Adaptive rent-seeking" and "matching between resources supply and demand sides".

See Public Seeking Platforms have not established "Adaptive Rent Seeking" and "matching mechanism of the resources".

Characteristics of Business Resources such as "dispersity, magnanimity, randomness, commonweal and heterogeneity".

Questions are raised on the "utilization ratio" and "overall benefit of the system are not ideal".

It will increase the transaction cost, also make resource demand and supply parties to withdraw from the "strategy choice behaviour" of the public service platform.
The platform is not that secure which can cause – "unauthorized access" to and tampering leading to "illegal misuse" or "misappropriation of the right to allocate and use resources" and the right to deferred payment, Distributed Scheduling

We can have a “computer distributed data storage, point-to-point transmission, encryption algorithm, consensus mechanism and other technologies.” Block chains can be generally understood as an “Excel table without central management,” which has limited functional permissions, such as “add”, “query”, “modify”, “delete”. The table also stores different contents for different tasks. In essence, a block chain is a rule, and in general, it is a process in which a group of people who abide by the rule jointly record contact information.

Let us understand how Blockchain can make a big difference

Blockchain is composed of blocks, From the name itself, the block chain is a system composed of blocks and linked by chains;

from the form of expression, the block chain is a distributed account; from the technical point of view, the block chain is a distributed chain database, from the point of view of users, block chain is an information sharing platform without third parties.

Block chain is the next generation of infrastructure in the process of social development, is an infrastructure to solve the credit problem, based on such infrastructure all social activities will be credible, people can rely on across the credit barrier to return to the essence of things.

Core Aspects

1. Distributed account books. Transaction accounting is performed by “multiple nodes distributed in different places, and each node records a complete account”, which can participate in monitoring the legitimacy of the transaction.

2. The transaction information stored on the block chain is public, but the “account identity information is highly encrypted” and can only be accessed under the authorization of the data owner,

3. “checkout nodes” reach a consensus and can determine the validity of a record

4. To give intelligent contracts a shape we can have some “ predefined rules and clauses to be executed automatically ”.

5. Even this Internet of Things (IoT) may not suffice, even though it collects and manages all the information through a central organization, there can be "lifecycle and security problems of the equipment "

6. Through Blockchain we can have a “centralized area of architecture”

The data blocks in the block chain are connected sequentially and form a data chain which can not be tampered with. The timestamp attaches “a set of real data which can not be forged for all transactions”. It is very helpful to crack down on counterfeit and inferior behaviour in real life.

Both The Steel and the Automobile Company can have Flexible programmability which will help them to "standardize the existing market order". At present, the “market order of the society is still not standardized enough, such as the government's subsidies or tax or duty exemptions for Steel or Automotive Components, the misappropriation of charitable funds and so on. Means both the companies “will have a standardized form of Market Order”. By using the “programmable property of block chain technology”, we can “embed a piece of code” to specify the “future use scope of the assets” while transferring the assets, so as to solve the above problems thoroughly.

At present, using block chain technology, III M has reduced the time spent on dispute settlement from more than 40 days to about 10 days and saved about $100 million in costs. Combined with the Internet of things technology, block chain can also achieve strong sharing of logistics information and coordinate logistics activities. Manufacturers and retailers can also significantly increase the accuracy of demand forecasting and inventory replenishment capacity.

Maersk, a world-renowned shipping company, is working with MM to establish an alliance chain among customs, ports, freight forwarders and agents to track the dynamic information of tens of millions of shipping containers in real time. The technology is expected to save about $1.0 billion for Maersk's shipping business.

From three aspects: object dimension, attribute dimension and function dimension, the overall model of supply chain logistics information resources management can be analysed.

Block chains have transformed the “information ownership model” from single owner ownership to “account information shared by all participants” throughout the life cycle of the transaction.

It is based on the state of information rather than the transmission of information. In the past, vague information is now clearly visible. At the same time, the block chain is the public issue of ledger, ledger is a decentralized structure, neither party has the ownership of ledger, nor can it manipulate data according to their own wishes.

Both the Steel Company (Raw Materials and Product Mix Grade (Electrolytic Cleaning, Push and Pull Pickling, Moulding Finishing Lines) and the Automobile Company (Diesel Engine - Connecting Rod, Piston, Starter Solenoid, Starter Motor, Crankshaft, Crankpins, Push Rod, oil pan, oil drain plug, oil screen assembly; Axle – ring gears, spur gears and worm gears) can allows every commodity to have a unique identity ID. Users get the goods, sweep this ID can be traced back to the commodity's origin, raw materials, suppliers, storage, transportation, production and other information, and these information can
not be tampered with. Because identity D is unique, fraud or fraud, or illegal transactions, can be detected. In addition, block chains also speed up the response to emergencies.

Now hear Every Part of a Heavy duty Truck will "open up as data islands, link digital assets, and "build a new mode of supply chain finance".

Connect fragmented databases ( Engine Block, Axle, Gear Box, Propeller Shaft, Cabin and Cowling ) into a network, and to protect the private information of enterprises in the supply chain through encryption algorithm.

Here the role of the Data Played becomes better,

How Does The Automobile and the Steel Company stand to gain

1. For example, the core enterprise ( truck manufacturing company ) can inform the supplier of the goods ( steel company ) producing "ultra-light thin panel steel" needed, but will not disclose the specific name of the supplier to other enterprises ( tyres or battery or bearings or head or tail lights, disc or drum brakes, upholstery items, Windshield ) in the ecosystem.56
2. It Will help both the Truck Manufacturing Company and the Steel Company to explore and develop options for more possible uses like enterprises "to use data for credit reporting", thus "promoting the establishment and prosperity of large data trading market".

How it will benefit both the Truck Manufacturing Company and the Steel Company

Develop Multi Center Access Points

Each node in the block chain contains a complete set of data, which can be synchronized and checked in real time among multiple enterprises.

Data Stored is more secured

Say if the information stored in one node is destroyed, the data security of the whole network will not be affected.

Low cost in disclosing data – create several layers or filters for disclosing of data – "consensus module, certificate module, log module, memory pool module, intelligent contract module, peer-to-peer computer network module, distributed data storage module, block management module," to get the data filtered out from each module – "proper justification has to be given"55

Like A tyre supplying company can in no way ever get to know the "terms of credit" and "periodic circles of purchase" when it comes to dealing with an "battery procurement company"

Like Even deals undertaken with Two Tyre supplying companies will be more "intelligently managed" based on actual needs, specific needs like procurement funds financing, warehouse receipt pledge financing, cross-enterprise points exchange, collaboration mechanism separates the core and non-core processes or things, and some simple routine queries, authentication and other operations are performed by ordinary nodes.55

Even smart contract governance can work with "actor certification", and scope to change the rules with some form of consensus process. A smart contract between two trading partners can legally update the automated record of what goods were bought, sold, and delivered in real-time by end users across the line of business.57

The idea of PoS ( Proof of stake ) consensus algorithm is to replace the Hash rate based on SHA256 with proof of stake.

Because of the large number of participating nodes, the low availability, and huge information amount, public block chain generally adopts consensus algorithms such as proof of workload (PoW), proof of stake (PoS) and DPoS – Deligated Proof Of Stake

Compared with PoW ( Proof of Workload ) that requires a great deal of computational power, PoS requires only a small amount of computing time and ability to ensure the normal operation of the block chain.

Inter-Organizational Barriers :

Different privacy policies related to information and data usage and release in supply chains might lead to new challenges for data sharing between partners57

What will be "challenges for the truck manufacturing company and the steel company" in implementing Blockchain?

Both the truck manufacturing company and the steel company will have to "identify as to how a platform based ecosystem" has to be created with each having a different group of actors around themselves with rules governing interactions. The "level of openness" and the "level of fair value to be captured" has to be accessed from time to time against three overarching governance mechanisms: access ( decisions taken are transparent to every actor in the infrastructure ), control ( a central consensus ledger mirrored across every node) and incentive ( facilitate innovate outputs with more new parties interacting and co-creating value ).58

Both The truck manufacturing company and the steel company can look forward to have an "IoT layer, data layer, contract layer and business layer". The proposed model is expected to serve as digital identity and help in real-time quality monitoring, logistics planning, and contract automation.
All the departments (Engine Block, Axle, Gear Box, Propeller Shaft, Cabin and Cowling) and (Hot Rolled, Cold Rolled, Blast Furnace, Finishing and Roughing lines) can use additive manufacturing in a more “documentable and attributable” way like “using unique ID” by eliminating the possibility of counterfeit items entering the supply chain.

Even Things like the body frame material say for an Axle or Cabin can be procured from the sheet metal designing team using (Autonomous Decentralized Peer-to-Peer Telemetry) low-cost way to initiate the smart contract-based order to procure the product and later pay accordingly an example cross enterprise collaboration.

Bayesian Networks (BNs) (Probability- probabilistic causal relationships), hybrid Multi-Criteria Decision Making (MCDM) method, and Cyber-Physical 3D Printer (CP3DP) can bring in more changes.

Now in the data layer we have Both users (truck and the steel company) and other services in the cloud querying the knowledge model through the inference engine. A hybrid MCDM method is then applied to help customers explore the “option space and find the most suitable services” have a design assistance module optimise the structure of design models for different purposes like It need not be that the truck and the steel will be dealing only with themselves, like Gearbox Department can contact the piston manufacture or the crankshaft making company or proposing new changes in the design with respect to the changes in the model and the haulage capacity of the truck or the Cold Rolled Department can contact the white goods manufacture (refrigerators and washing machines) for supply of coated skin panels.

We (both the truck manufacturing and the steel making company) can use deterministic manufacturing time where more than one server in general (M/D/n) queuing system with multi-level arrival rates supported with FIFO (first input first output) rule is used to bring down the total sojourn time, applicable to both Truck Manufacturing Company and the steel company as both have like in case of regional distribution centres for design and assembly or locations for other services.

AM (Additive Manufacturing) empty capacity can be allocated to other jobs (like Truck making company instead of manufacturing tractor trailers can utilise its “assembly line”, it can look forward to make Car Transporters or Oil Tankers if there is not much difference in terms of specifics of geometry like rear driven axles are used for all kinds of trucks, or a Steel Company can use Cold Rolled Sheets to design panels for Water Coolers, Geysers etc concern is specifics of geometry, cost if capacity utilisation, raw material usage and pre- and post-processing is not that much related.

Block Chain can shape innovation and competition manufacturing by “verifying the state” and “bootstrap in a market” without the help of any centralized intermediary.

Both the truck company and the steel company approaches to the exchange of digital assets like developing “more new formal representations of real things” the problems relating to dealing with the manufacturing of a new prototype (like on Fused Deposition Method) instead of going alone and producing it serially like sharing of data on technical objects (particle diameter distribution, volumetric air, gas flow rate) methods (configuration, selection of settings) used.

When it comes to using of hypoid gears and rear-differential assemblies (layer thickness, printing temperature and speed on the tensile properties) that are used in propeller shafts based on (strength/weight ratio, ID (Infill density) (No. of shells) TBSL (Top-bottom solid layer))

and owning the data shared like what kind of Carbon Reinforced Fibre Plastic (CRFP) thickness bonding be used on steel grades like “SM45C” given the load in the section of tensile yielding or where should a hole in the crack be placed.

And how to manage meaning of the data across the organisation keeping a “handle on the business meanings of “information artefacts” across the enterprise.

Like For Eg, Both the Truck Manufacturing Company and the Steel Company can invest in “Unspecified selective laser melting prototype production systems”, Renishaw AM250 selective laser melting (SLM) system, in each others facilities, exchange data on “etching and metallographic imaging of the samples” and exchange information

like which province or country has different weight limits, rules on “spreading truck poundage over multiple axles with certain minimum distances” for protecting bridge spans and road pavements.

Developing Prototypes

Patterns of Machine Operation

Wherein the degree of utilization of the available build space, distinguishing in this research between single part (“1P”) and full build (“FULL”) configurations.

The design process for Prototype development has got some basic principles to be followed, Equitable use (no discrimination), Flexible to be used, Simple and intuitive use (regardless of the regardless of the user’s experience or knowledge), Perceptible Information (The product communicates necessary information to the user), Tolerance for Error (minimizes hazards and the adverse consequences of accidental or unintended actions) Requires Less Physical effort, Appropriate size and space is provided to fulfil the approach to and use it regardless of user’s body size, posture, or mobility.

Prototypes should create room for practicing differentiated instruction (DI) connecting concepts, integrates beliefs of constructivism, contextually assess students’ realistic learning circumstances: dimensions of goal orientation, self-efficacious attribution.
Now if Innovation is a concern then compatibility, perceived use of usefulness, sense of self-efficacy in adopting an operation or technology has to be looked into, so if we talk of 3D printing that brings together three different technologies, i.e. information, advanced materials and digital manufacturing can work for us if we investigate factors like "size, weight, height, stance, and gait".

To understand "stress and map movements" for any part of the body or object we can look forward to use 3D models to understand "why there are no straight times in gravity as spacetime itself is curved" or debate "on extra dimensions as to why big particles like quarks, leptons, electrons cannot leave the surface when electromagnetic or nuclear forces of all kind act upon which we call it BRANE that vibrates through space "or use Photons as a little string over Grand Unified Theory" (Interview with Nobel Laureate Theoretical physicist Sean Carroll, PhD).

Or get even close to understanding why singularity of a black brane is not a point like a black hole because of the electromagnetic charges it carries with itself. If we talk of machines can we look beyond "faster deposition", "use liquid as an interface", print electronic circuitry onto the walls of objects. In fact truck manufacturing can get generative designs for body-styling, engine block, chassis development from "attributes specified" and thereafter successive designs can be built upon optimizing on performance and cost through softwares.

Or in the steel industry should a new layer be printed and applied to the underlying layer by means of sintering, melting, polymerizing or other processes where just through light beam (eg, a laser beam) or an electron beam we consolidate the layers but how do we energy-process each single layer by moving the substrate and recoating it is a question and more so the challenge becomes interesting we use this same laser beam to solidify powders as a feedstock to process layers in the bed for fusion or compaction through heat or pressure.

Even gathering real time data on "thermal history of thin wall builds" with microstructure should not surprise us if our machines, prototypes and processes have to investigate the "material properties as they can effect the mechanical properties of the final product."

Basic principles of light like beams used for polishing that re-melts the surface of machined metal or how can we use. Or how can we use electrical discharges to give shape to a metal and how important will "dispersion of energy" in this spectroscopy analysis will matter when it comes deciding on roughness and roundness.

When it comes to consuming of energy where do we move the printing bed underneath the dryer to evaporate the undesired binder or fix the controller of the belt system to be driven by a step motor and in in this how does geometry and orientation in Binder Jetting (BJT) goes hand in hand?

Now for tolerating movements on the joints of the beads our ability to "direct the transfer of heat" to cure and shape, design experiments, improve crystallization for in-process treated samples and discover ways to increase thermal stability.

Even so while building body frames and chassis parts of trucks can we measure "longitudinal gradients" spanwise velocity variants that affect the streamwise heat flux and thus the buoyancy effect in the TKE (total kinetic energy) budget equation, because gentle or steep slopes and speed of winds can cause the truck which has a physical property under turbulence anisotropy to assume different properties in different directions as opposed to isotropy. Therefore the need for a "multi-resolution decomposition on a stable boundary-layer dataset" becomes necessary.

For CFD can also be used to improve laser- and non-laser-based metal Additive Manufacturing processes, including Laser Beam Powder Bed Fusion (PBF-LB), Directed Energy Deposition (DED), Binder Jetting (BJT) and Material Extrusion (MEX).

https://www.metal-am.com/metal-additive-manufacturing-magazine/

There are a couple of different ways to measure a proton's charge radius. One is to bounce other charged particles off the proton and infer its size by measuring the deflections. Another is to look at how the proton's charge influences the behavior of an electron orbiting it in a hydrogen atom, which consists of only a single proton and electron. The energy difference between different orbitals is the product of the proton's charge radius.

The new work is largely an improved version of past experiments in that it measures a specific "orbital transition in standard hydrogen composed of an electron and a proton". To begin with, the hydrogen itself was brought to a very low temperature by passing it through an extremely cold metal nozzle on its way into the vacuum container where the measurements were made. This limits the impact of thermal noise on the measurements.

The second improvement is that the researchers worked in the ultraviolet part of the spectrum, where shorter wavelengths helped improve the precision. They measured the wavelength of the photons emitted by the hydrogen atoms using what's called a frequency comb, which produces photons at an evenly spaced series of wavelengths that act a bit like the marks on a ruler. All of this helped measure the orbital transition with a precision that was 20 times more accurate than the team's earlier effort.

The result the researchers get disagrees with earlier measurements of normal hydrogen (though not a more recent one). And it's much, much closer to the measurements made using muons orbiting protons. So, from the perspective of quantum mechanics being accurate, this is good news.

Diesel Engine – Since Combustion Engine is the most expensive part of the Truck, therefore we need to give it some importance.

Should Eddy Breakup Model be used by the intermixing of cold reactants with hot combustion products or should a "flame surface density transport equation" be used against differing levels of engine load, where errors against the mean effective pressure, % of indicated efficiency, % of maximum cylinder
pressure and how does a difference even for delay in 1 CAD (Crank angle degree) matter.\textsuperscript{85}

Should exhaust gas be used to meet the load of the engine while it is being blown down or emptied out when air pressure is controlled through a “late intake valve” \textsuperscript{86}.

Improvement of instantaneous turbine efficiency through late intake valve phase (LIVP) in a turbocharged-gasoline direct injection (T-GDI) engine.

Why not use a multi-dimensional computational fluid dynamics (CFD) code with a genetic algorithm (GA) to monitor Soot formation, timing to inject gas and diesel and set the nozzle holes for both based on the circumference and the angle incident to the reflected ray that any given sample represents \textsuperscript{87}

Should we find out what accelerates flame propagation like (n-butanol, sec-butanol, and iso-butanol) and what shortens the duration for the combustion and affect particulate number (PN) based on different injection process timings and consume less fuel, less CO, unburnt hydrocarbon, even which can be the attributed to the shift in the local mixture of air owing to highly sooty peninsula with the cooling effect of Exhaust Gas Rate \textsuperscript{88}

Opening ourselves to having “less energy dissipating turbulence models” (Zimont Turbulent Flame Speed Closure Method (ZTFSC) and Extended Coherent Flamelet Method (ECFM)) such as “scale resolving simulation (SRS)” can work if we able to measure concentration of the species and the pattern of the flame or the temperature closer to the injection model of the combustor \textsuperscript{89}

\textbf{Open Cost Modelling}

If we are serious about the Cost of Obtaining Usable Datasets then we must pay attention to the idea of identifying the “out-of-working range parameters”

In the process we need to find out the “optimum level of independent variables” to obtain “the most acceptable responses on the dependent variable” and “maximizing the overall desirability of the responses in the range of the independent variables”\textsuperscript{90}

In the area of Engine block development - “antimatter” can be used to detect flaws and impurities on surface panels, Here all of them - Engine Block Designer, Body Frame designer can share data with the Sheet Metal Designer

AR (Augmented Reality), VR (Virtual Reality) and MR (Mixed Reality) can use ‘Antiproton Projections’ - like whether shooting of an anti-proton beam on a particular casting make sense given its density\textsuperscript{91}

Conduction studies on key commonalities between apparently distinct forces and particles, symmetries inherent in the ways that the known particles transform from one to another\textsuperscript{92}

Just think what will happen to an engine block surface if particles used on the panels react to electromagnetic forces and get charged or develops an electromagnetic field and can interact with charges and currents, it can jeopardize movements of the truck or any other automobile vehicle.\textsuperscript{93}

Unless the distribution of the field is identified and thereafter be guided. AR, VR and MR projections will not be able to reasonably provide us with data to magnify or enhance signals to study thermal contrast of omnidirectional micro fatigue cracks of different surfaces\textsuperscript{94}

Things can get worse if the engine block or body frame if exposed to cosmic rays which on “Antimatter collision” can produce pairs of pions, unstable particles that quickly can decay into positrons, electrons, neutrinos and antineutrinos;\textsuperscript{95}

Even from a thundercloud electrons bumping into an atomic nuclei in air molecules can emit gamma rays and form pairs of particles, electrons and their antimatter twins, positrons and in this just think if gamma ray photons interacting with atomic nuclei on gaining energy from the electric field will make the positrons run away, electron and positrons having opposite electric charges will create discharges and with this comes in harmful effects making the vehicle not fit to be touched upon\textsuperscript{96}

Just think if feedback is obtained on “build rate and the height deposition of the laser scan” then obviously we can map the “level of energy density” and the width of the deposited layer that decreases with the number of deposited layers, resulting in triangular shaped cross-sections of walls/ sheets of a metal.\textsuperscript{97}

Understand through Terrain And Subsurface Modelling (Integrated Digital Delivery), 2D /3D Design Review, 4D/5D construction Modelling (Digital Workflows and Capabilities) Immersive Visualization (AR / VR / MR) (Immersive Digital Operations) where repeated melting of the surface removes pores in Direct Energy Deposition\textsuperscript{89}, where to lower the melt pool temperature in case if the truck has to pass through a pool of water that affects the hydrodynamic stability owing to poor temperature gradient leading to the breakup of the molten body frame surface.\textsuperscript{99}

Get more feedback on dark matter particles, intense particle beams and where powerful accelerators should be used to create new particles to be used in the making of a body frame.\textsuperscript{100}

Now collaboration between cross industry teams is possible through Cloud A360 but the question is how productive it is when tools like Filter, Auditor, Tipline, Home (Parent app with activity tracking), Go (parental monitoring from any location) and Visitor Management are installed.\textsuperscript{101}

Because parameters for quality of service (QoS) for every application has to be identified based on the model for application (like something based on thread, task, map reduce, bag of tasks or sweep tasks, where streams have to be processed, messages have to be passed, graphs have to be processed), type of workload (batch styles and critical initiatives can be different) and the kind of architecture\textsuperscript{102}
Or let's even think if sensitive information like use of a laser induced plasma ignition system to assist on the combustion of blends of fuels with less reactivity than pure diesel.

Now if a 100 GB thermal image data of a single-track thin wall of a would-be combustion chamber is to be shared and if the melt pool cannot be detected because of "low level of signal-to-noise ratio" and missed temperature readings. Then where to place the Crank Angle Degree to arrest "blend ignition delay" and "flame lift-off length" cannot be discussed. To think further if let us imagine how can lasers be used in fabricating parts of sheet metal as well in igniting the combustion of blended fuels, here both the steel company and the truck manufacturing company can discuss ways how to create a signal or make use of photons like by using a continuous wave optical parametric oscillator that converts the photons into a visible range of spectrum (450–650 nm). Here the steel company gets to create a Sheetmetal with thickness less than 1.6 mm and use it to create the surface for carbon nanotubes microscopic structures that can be used to house electrical wirings in the truck. In this case the basic principle will be to "excite the local plasmons on the surface" and create a "strong magnetic field" that which also enhances the incoming and Raman-scattered radiation by orders of magnitude. The best example is that of creating large arrays that can stack batteries,

Or studying the method of influence coefficients (MIC), like change of lengths of the springs attached from initial state to equilibrium state or when two parts are assembled, the initial lengths of the springs can be defined as the distances of the defined points from ideal surface to the surface of deviation. So that the negative value of the length is to be allowed in this modelling and thereafter hold discussions regarding geometric variations of mating surfaces directly affecting the angular errors around X-axis and Y-axis between two parts.

Standardization of Documents and Processes:

Two Approaches:

a) Intelligent Push – Self Organizing Network

b) Centralized Data Center

In this Self Organizing Network both the Steel and the truck manufacturing company apart from having Digital Twins and Point Numbered Clouds, they can use QL-SON (Question Learning-Self Organising Method) systems wherein "scenarios can be mapped according to indices of functionalities" identified.

The Structure is clear with 5 step process

1. Self Organizing Network Functions, 2) States (mobility status because of queueing issues) 3) Solutions, a) those identified, b) still being looked into as answers have not yet been found and c) those capable of justifying the scope of the assets) 4) Multi-agent Question Learning with rewards and alternatives (Radio Link Failure degradation and ping-pong handovers)

Self Organizing Network Functions Approach:

Here handovers can be both horizontal (within the same network) or vertical (different networks with decision trees working)

handover (HHO) deals with the transfer of ongoing sessions within the same technology or the same network, while vertical handover (VHO) happens between cells of different technologies.

Centralized Data centre Approach to help big sized trucks to run in smart cities, lessen impact on roads and bridges, compliment railways by loading on to themselves without any problem.

Centralized Data set on "advanced materials and componentry"

Both the Steel and the truck making company to have easy access to heavy truck development data like –like compliant series of lifter axles like compliant tie rod (CTR) with "PerfecTrak" Technology, axle spacing, bolt patterns, torque rods, transverse rods that absorb braking, acceleration and cornering forces to further improve handling. Variable rate rubber spring systems

Here the focus will be on going in for weight saving designs

If Spares made of steel without tungsten and cobalt can be used in Aerospace like grade AF-9628 then why can we not try-out some more research in the constructing the body frame for the

Valves used in the cylinder,

The logic is can a new hot rolled grade be created with a unique combination of properties for “maximised hole expansion” and “edge ductility”, like tensile strength exceeding exceed 800 and 1,000 megapascals (MPa) to be used for chassis applications.
Long Chassis Truck manufactures can look into migrating to high-strength steels (carbon-manganese, bake hard enable and high-strength, low-alloy steels) from traditional mild steels in their designs. \textsuperscript{114}

A few key measurements of mechanical properties are determined in a tensile test. Yield strength is a measure of the strength level at which steel starts to permanently deform. This is an important metric in sheet metal forming and also for the onset of a crash. By changing this value during repair, we may affect the performance of safety-critical components like an airbag sensor. Elongation is a measure of the “amount of stretch” in the steel before fracture occurs. Decreasing elongation by a repair procedure can affect the amount of total energy the repaired component can absorb. The total strength of a material before the failure is the ultimate tensile strength (UTS). If this value is lowered during repair, the part may fail at a lower force than initially designed for the vehicle. Strength values are measured in force (newton) over area (meters squared) and reported in units of megapascal (MPa). \textsuperscript{115}

Even Hot / Cold Straightening and welding methods can also be assessed in identifying

He also asked OEMs to provide details on potential repair methods in real value to the repairer community.\textsuperscript{116}

Here value can also be accessed in terms of the position in turbo brake fittings when a blade ring in the turbocharger slides forward, redirects airflow against the turbine blade and accelerates the turbine wheel, thus increasing the air mass flow and compression brake power.\textsuperscript{117}

Other techniques include like increasing the number of valves in the cylinder for better engine breathing or should a gear driven air compressor with an idle feature be there to bring down the horsepower drain.\textsuperscript{117}

Techniques like improved hill-climbing capability with A comparatively high-output turbocharger to quickly respond to the throttle, so that strong acceleration can be provided to get heavy loads moving.

Apart from this joystick-type controls like enhanced steering geometry\textsuperscript{120} with reengineering of the Bridgemaster axle;

Improved axle design. The axle has been redesigned to improve steering. Ackerman steering arms angled outside of the center of the king pin allow the axle to accurately track the chassis. The result is reportedly tighter turning geometry, improved handling, and less wear on tires and axle components. In addition, the fenders over the rear steering axle turn with the axle.\textsuperscript{117}

Improvement in “I beam” of the steel grade 700 L can be effective in reducing the weight of the chassis instead of using Q345 having the same kind of strength in bending and capacity of the flange, the only point being here is that the thickness gets reduced to 8mm and 4 mm respectively.\textsuperscript{118}

Create Alloys of weight saving materials

The Bridgemaster assembly is fastened with HuckBolts, rather than welded to the frame rails, so it can be removed easily for maintenance. With more gripping power than fine-thread bolts, developers report, HuckBolts resist vibrations and can be accurately torqued for enhanced longevity. The model is available with drum sizes rated for 9 to 14 yd. and available on a choice of commercial chassis, including Mack, International and Kenworth. Four, five, six and seven-axle configurations are available to comply with state-specific federal bridge law formulas.\textsuperscript{117}

Explore in which way can Steel Grades like Q235 and Q345 be used for further improvement in the construction of trailer chassis of a truck.\textsuperscript{118}

Carry Out More Research on Steel Grades like HSLA 340, FB450, FB600/DP 600, B800/DP800, 590 CL\textsuperscript{119}

Limitations Of The Paper

Much of the ideas in this paper has been taken from secondary sources like journals and information available on the internet whereas executives from the steel, truck and spare parts manufacturing companies have hardly been interviewed.

Because from interviewing at least the “range of tasks yet to be performed by a truck” or the kind of steel required for the development of lighter and a sturdier chassis could have been known, more no of applications could have been thought of, for more number of specialized behaviours.

The subject on Mechatronics has not been touched like how can a switch trace the “variable amplitude” adaptively in different vibration situations while bringing less damping to the system dynamics as possible. Its all about analysing energy currents for different parameters where oscillator’s slow responses and the relaxation process of the viscous materials reduce switching phase mismatches.\textsuperscript{121}

On manufacturing process capability indexes (PCIs)\textsuperscript{122} nothing has been touched

As to how worldwide availability of production data can be made available For example, as the lead plant for compact models, the said truck manufacturing plant is able to access production data from all the other plants including the steel company’s furnace charging and colour coating, galvanizing, hydrotesting sheet programs and the spare parts companies delivery schedules like batteries, steering systems, bearings, braking systems, tyres, paints in the worldwide production network, e.g. the concerned Truck Manufacturing company on receiving inputs would even be far more well equipped to reprogram its robots in operation as the materials start arriving.\textsuperscript{123}

This paper does not talk of Machines assisting their users i.e. the path to be followed by lightweight robots can be generated by “demonstration”, i.e. the worker leads the robots and the machine learns the path.\textsuperscript{123}
So recent techniques like Turtle Diagrams and "Verband der Automobilindustrie - Flächenschnittstelle", which translates to the "automotive industry association - surface data interface" German quality management system standard need to be used which this paper 124

This paper does not think of the bringing about changes in the way machines work like reconfiguring machine tools on a modular basis. 125

Like where IoT (Internet of Things) can be used from the making of an event to that of sourcing ideas from the platforms of Communities of Practitioners (CoP)126

So on so forth we have not thought of having "a fuzzy control system developed to determine when to re-balance the assembly line and how to adjust the production rates to smooth the workloads of the workstations" while assembling the parts of a truck 127

On the issue of disposal of waste, the paper does not talk of any kind of routing programs to handle dissembles and regular usable items based on single-component distribution, multi-component distribution, inventory cost, and multi-period conditions.128

When it comes to scheduling does this paper look at the problem of constraint between ladle cranes in a steel melting shop, a ladle crane in a steel industry cannot be easily moved upon from one place to another filled with molten iron to the basic oxygen furnace (BOF) because of a station-capacity constraint, and added to these will be jobs with inaccurate release times and different temporal scheduling objectives. The issue here is how far is the "crane trajectory solution" of steel industry's blast furnace division heuristically aligned to coordinate and match the frequency of work with the Robotic Arms being used in the assembly line of a truck manufacturing company on a real time basis.129

This paper talks of using photons but how less expensive it is when it comes to producing hydrogen when we see that fossil fuel reforming and biomass gasification can produce cheaper hydrogen efficiently. It should not surprise us that all what a truck would need a motor where where power is generated by the process of reacting hydrogen atoms with oxygen atoms using a fuel cell stack having a tank for storing hydrogen with high-power density batteries but what will happen to investments we make in creating the castings, dies and the moulds for making of the engines, fuel tanks, and transmissions when they are no longer to be needed with this new technology coming in which this paper does not address at all 130

**Future Directions**

The most important area lies in how Both the steel and the truck manufacturing company can carry out joint studies on the motion of the particle like photons that depend on the impact parameter and the effective potential where it can be plotted for parameters of different states

Because some components whether connected to the engine or the chassis of a truck vibrate and what "if light is to be used as a resource to communicate between the said components" and eventually deflects owing to differences in distances between the events those that take place at the horizon and those that are being observed (near cosmological horizon) wherein a layer of outer communication comes in with "different orders of intensities" that tells us that we need to calculate "stress-energy tensor" that is commonly averages across all directions be it the velocity at which light travels, or the trajectory it takes or the equatorial plane on which it travels, how do profiles of accretion influence light's propagation, And if use photons then we should understand that rays of photon's light intersect the plane of the disk three or more times than that of the rays of light of a lensing ring that intersect the plane. Thus, the trajectory of the photon becomes important to distinguish the photon ring from that of the lensing ring which has a higher spike in brightness.131

So studies on Doppler Effect is required132

and its effect on hearing or observing things from a distance133

**Conclusion**

Though this paper tries to understand cross industry collaboration wherein a steel company gets to work along with a heavy truck manufacturing when it comes to developing chassis "how important particle physics can be" when it comes to "masses and their interactions" that this paper discusses in "Genesis or Core Material Information" and how to measure them.

And how "differences in body angles be it part wise or in full, velocity of directed actions" apart from this how kickstart counts, glide time, time to flow within the medium and drag forces, matter in the part that talks about "Kinematics"

Even in allocating resources also I learn how "a job on being divided into several independent small tasks interact with each other to process one block or set of data, and thereafter how can multiple tasks can be executed in parallel,"component wise as it talks about creating an forwarding information table in the portion "Connecting Parts"

Hence the larger picture is that Factors like time, frequency, range and rules set does matter so developing "Prototypes" becomes necessary.

**References**

1Bibliometrics in operations research and management science: a university analysis. By: Laengle, Sigifredo, Merigó, José M., Modak, Nikunja Mohan, Yang, Jian-Bo. *Annals of Operations Research, 02545330, Nov2020*, Vol. 294, Issue 1/2

2https://www.daimler-truck.com/innovation-sustainability/efficient-emission-free/mercedes-benz-genh2-fuel-cell-truck.html, Last accessed on 12-01-2021 at 16:43
The Smart Vehicle Architecture, a holistic approach. By: Vollmer, Alfred, Automobil-Elektronik, 09395326, 2019, Issue 6

Applying data mining technique to disassembly sequence planning: a method to assess effective disassembly time of industrial products. By: Marconi, Marco, Germani, Michele, Mandolini, Marco, Favi, Claudio, International Journal of Production Research, 00207543, Jan2019, Vol. 57, Issue 2

Grouping products for the optimization of production processes: A case in the steel manufacturing industry. By: Casado, Silvia; Laguna, Manuel; Pacheco, Joaquín; Puche, Julio C. European Journal of Operational Research, Oct2020, Vol. 286 Issue 1, p190-202. 13p. DOI: 10.1016/j.ejor.2020.03.010

Comparative analysis of environment losses in steel manufacturing supply chain using Taguchi loss function and design of experiments. By: Goyal, Shishir; Agarwal, Aman; Routroy, Srikanta. Journal of Enterprise Information Management. 2020, Vol. 33 Issue 3, p684-700. 17p. DOI: 10.1108/JEIM-03-2019-0080.

Comparing Service, Product, and Process Innovations: Insights from the Internal Supply Chain Network of a European Steel Manufacturing Firm. By: Yazdanparast, Atefeh; Manuj, Ila; Plasch, Michael; Gerschberger, Markus; Freudenthaler, Daniela. International Journal of Innovation Management. Feb2020, Vol. 24 Issue 2, pN.PAG-N.PAG. 38p. 8 Charts, 1 Graph. DOI: 10.1142/S1363919620500188.

Coordination Control of Differential Drive Assist Steering and Vehicle Stability Control for Four-Wheel-Independent-Drive EV. By: Wang, Junnian; Luo, Zheng; Wang, Yan; Yang, Bin; Assadian, Francis. IEEE Transactions on Vehicular Technology, Dec2018, Vol. 67 Issue 12, p11453-11467. 15p. DOI: 10.1109/TVT.2018.2872857.

Hierarchical scheduling of continuous casters and hot strip mills in the steel industry: a block planning application. By: Mattik, Imke, Amorim, Pedro, Günther, Hans-Otto. International Journal of Production Research, 00207543, May2014, Vol. 52, Issue 9

Physical Simulation-Based Characterization of HAZ Properties in Steels. Part 2. Dual-Phase Steels. By: Gáspár, M., Sisodia, R. P. S., Dobosy, A., Strength of Materials, 00392316, Sep2019, Vol. 51, Issue 5

An improved method for the hot strip mill production scheduling problem. By: Hu, Wanzhe, Zheng, Zhong, Gao, Xiaoyi, Pardalos, Panos M., International Journal of Production Research, 00207543, May2019, Vol. 57, Issue 10

https://www.wired.com/story/huawei-5g-polar-codes-data-breakthrough/?bxid=5cec28c324c17c4c6463a1d8&ndid=5646787568&src=source&source=EDT_WIR_NEWSLETTER_0_DAILY_ZZ&utm_brand=wired&utm_campaign=aud-dev&utm_content=A&utm_mailing=WIR_Daily_111620&utm_medium=email&utm_source=nl&utm_term=list1_p4

Last accessed on 18-11-2020

https://www.brighttalk.com/webcast/14645/450272?utm_campaign=channel-feed&utm_source=brighttalk-portal&utm_medium=web

Last accessed on 19-11-2020 at 10:14

Fuzzy and Fuzzy Grey-Box Modelling for Entry Temperature Prediction in a Hot Strip Mill. By: Barrios, José Angel, Cavazos, Alberto, Leduc, Luis, Ramirez, Jorge. Materials & Manufacturing Processes, 10426914, Jan2011. Vol. 26, Issue 1

Digital twin-enabled Graduation Intelligent Manufacturing System for fixed-position assembly islands. By: Guo, Daqiang; Zhong, Ray Y.; Lin, Peng; Lyu, Zhongyuan; Rong, Yiming; Wang, George Q. Robotics & Computer-Integrated Manufacturing. Jun2020, Vol. 63, pN.PAG-N.PAG. 1p. DOI: 10.1016/j.rcim.2019.101917.

https://video.sas.com/category/videos/sas-event-stream-processing. Last accessed on Nov 19, 2020, 3:55 PM

OPTICAL RESERVOIR COMPUTING USING MULTIPLE LIGHT SCATTERING FOR CHAOTIC SYSTEMS PREDICTION

1,2Jonathan Dong, 1Mushegh Rafayelyan, 2Florent Krzakala, & 1Sylvain Gigan

https://arxiv.org/pdf/1907.00657.pdf

Last accessed on 08-01-2021 at 12:13

https://video.sas.com/category/videos/sas-event-stream-processing

Last accessed on 10-01-2021 at 11:41

Effect of Water Jet Orientation and Other Controlling Parameters on Work Roll Temperature in a Hot Strip Mill. By: Sikdar, Sudipta, John, Shylu, Travancore. Materials & Manufacturing Processes, 10426914, Jan2007. Vol. 22, Issue 1

Diving into Coral-based machine learning with a Raspberry Pi. Electronics Weekly, 00135224, 10/2/2019, Issue 2756

Research on the influences of material properties and forming parameters in T-shaped closed cold ring rolling process. By: Lanyun Li; He Yang; Lianggang Guo; Zhichao Sun. International Journal of Materials & Product Technology. 2010. Vol. 38 Issue 2/3, p323-336. 14p. DOI: 10.1504/IJMPT.2010.032108.
22) Nonlinear short-term prediction of aluminum foil thickness via global regressor combination. By: Ozturk, Ali; Seherli, Rifat. Applied Artificial Intelligence. 2017, Vol. 31 Issue 7/8, p568-592. 25p. DOI: 10.1080/08839514.2017.1412815.

23) Machine learning for anomaly detection and process phase classification to improve safety and maintenance activities. By: Quatrini, Elena; Costantino, Francesco; Di Gravio, Giulio; Patriarca, Riccardo. Journal of Manufacturing Systems. Jul 2020, Vol. 56, p117-132. 16p. DOI: 10.1016/j.jmsy.2020.05.013.

24) Detection of interferences in an additive manufacturing process: an experimental study integrating methods of feature selection and machine learning. By: Stanisavljevic, Darko; Cemernke, David; Gursch, Heimo; Ural, Günter; Lechner, Gernot. International Journal of Production Research. May 2020, Vol. 58 Issue 9, p2862-2884. 23p. 1 Color Photograph, 4 Diagrams, 2 Charts, 7 Graphs. DOI: 10.1080/00207543.2019.1694719.

25) Unblocking changes. By: Chevee, Alain, Process Engineering, 03701859, Jan/Feb 2020. Vol. 101, Issue 1

26) A robust block-chain based tabul search algorithm for the dynamic lot sizing problem with product returns and remanufacturing. By: Li, Xiangyong; Baki, Fazle; Tian, Peng; Chaouch, Ben A. Omega. Jan 2014, Vol. 42 Issue 1, p75-87. 13p. DOI: 10.1016/j.omega.2013.03.003.

27) Real-World Image Denoising with Deep Boosting. By: Chen, Chang; Xiong, Zhiwei; Tian, Xinmei; Zha, Zheng-Jun; Wu, Feng. IEEE Transactions on Pattern Analysis & Machine Intelligence. Dec 2020, Vol. 42 Issue 12, p3071-3087. 17p. DOI: 10.1109/TPAMI.2019.2921548.

28) INFRA RED THER MOGRAPHY METHOD FOR THE ASSESSMENT OF THE RISK OF BURNING. By: Štrbac, Branko; Lanc, Zorana; Željković, Milan; Živković, Aleksandar; Hadžistević, Miodrag. Proceedings on Quality. Jun 2019, p191-195. 5p.

29) The relative role of digital complementary assets and regulation in discontinuous telemedicine innovation in European hospitals. By: Steinhauser, Stefanie, Doblinger, Claudia, Hüsig, Stefan, Journal of Management Information Systems, 07421222, 2020, Vol. 37, Issue 4

30) Inverse kinematics techniques in computer graphics: A survey. By: Chrysanthou, Y., Aristidou, A., Sharim, A., Lasenby, J., Computer Graphics Forum, 01677055, Sep 2018, Vol. 37, Issue 6

31) https://www.youtube.com/watch?v=tRqJSObUWgQ&app=desktop

Last Accessed on 04-12-2020 at 15:45

32) Sampling frequency influences sample entropy of kinematics during walking. By: Raffalt, Peter C., McCamley, John, Denton, William, Yentes, Jennifer M., Medical & Biological Engineering & Computing, 01400118, Apr 2019, Vol. 57, Issue 4

33) Multi-variate Gaussian-based inverse kinematics. By: Huang, Jing; Wang, Qi; Fratarcangeli, Marco; Yan, Ke; Pelachaud, Catherine. Computer Graphics Forum. Dec 2017, Vol. 36 Issue 8, p418-428. 11p. 4 Color Photographs, 1 Diagram, 1 Chart, 2 Graphs. DOI: 10.1111/cgf.13089.

34) Five-axis trajectory generation based on kinematic constraints and optimisation. By: Shen, Hongyao, Fu, Jianzhong, Lin, Zhiwei, International Journal of Computer Integrated Manufacturing, 0951192X, Mar 2015, Vol. 28, Issue 3

35) Quantum Key Distribution: A Networking Perspective. By: MEHIC, MIRALEM; NIEMIEC, MARCIN; RASS, STEFAN; MA, JIAJUN; PEEV, MOMTCHIL; AGUADO, ALEJANDRO; MARTIN, VICENTE; SCHAUER, STEFAN; POPPE, ANDREAS; PACHER, CHRISTOPH; VOZNAK, MIROSLAV. ACM Computing Surveys. Sep 2020, Vol. 53 Issue 5, p96-136. 41p. DOI: 10.1145/3402192.

36) Contribution of angular measurements to intelligent gear faults diagnosis. By: Fedala, Semchedine, Rémond, Didier, Zegadi, Rabah, Felkaoui, Ahmed, Journal of Intelligent Manufacturing, 09565515, Jun 2018, Vol. 29, Issue 5

37) Regrouping particle swarm optimization based variable neural network for gearbox fault diagnosis. By: Liao, Yixiao, Zhang, Lei, Li, Weihua, Li, Chuan, de Oliveira, José Valente, Journal of Intelligent & Fuzzy Systems, 10641246, 2018, Vol. 34, Issue 6

38) An intelligent fault diagnosis approach for planetary gearboxes based on deep belief networks and uniformed features. By: Wang, Xin, Qin, Yi, Zhang, Aibing, Li, Chuan, de Oliveira, José Valente, Journal of Intelligent & Fuzzy Systems, 10641246, 2018, Vol. 34, Issue 6

39) Adaptive strategy for fault detection, isolation and reconstruction of aircraft actuators and sensors. By: Taimoor, Muhammad, Aijun, Li, Journal of Intelligent & Fuzzy Systems, 10641246, 2020, Vol. 38, Issue 4

40) Global light vehicle transmissions and clutches market - forecasts to 2033. Aroq - Just Auto. Apr 2019, p1-95. 102p.

41) Kia launches eight-speed automatic transmission. Automotive Engineer. Oct 2016, Vol. 41 Issue 8, p41-41. 1/3p.

42) https://www.zf.com/products/en/cars/products_29289.html

Last accessed on 06-01-2021 at 14:27

43) Development and Control of an Electric Oil Pump for Automatic Transmission-Based Hybrid Electric Vehicle. By: Yeonho Kim; Jaesang Lee; Chihoon Jo; Yongha Kim; Minseok Song; Jonghyun Kim; Hyunsoo Kim. IEEE Transactions on Vehicular Technology. Jun 2011, Vol. 60 Issue 5, p1981-1990. 10p.
44 Eaton to launch heavy-duty transmission for electric vehicles. Bulk Transporter, 15553795, Dec2019, Vol. 82, Issue 6

45 Allison equips HD trucks with 10-speed automatic transmission. By: Warburton, Simon, Aroq - Just-Auto.com (Global News), 1/24/2019

46 Allison unveils FuelSense 2.0 software upgrade. By: Kilcarr, Sean, Fleet Owner, 1070194X, Apr2017

47 Hendrickson provides Freightliner 6x2 liftable forward tandem axle. Bulk Transporter, 15553795, Nov2017, Vol. 80, Issue 5

48 Too many tonnes? By: Banner, Steve, Motor Transport, 0027206X, 5/24/2007

49 AAM supplies new independent rear drive axles for GM full-size SUVs. By: Leggett, Dave, Aroq - Just-Auto.com (Global News), 8/20/2020

50 Bosch makes the rear axles of trucks intelligent. Automobil-Produktion, 09340394, 10/11/2018, Issue 10

51 Networked rear axle drive. Automobil-Produktion, 09340394, 12/6/2018, Issue 12

52 Navistar makes Dana Spicer single rear axle standard for medium-duty trucks, buses. Bulk Transporter, 15553795, Sep2018, Vol. 81, Issue 3

53 By: BEECH, BOB. Commercial Motor. 5/28/2020, p38-45. 8p.

54 Global light vehicle turbochargers market - forecasts to 2034. Aroq - Just-Auto. Jan2020, p1-55. 61p.

55 Analysis of coordination mechanism of supply chain management information system from the perspective of block chain. By: Yuan, Huiqun, Qiu, Hongbin, Bi, Ya, Chang, Sheng-Hung, Lam, Anthony, Information Systems & e-Business Management, 16179846, 2020, Vol. 18, Issue 4

56 https://modelagarage.com/service_bulletin/new-four-speed-transmission-for-model-aa-truck/

Last Accessed on 18-12-2020 at 16:31.

57 Blockchain technology and its relationships to sustainable supply chain management. By: Saberi, Sara, Kouhizadeh, Mahtab, Sarkis, Joseph, Shen, Leija, International Journal of Production Research, 00207543, Apr2019, Vol. 57, Issue 7

58 Designing Governance Mechanisms in Platform Ecosystems: Addressing the Paradox of Openness through Blockchain Technology. By: Schmeiss, Jessica, Hoelzle, Katharina, Tech, Robin P. G., California Management Review, 00081256, Nov2019, Vol. 62, Issue 1

59 Understanding the Blockchain technology adoption in supply chains-Indian context. By: Kamble, Sachin, Gunasekaran, Angappa, Arha, Himanshu, International Journal of Production Research, 00207543, Apr2019, Vol. 57, Issue 7

60 IoT-enabled cloud-based additive manufacturing platform to support rapid product development. By: Wang, Yuanbin, Lin, Yuan, Zhong, Ray Y., Xu, Xun, International Journal of Production Research, 00207543, Jun2019, Vol. 57, Issue 12

61 The influence of additive manufacturing on the configuration of make-to-order spare parts supply chain under heterogeneous demand. By: Li, Yao, Cheng, Yang, Hu, Qing, Zhou, Shenghan, Ma, Lei, Lim, Ming K., International Journal of Production Research, 00207543, Jun2019, Vol. 57, Issue 11

62 Informing additive manufacturing technology adoption: total cost and the impact of capacity utilisation. By: Baumers, Martin, Beltrametti, Luca, Gasparre, Angelo, Hague, Richard, International Journal of Production Research, 00207543, Dec2017, Vol. 55, Issue 23

63 Some Simple Economics of the Blockchain: Blockchain technology can shape innovation and competition in digital platforms, but under what conditions? By: CATALINI, CHRISTIAN; GANS, JOSHUA S. Communications of the ACM. Jul2020, Vol. 63 Issue 7, p80-90. 11p. 1 Color Photograph, 1 Diagram. DOI: 10.1145/3359552.

64 Design with Use of 3D Printing Technology. By: Rozmus, Magdalena; Dobrzaniecki, Piotr; Siegmund, Michat; Herrero, Juan Alfonso Gómez. Management Systems in Production Engineering. Dec2020, Vol. 28 Issue 4, p283-291. 9p. DOI: 10.2478/mspe-2020-0040.

65 MarketLine Company Profile: Showa Corporation. Showa Corporation MarketLine Company Profile, 9/4/2020

66 Experiment and analysis of unidirectional CFRP with a hole and crack as sandwich-form inhomogeneous composite. By: Park, Jae-Woong, Cho, Jae-Ung, Advanced Composite Materials, 09243046, Feb2019, Vol. 28, Issue 1

67 Blockchain, artificial intelligence and knowledge graphs: What does it mean for the business? Journal of Securities Operations & Custody. Autumn-Fall2020, Vol. 12 Issue 4, p357-366. 10p.

68 Selective Laser Melting of Duplex Stainless Steel Powders: An Investigation. By: Davidson, Karl, Singamneni, Sarat, Materials & Manufacturing Processes, 10426914, 2016, Vol. 31, Issue 12

69 https://www.truckinginfo.com/150236/lift-axle-considerations
109 Mobility robustness optimization and load balancing in self-organized cellular networks: Towards cognitive network management. By: Hashemi, S. Ahmad, Farrokh, Hamid, *Journal of Intelligent & Fuzzy Systems*, 10641246, 2020. Vol. 38, Issue 3

110 Mobility Management in 5G-enabled Vehicular Networks: Models, Protocols, and Classification. By: ALJERI, NOURA; BOUKERCHE, AZZEDINE. *ACM Computing Surveys*, Sep2020. Vol. 53 Issue 5, p92-126. 35p. DOI: 10.1145/3403953.

111 https://www.vda.de/en/press/press-material/long-truck.html

Last accessed on 13-01-2020 at 16:05

112 AIR FORCE DEVELOPS Steel Alloy for 3D Printing. *Machine Design*, 00249114, Oct2019, Vol. 91, Issue 10

113 STEEL VS AL: SSAB launches new auto high-strength steel grades. *Metal Bulletin Daily*, 20572379, 11/2/2015

114 STEEL 101: GRADES AND REPAIRABILITY: THERE ARE MORE THAN 200 AUTOMOTIVE STEEL GRADES IN THE MARKET TODAY. By: ANDERSON, DAVID W. *Auto Body Repair Network*, May2017, Vol. 56 Issue 5, p47-50. 4p.

115 ADVANCED HIGH-STRENGTH STEEL REPAIRABILITY: THE INDUSTRY CONTINUES TO WORK TO DEVELOP ACCEPTABLE, PRACTICAL REPAIR PROCEDURES. By: ANDERSON, DAVID W. *Auto Body Repair Network*, Dec2017, Vol. 56 Issue 12, p40-44. 4p.

116 DRIVING THE REPAIR FOCUS: REPAIRABILITY TAKES CENTER STAGE AT SMDI’S "GREAT DESIGNS IN STEEL". By: HALL, JODY N. *Auto Body Repair Network*, May2019, Vol. 58 Issue 5, p42-44. 3p.

117 TRUCKS & COMPONENTS. *Concrete Products*, 00105368, May2000, Vol. 103, Issue 5

118 Innovative manufacturing technology enabling light weighting with steel in commercial vehicles by Hardy Mohrbacher Advances in Manufacturing · March 2015 DOI: 10.1007/s40436-015-0101-x

119 file:///C:/Users/dell/Downloads/Innovative_manufacturing_technology_enabling_light.pdf

last accessed on 13-01-2021 at 16:15

120 Preparation and printability of high performance 15Cr13MoY alloy steel powder for direct laser deposition. By: Chen, Xueting, Chen, Suiyuan, Liang, Jing, Cui, Tong, Liu, Changsheng, Mei, Wang, *Powder Metallurgy*, 00325899, Sep2019, Vol. 62, Issue 4

121 Energy Current Analysis of an Improved Self-Adaptive Mechatronic Approach for P-SSHl. By: Liu, Weiqun; Huang, Yao; Wang, Jindong; Qin, Gang. *IEEE Transactions on Industrial Electronics*, Feb2021. Vol. 68 Issue 2, p1434-1444. 11p. DOI: 10.1109/TIE.2020.2970662.

122 Process capability analysis for manufacturing processes based on the truncated data from supplier products. By: Yang, Jun; Meng, Fanbing; Huang, Shuo; Cui, Yanhe. *International Journal of Production Research*, Oct2020. Vol. 58 Issue 20, p6235-6251. 17p. 1 Color Photograph, 1 Black and White Photograph, 3 Charts, 5 Graphs. DOI: 10.1080/00207543.2019.1675916.

123 https://www.daimler.com/innovation/case/connectivity/industry-4-0.html

Last accessed on 23-10-2020 at 12:08

124 Sustainable quality control mechanism of heavy truck production process for Plant-wide production process. By: Guo, Hongfei; Zhang, Ru; Zhu, Yingxin; Qu, Ting; Zou, Min; Chen, Xiangyue; Ren, Yaping; He, Zhiliu. *International Journal of Production Research*, Dec2020. Vol. 58 Issue 24, p7548-7564. 17p. 7 Diagrams, 4 Charts, 3 Graphs. DOI: 10.1080/00207543.2020.1844918.

125 Configuration design of scalable reconfigurable manufacturing systems for part family By: Moghaddam, Shokraneh K.; Houshmand, Mahmoud; Saitou, Kazuhiro; Fatahi Valli, Omid. *International Journal of Production Research*, May2020, Vol. 58 Issue 10, p2974-2996. 23p. 1 Black and White Photograph, 8 Charts, 4 Graphs. DOI: 10.1080/00207543.2019.1620365.

126 Modularity in making: simplifying solution space for user innovation. By: Naik, Hari Suman; Fritzschke, Albrecht; Moeslein, Kathrin M. *R&D Management*, Jan2021, Vol. 51 Issue 1, p57-72. 16p. 4 Charts. DOI: 10.1111/radm.12427.

127 A fuzzy control system for assembly line balancing with a three-state degradation process in the era of Industry 4.0. By: Huo, Jiage; Zhang, Jianghua; Chan, Felix T. S. *International Journal of Production Research*, Dec2020. Vol. 58 Issue 23, p7112-7129. 18p. 5 Diagrams, 6 Charts, 6 Graphs. DOI: 10.1080/00207543.2020.1786186.

128 Integrated disassembly line balancing and routing problem. By: Diri Kenger, Zülal; Koç, Çağrı; Özceylan, Eren. *International Journal of Production Research*, Dec2020, Vol. 58 Issue 23, p7250-7268. 19p. 9 Diagrams, 9 Charts, 4 Graphs. DOI: 10.1080/00207543.2020.1740346.
129 Simulation-based solution for a dynamic multi-crane-scheduling problem in a steelmaking shop. By: Li, Ji; Xu, Anjun; Zang, Xuesong, *International Journal of Production Research*. Nov 2020, Vol. 58 Issue 22, p6970-6984. 15p. DOI: 10.1080/00207543.2019.1687952.

130 Scenario input–output analysis on the diffusion of fuel cell vehicles and alternative hydrogen supply systems. By: Yamada, Mitsuo, Fujikawa, Kiyoshi, Umeda, Yoshito, *Journal of Economic Structures*, 21932409, 2/6/2019, Vol. 8, Issue 1

131 Influence of quintessence dark energy on the shadow of black hole. By: Zeng, Xiao-Xiong, Zhang, Hai-Qing, *European Physical Journal C – Particles & Fields*, 14346044, Nov 2020, Vol. 80, Issue 11

132 https://www.wired.com/story/the-physics-nobel-goes-to-the-big-bang-and-exoplanets/?bxid=5cec28c324c17c4c6463a1d8&cndid=56487875&esrc=burn&source=EDT_WIR_NEWSLETTER_0_DAILY_ZZ&utm_brand=wired&utm_campaign=aud-dev&utm_content=C&utm_mailing=New%20Campaign&utm_medium=email&utm_source=nl&utm_term=list2_p2
Last accessed on 12-01-2021 at 12:11

133 https://www.wired.com/story/how-two-nobel-laureates-spotted-the-first-exoplanet/?bxid=5cec28c324c17c4c6463a1d8&cndid=56487875&esrc=burn&source=EDT_WIR_NEWSLETTER_0_DAILY_ZZ&utm_brand=wired&utm_campaign=aud-dev&utm_content=C&utm_mailing=New%20Campaign&utm_medium=email&utm_source=nl&utm_term=list2_p2
Last accessed on 11-01-2021 at 11:59

134 Dredas: Decentralized, reliable and efficient remote outsourced data auditing scheme with blockchain smart contract for industrial IoT. By: Fan, Kuan; Bao, Zijian; Liu, Mingxi; Vasilakos, Athanasios V.; Shi, Wenbo. *Future Generation Computer Systems*. Sep 2020, Vol. 110, p665-674. 10p. DOI: 10.1016/j.future.2019.10.014.

135 Title: How EY and Microsoft Are Unlocking New Uses for Blockchain
Summary: Jun.20 – Blockchain enthusiasts have been boasting all the various solutions and applications for the technology. Now EY and Microsoft are pairing up to use blockchain within the gaming industry. EY Global Innovation Blockchain Leader Paul Brody joined “Bloomberg Technology” to discuss.
Accession number: 1_6yjruh5h
https://video.ebscohost.com/details/1_6yjruh5h?q=blockchain&deviccid=73e707f0-5119-400a-b9d2-f31bb38e262b&lang=en&minDate=&maxDate=

136 A Survey on Ethereum Systems Security: Vulnerabilities, Attacks, and Defenses. By: CHEN, HUASHAN; PENDLETON, MARCUS; NJILLA, LAURENT; SHOUHUI XU. *ACM Computing Surveys*, May 2020, Vol. 53 Issue 3, p67-67:43. 43p. DOI: 10.1145/3391195.

137 UK STEEL SCRAP WEEKLY: 5C grade market hits 2020 peak on rm fundamentals. By: Conway, Declan, *Metal Bulletin Daily*, 20572379, 12/14/2020

138 On Applicability of Multilayer Coated Tool in Dry Machining of Aerospace Grade Stainless Steel. By: Mohanty, A., Gangopadhyay, S., Thakur, A., *Materials & Manufacturing Processes*, 10426914, 2016, Vol. 31, Issue 7

139 Minimising work overload in mixed-model assembly lines with different types of operators: a case study from the truck industry. By: Aroui, Karim, Alpan, Gülgün, Frein, Yannick, *International Journal of Production Research*, 00207543, 11/1/2017, Vol. 55, Issue 21

140 Review of mechanisms and deformation behaviors in 4D printing. By: Ding, Han; Zhang, Xiang; Liu, Yong; Ramakrishna, Seeram. *International Journal of Advanced Manufacturing Technology*, Dec 2019, Vol. 105 Issue 11, p4633-4649. 17p. 6 Color Photographs, 1 Black and White Photograph, 6 Diagrams, 2 Charts. DOI: 10.1007/s00170-019-03871-3.

**Figures**
Figure 1

A pentagonal framework

Figure 2

Business Model: Creating Value Streams