서울대학교 | 생산시스템공학연구실
Computer-Aided Systems and Production Engineering Research Lab.

2009. 12. 17

Digital Shipyard를 이용한 조선생산성 개선 사례

신 종 계 교수, 서울대 조선해양공학과
우 종 훈 박사, ㈜지노스
송 영 주 박사, 서울대 해양시스템공학연구소

서울대학교 생산시스템공학연구실

관련 연구 경험

- 1999년 미국 해군/미시간 대학과 생산 시뮬레이션 연구
- 2001년 다쏘시스템의 Delmia+PLM tool 지원
- 삼성중공업과 Digital Shipyard구축→ Digital Shipbuilding System(DSS)개발
  - 해외 워크샵에 참석하여 선진 기술 습득
  - 국내조선공정 상세 분석→생산성향상 요소 도출
  - 주요 공정별 Digital Factory구축
    - 적재, 전처리, 가공, 성형, 소조,중조, 대조, 선행의장, 선행탑재, 탑재, 안벽의장, 도장
- 대우조선해양,STX조선, 21세기조선, 삼진조선 등과 DSS 지속
- 미국해군 과제 수탁하여 DSS 연구
- 해외 조선소 건설에 컨설팅
  - 브라질, 인도네시아, 인도

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관련 강의 과목

- 생산시스템 관련
  - 조선생산공학개론, 생산시스템 이론
  - 생산기술, 생산계획과 관리
  - 생산 시뮬레이션 tool 실습
- 시스템 엔지니어링 관련
  - 시스템엔지니어링 개론, 관리
  - 시스템 분석(analysis)과 설계(synthesis), 검증(VV&A)
- PLM 관련
  - PLM이론과 개념, 사례
  - Modeling & Simulation 이론, 기술

디지털 팩토리 관련 주요 이슈들

- Digital (virtual) Factory/Manufacturing 의 핵심
- Digital Shipyard와 Digital Shipbuilding
  - 조선소와 조선공정의 특성
  - 조선소에서의 생산성 정의
  - 생산성 향상을 위한 개선 요소들 (AS-IS와 TO-BE정의)
  - 필요 기술, 방법, 규정, 요구조건, 입력자료 확인
- Digital Shiyard 구축과 응용 사례
  - Digital Shipyard 구축 방법론
  - Digital Shipyard 구축을 위한 tool 선정
  - 사례와 효과
  - 성공을 위한 핵심 요소들

조선산업 적용한 주요 사례들 I

- 각 공정/기계의 cycle time 상세 시뮬레이션
  - 절단기, 용접로봇, 도장, 크레인, 정반
- 각 공장내 물류 시뮬레이션
  - Lead time 감축, 재고/재공 감소
- 생산계획 검증
  - 중장기계획 검증, 주간 및 일일 계획 검증. 계획 변경시 생산 예측
  - 최적 생산 계획/생산량 결정, 장기 발주/추가 발주 검증
- 공장 레이아웃 설계 및 생산계획 수립
  - 공장 확장, 신규 조선소 설립
- 작업자 시뮬레이션
  - 근골격계 질환 예방, 최적 작업/휴식시간 할당
- R&D 항목 도출 시뮬레이션
  - 병목공정 확인. 핵심 개선사항 확인
- 타 시스템과 연동(CAD, ERP, APS, MES, …)

주요 사례들 II

- 요트 생산 공장 Digital Factory
  - 요트 생산 라인의 검증 및 재배치
  - 생산성과 효율을 극대화한 공장 모델 결정
- 함정 시뮬레이션
  - 함정 데이터 구축 및 PDM 설계
  - 함정 설계 검증과 승조원 시뮬레이션
- 특수선박(위그) 설계-건조 통합 시뮬레이션
  - Design for manufacturing
  - Factory layout 설계

오늘 발표 주제

- DSS관련한 이론과 방법론은 제외
- 사용 software에 대한 설명 제외
- 조선 공정중 핵심공정에 대한 사례 /효과 중심 발표
  - 기계 시뮬레이션
  - 단위 공장 시뮬레이션
    - 가공공장
    - 성형공장
    - 판넬공장
    - 생산계획
      - 선표, 대일정(2~3년) 시뮬레이션
      - 긴급 물량 수주시 시뮬레이션
- Digital Factory 구축을 위한 제언

AGENDA

Digital Shipbuilding

Ch.1	Digital Manufacturing
Ch.2	Digital shipbuilding introduction
Ch.3	Several practices of the main shipbuilding processes
Ch.4	Business strategy with digital shipbuilding
Ch.5	Advanced practices
Ch.6	Concluding Remarks

AGENDA

Definition of Digital Manufacturing

- **Background**
  - Marginal utility is being decreased… with the existing & the traditional approach for the efficiency upgrade of manufacturing
- **Digital Manufacturing…**
  - Totally new approach
  - Transition of the physical atoms' behavior of manufacturing system into virtual bits' behavior
  - Focus is on the implementation of virtual production
    - E.g. 3D CAD is focus on the virtual product
  - DM could be beneficial enough by its own…
  - There could be a big synergy when DM is implemented within the global PLM boundary

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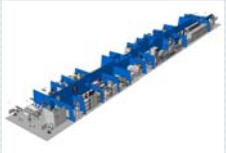
3D modeling of warship

- 3D war ship
  - 3D modeling
  - Design review
  - Essential requirements
- References
  - Hanjin
  - Hyundai
  - Kangnam



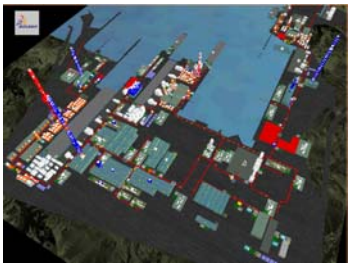
Digital Shipbuilding

Define Monitor and Control the Physical World”

VIRTUAL ⟷ **PHYSICAL**

Non Tangible Assets | Tangible Assets

Product & Process Knowledge



INTELLECTUAL PROPERTY

Production

REAL OPERATIONS

Courtesy DSME - Shipyard

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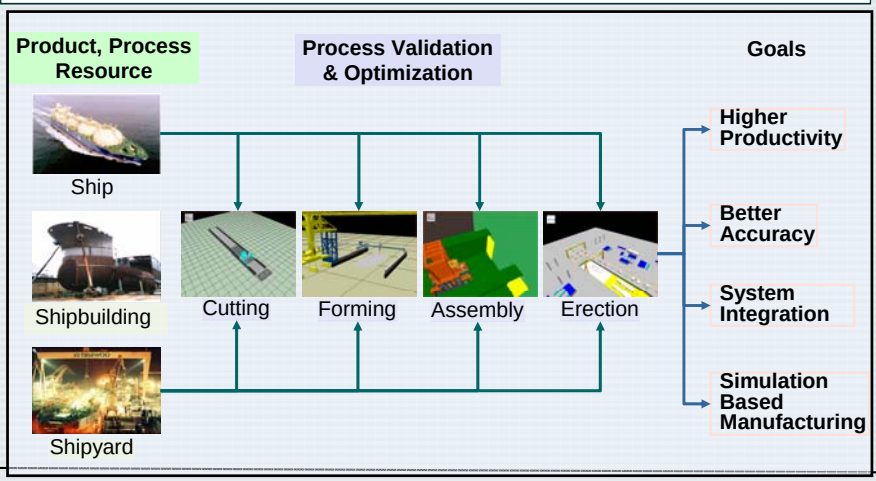
Introduction

Computer system that could simulate the shipbuilding processes in the virtual environment in order to optimize the productivity by digitalizing PPR



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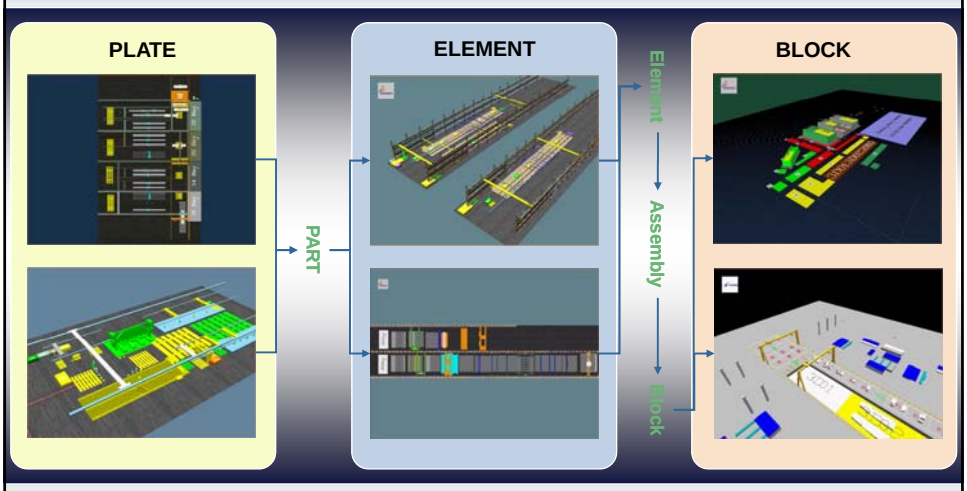
Digital Shipbuilding

- **Independent domain!**
  - Digital shipbuilding system is not belong to any specific part or system.
  - Digital shipbuilding system has its own independent domain, that could be simulate with any input and any object.

- **Implementation level is flexible along with requirements**
  - Design → DFM, DFP
  - Planning & Scheduling → Simulation Toolkit for validation and optimization
  - Production method → Optimize new production method in virtual environments
  - Labor → Prevention of MSD

AGENDA

Digital Shipbuilding w.r.t. Shipbuilding Process



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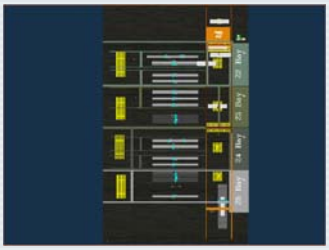
Fabrication factory – Shop level



Object	• To predict the future status of the fabrication factory along the planning & scheduling
Contents	• Flow simulation modeling for the fabrication factory • To connect the simulation system with the scheduling system
Strategy	• To verify & validate the schedule data using the virtual factory (→ simulation model that is more concrete & detailed.)

Key goal	Main output
•Digitalization of the fabrication factory	•To predict the lead time.
•To validate the scheduling data	•To predict the utilization of each facilities.
•To construct the framework for the simulation based scheduling	•To validate the capacity of each buffer.

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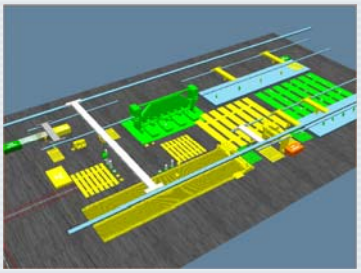
Forming shop – Shop level



Object	• To predict the future status of the forming shop along the planning & scheduling
Contents	• Flow simulation modeling for the forming shop • To connect the simulation system with the scheduling system & the database including line heating information.
Strategy	• To verify & validate the schedule data using the virtual factory (→ simulation model that is more concrete & detailed.) • Master data collaboration by interface middleware development.

Key goal	Main output
•Digitalization of the forming shop •To validate the WOD information. •To construct the middleware development framework for collaboration the production master data with	•To predict the lead time. •To predict the utilization of bending machine & line heating labor. •To validate & estimate the capacity of Gantry crane.

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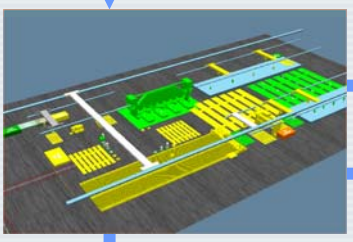
Forming shop - Shop level

Production scenario → **Estimate capacity of each machine & labor**



Problem investigation thru. The simulation

- Overload of RPM400.
- NC machine low utilization of NC machine
- High dependence of 20T Magnetic crane → proposal parallel usage of 20T hook crane.

	Valid time (Hour)	Working time(Hour)	Utilization(%)
NC cutting	123	4	3
RPM1500	98	29	23
RPM400	63	64	51
RPM2200	98	29	23

	Valid time (Hour)	Working time (Hour)	Utilization(%)
Labor 1 (Line Heating B)	96	31	24
Labor 2 (Line Heating B)	99	28	22
Labor 3 (Line Heating B)	99	28	22
Labor 4 (Line Heating B)	102	25	20
Labor 5 (Line Heating B)	102	25	20
Labor 1 (Line Heating A)	63	64	50
Labor 2 (Line Heating A)	66	61	48
Labor 3 (Line Heating A)	66	61	48
Labor 4 (Line Heating A)	66	61	48

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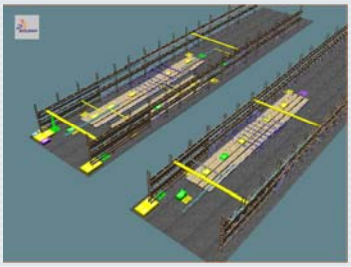
Sub-assembly line – Shop level



Object	• To predict the future status of the sub-assembly line along the planning & scheduling
Contents	• Flow simulation modeling for the sub-assembly line along part (skid) sequencing • To connect the simulation system with the scheduling system & the database.
Strategy	• To verify & validate the schedule data using the virtual factory (→ simulation model that is more concrete & detailed.) • Master data collaboration by interface middleware development.

Key goal	Main output
•To validate sequencing information of the part sequencing skid. •To construct the middleware development framework for collaboration the production master data with	•To predict the lead time •To optimize part sequencing schedule & labor management plan. •To validate & estimate the capacity & utilization of facilities.

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  - Ch.1 Digital Manufacturing
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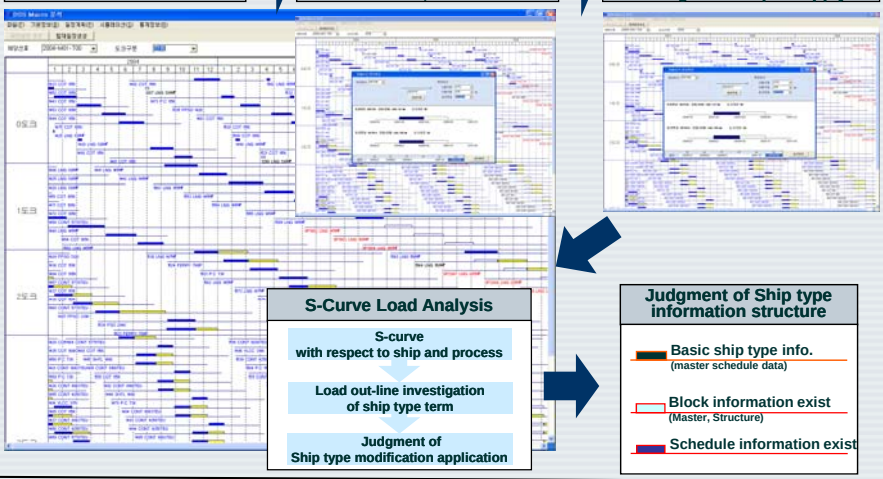
Digital shipbuilding model as a decision-making system - application level description

Business strategy validation (Very long – Year ~ Month)	• Long time load analysis using the previous record data and the mother ship data.
	• Impact and availability analysis of product mix change
Planning validation (Long – Month ~ Week)	• Panel line schedule verification (Production rate, lead time, etc.)
	• Out-door block movement planning validation (Block monitoring/ Route load/ Facility, Area load, etc.)
	• Assembly line planning validation (Production rate/ Material volume analysis each tact time)
Execution validation and advancement (Short – day)	• Lead-time decreasing through the optimized inserting order decision in assembly line
Impact analysis of facility investment & change	• Effect analysis of the resource change or spec. change

Business strategy validation

Very long-term analysis (normally over 1 year plan)

1. Simulation project plan selection → 2. Ship type modification & addition, deletion → 3. Modified ship type arrangement & plan apply



S-Curve Load Analysis

S-curve with respect to ship and process

Load out-line investigation of ship type term

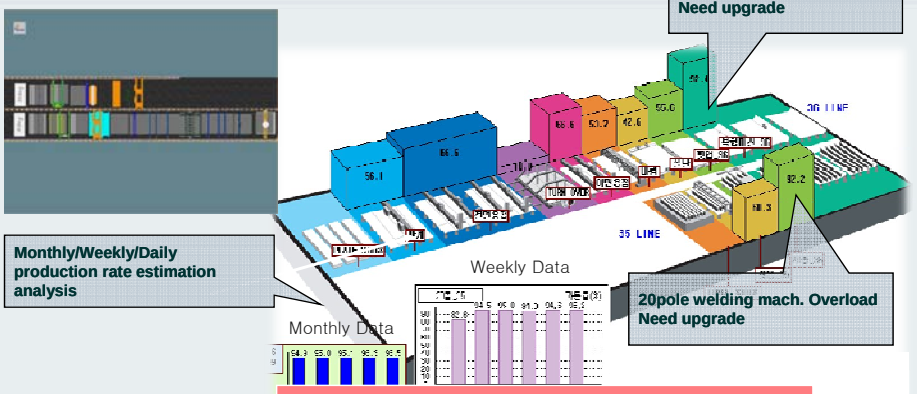
Judgment of Ship type modification application

Judgment of Ship type information structure

- Basic ship type info. (master schedule data)
- Block information exist (Master, Structure)
- Schedule information exist

Planning validation

- Planning manager can resolve the variety problem based on analyzing thru simulation of the production information such as the production rate / lead time



26% capa. increase possibility
through bottleneck process (complex mach. & welding mach.) **improvement**

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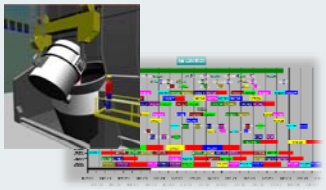
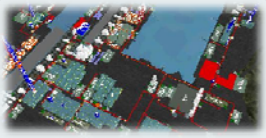
Advanced practices

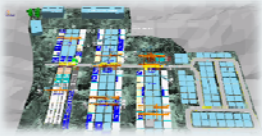
- **Case #1**
  - **Virtual simulation based planning and scheduling system of Rautaruukki Steel company**



- **Case #2**
  - **Ship block movement simulation for the decision making of the material flow (here, material means ship block) planning system**



- **Case #3**
  - **Consulting about the production system of the ship block assembly**



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Advanced practice

Case #3

Second Phase [Critical factory]

1안

- **Advantage**
  - Production rate is continuous and stable
  - Simple process
  - Enough part stock area
- **Disadvantage**
  - Too many transporters are required to satisfy the block transportation
- Predicted lead time / a ship
  - 14 -> 7 -> 7 -> 7

2안

- **Advantage**
  - Easy management of curved block owing to skid production method
  - Less transporters are required comparing with 1st scenario
- **Disadvantage**
  - Crane util. is too high
  - More workstage area is required → shortage of part's stock area
- Predicted lead time / a ship
  - 17 -> 8 -> 9 -> 8

3안

- **Advantage**
  - Time for the arrangement process is reduced owing to the matrix production method
  - Additional type of crane adopted → advance the block transportation
- **Disadvantage**
  - Still, the area for the part's stock have to be considered more carefully.

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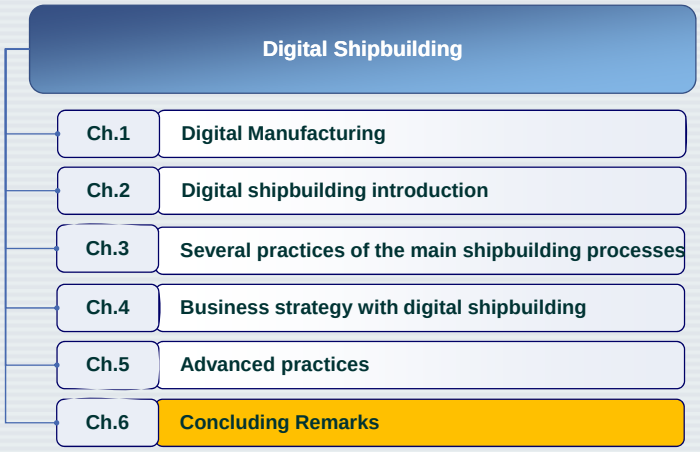
AGENDA



Digital Shipyard구축 효과

- 조선 핵심공정에서 획기적인 생산성 향상 확인
- 조선소 기간시스템과 연동하여 데이터의 품질 확인, 생산 계획 확인, 추가/긴급 물량 투입 확인
  - 회사의 기간 시스템과 연계하여 가상환경에서 미리 생산해 봄으로써 제품의 품질, 일정의 합리성, 작업 환경의 안정성, 작업 효율 등에 대한 검증이 가능함
- 조선소의 각 공장 개선이 가능
  - 적은 비용으로 최대 효과
  - 필요한 곳의 개선과 R&D의 효과 극대화
- 공장-공장 연계 시뮬레이션으로 전체 공정 최적화
- 생산 계획 검증을 통해 주문자-생산자 동시 만족
  - 신속하고 빠른 합리적인 의사 결정
  - 상세한 생산 일정 확인

제언 및 성공요소

- **Digital Factory** 구축은 제조업 경쟁력에 지대한 영향을 끼칠 것 임
  - 공정이 복잡할 수록 인간이 직관적으로 판단하는데 한계가 있음
  - **3D CAD, CAPP, PLM, MES, ERP, APS, SCM** 등의 기간 시스템과 연계하여 가상환경에서 미리 생산해 봄으로써 제품의 품질, 일정의 합리성, 작업 환경의 안정성, 작업 효율 등에 대한 검증이 가능 함
- 초기에 **DF** 설계와 구축 전략을 잘 짜야
  - 상세한 공정분석
- 이론과 경험이 조화되어야….
  - 경험없는 이론이나 이론없는 경험은 실패를 보장
  - 서두른 진행은 구현시 시간과 비용 증가
- **Tool** 선정보다 활용이 중요
- 성공요소
  - 팀리더와 구성
  - 이론, **tool**, 기술, 경험의 조화
  - 시스템분석, 설계와 **VV&A**