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Source #3741 Bibliography (MLA) 10 pts	Ahmed Al-Ashaab, Matic Golob, John Oyekan, Zehra Canan Araci, Muhammad Khan, Dhuha Deli AND Esraa Al-Ali, eds. "Flying Into Aerospace's Next Generation." Literary work to inform all. Cranfield University. 2013
Annotation: (Describe ALL info. that might be important for your paper. Explain to the reader and/or summarize what might be found in this source) 35 pts	Describes the new system and subsystems of aerospace/ industrial engineers. They are attempting to inform as well as sell a system that can be used to educate students in their field. This specific field was Industrial engineering. The students were put through certain tasks to evaluate their strength in their field as well as newly learned fields. This shows how they all see the tasks differently through their degrees. They all perform in this task to show how different each field as well as how they say it has changed.
Potential Quotes: (Are there any significant quotes you can use or paraphrase from this source?) 15 pts	"These enablers were derived from the LeanPPD project. Each enabler and its current state are briefly discussed in the following sections. Set-based design The set-based design concept…" "Work at this stage includes exploring subsystem sets, such as simulation, prototyping and testing. Knowledge created during these activities is captured and used to evaluate different sets of solutions."
Assessment: (Analyze and explain why this source is credible) 15 pts	This source is incredibly credible because it has a copyright at the bottom as well as it mentions programs with companies were familiar with (Toyota) and shows how these companies have developed these programs. As well as it citing the company's program.
Reflection: (How will you potentially use it?) 25 pts	I will use this to backup my claims that the aerospace/ engineering field is changing and can use several quotes to back myself up. As well as show that it is from the middle east which shows that it is everywhere because there are also articles like this published in the UK and Europe.

38 Industrial Engineer Flying into aerospace's next generation A knowledge shelf. Set-based design. Trade-off curves. These are the lean enablers paving the way. BY AHMED AL-ASHAAB, MATIC GOLOB, JOHN OYEKAN, ZEHRA CANAN ARACI, MUHAMMAD KHAN, DHUHA DELI AND ESRAA AL-ALI October 2014 39 The aerospace sector is tasked with creating a step change in product performance and cost to meet the evolving requirements of airlines, their passengers and the environment. To meet this challenge, there is a need to develop a multidisciplinary set-based design capability that can deploy new technologies on novel configurations more quickly and with greater confidence. The Configuration Optimization of Next Generation Aircraft (CONGA) project was launched to respond to this need by delivering robust product concepts for novel wing and power propulsion configurations. CONGA is a two-year project supported by the Technology Strategy Board, a governmental research funding organization in the United Kingdom. Along with England's Cranfield University, the CONGA consortium has six industrial partners: Airbus, Airbus Group Innovations, Aircraft Research Association, Eurostep, MSC Software and Rolls-Royce. The project aims to create an environment that will help develop design concepts leading to the agile convergence of feasible aircraft configurations that fulfill the properties, capabilities and behaviors required by the stakeholders. Industry wants the capability to evaluate a set of aircraft concepts rapidly and exclude subsets of aircraft concepts that are not feasible. To achieve the CONGA project's goals, the Lean Product and Process Development (LeanPPD) research team at Cranfield University has been conducting research with industrial partners to develop a number of lean enablers, including set-based design, trade-off curves and a knowledge shelf. These enablers were derived from the LeanPPD project. Each enabler and its current state are briefly discussed in the following sections. Set-based design The set-based design concept (also known as set-based concurrent engineering) was derived from a Toyota product development system as described by James Morgan and Jeffrey Liker in their 2006 book The Toyota Product Development System: Integrating People, Process and Technology. Set-based design aims for high innovation with low risk. The LeanPPD project research team explored the set-based design concept, where design participants carry out product development and design activities by reasoning, developing and communicating about sets of solutions in parallel, as shown in Figure 1. As the design progresses, researchers gradually narrow their respective sets of solutions based on the knowledge gained, committing to staying within the sets so that others can rely on their communication. Critical design decisions are delayed deliberately to ensure that customer expectations are understood fully and that the design meets the requirements of different functions and stakeholders. By following the set-based design process, companies can explore highrisk solutions in parallel with low-risk design solutions, as implied by Figure 1. These solutions are analyzed, and those that are not feasible are ruled out based on the knowledge gained through this exploration. This results in a highly competitive design solution without losing sight of the company's capabilities, customer requirements, project time scale and budget. Currently, one of our major focus points is developing a multidisciplinary set-based design process model tailored for the specific needs of CONGA's industrial partners. Early in the project, 28 requirement statements were defined based on set-based design principles and the aspirations of the CONGA set-based design process model, including process simplification, knowledge-based environment, supply chain collaboration and collaborative information system framework. The CONGA set-based design process model is shown in Figure 2. The main outcomes of the four phases can be summarized as follows: Phase 1: Define value. The project is classified and defined according to the level of innovation incorporated. The customer value also would be identified in order to evaluate the "leanness" of the winnowing systems Figure 1. This baseline model for set-based design shows how solutions are narrowed down to ones that work. 1. Dene value Customer interaction Supplier involvement Subsystem A Subsystem B Subsystem C Subsystem D 2. Map design space 3. Develop concept sets 4. Converge on system 5. Detailed design 40 Industrial Engineer design alternatives and align the project with the company's strategy. Phase 2: Map design space. Design participants or subsystem teams define the scope of the design work required as well as the feasible design options/ regions. This includes deciding on the level of innovation of the system and subsystems. Phase 3: Develop concept sets. Each participant or subsystem team develops and tests conceptions of possible subsystem design solutions. Work at this stage includes exploring subsystem sets, such as

simulation, prototyping and testing. Knowledge created during these activities is captured and used to evaluate different sets of solutions. Sets of solutions are communicated within teams to receive feedback and understand constraints. Phase 4: Converge on system. Subsystem intersections are explored, and integrated systems are tested. Based on the knowledge produced in this phase, the weaker system alternatives will be purged, allowing a final optimum product design solution to progress to the detailed design phase. Elimination takes place in the light of several activities, which include evaluating robustness, assessing costs and gradually converging toward a solution. By working in a research environment with the CONGA project's aerospace partners, the LeanPPD research team developed the early phase of a product development process model that, while grounded in set-based design principles, is tailored specifically for the needs of our partners. This early stage aims to guide a multidisciplinary project team to explore the environment and understand all stakeholders' needs. Furthermore, it enables the team to identify and explore customer value and translate it into engineering requirements. Then these parameters are used to define system functionality and map the system design space. Multiple design concepts are identified and proposed at this stage; however, each design concept is analyzed later to make sure it corresponds with operational concepts to form the initial set of design concepts that are feasible. Essential knowledge and information from different activities are then captured in a summary template to be presented at a review meeting. This new process model was used in a research-based low-noise engine case study. The model successfully guided engineers through the fuzzy front end of the product development process, where a set of four design concepts was defined. The main conclusion from this research work to produce the tailored set-based process model is that our industrial partner now is provided with the first part of a product development environment that respects set-based principles. This will enable the company to develop several solutions in parallel. Since the new model is based on the company's existing model and detailed process documentation is being developed, its implementation should be relatively short and stress-free. Knowledge shelf The knowledge shelf is a tool that captures, compares and reuses key project design information to support designers with the knowledge they need throughout the set-based design process. A software prototype for the knowledge shelf is currently being developed in conjunction with the Rolls-Royce knowledge management platforms and practices with the aim of using this more in the future. The knowledge-shelf concept was conceived to help create an environment that enables collaborative set-based design by: capturing knowledge for reuse; relating multidisciplinary knowledge to alternate design concepts; creating a structure that enables storage, traceability, search and retrieval in a collaborative environment; and supporting engineers by providing summary reports from previous projects. During the initiation of a project, initial trade studies would be carried out to understand the problem and flying into aerospace's next generation review and pass Figure 2. The fundamental CONGA set-based design process model has four review gates that help separate the feasible solutions from infeasible ones. 1. Dene value 2. Map design space 3. Develop concept sets 4. Converge on system RG1 RG2 RG3 RG4 1.1 Explore customer value 1.2 Conduct performance studies 2.1 Identify subsystem targets 2.2 Dene feasible regions of design space 3.1 Pull design concepts 3.2 Create sets for each subsytem 3.3 Explore subsystem sets: Prototype and test 4.1 Determine set intersections 4.2 Explore system sets 4.3 Seek conceptual robustness 4.4 Converge on nal set of system concepts REVIEW GATE 1 (Produce system requirements document) REVIEW GATE 2 (Produce subsystem concept document) REVIEW GATE 3 (Document the dened sets) REVIEW GATE 4 (Agree on the nal system solution) October 2014 41 stakeholder requirements. The output of these trade studies would determine the set of design solutions to place on the knowledge shelf, solutions that would evolve toward the final design. The set would consist of previous projects, research and development projects, including newly developed concepts, as shown in Figure 3. The infeasible designs (shown in brown) are not just rejected and thrown away; instead, they are captured onto the knowledge shelf to be considered in future projects. The good solutions are evolved toward the optimal design solution using the set-based design process model. During this evolution, the design rationale for various activities is captured. After considerable investigation, the researchers proposed that the knowledge shelf should have the following capabilities to inform subsequent development of this software: 1. Dynamic knowledge capture by capturing the rationale of design decisions throughout the application of the set-based design 2. Store the captured knowledge in a well-structured manner 3. Generate project summary reports obtained from previous projects, research and development, and novel concepts 4. Support the generation of a set of designs 5. Support the comparison of sets of solutions (e.g., trade-off curves) 6. Knowledge reuse within the same project 7. Knowledge reuse for another project Currently, the knowledge shelf is used for the first listed capability. To capture information and ideas in a dynamic fashion, the knowledge base consists of a relational database that stores the current project's information and design rationale and a graphical user interface that allows users to interact with the knowledge shelf. These are shown in Figure 4. In addition, upon user request, the knowledge shelf can generate an A3 summary report containing key information and the design rationale. As the engineer follows the set-based design process model, knowledge is dynamically captured using the knowledge shelf's graphical user interface off the shelf Figure 3. Using the knowledge shelf during the set-based design process allows the team to capture designs that are not feasible (marked in brown) for possible use in future projects. 1. Dene value 2. Map design space 3. Develop concept sets 4. Converge on system Locate and extract key information Detailed design Fuzzy front end Capture key information Concepts from R&D Concepts from previous projects Entirely new concepts Infeasible concepts Knowledge shelf storing and revealing information Figure 4. The knowledge shelf dynamically captures and stores information that is generated through the set-based design process. User windows allow engineers to examine this information without wasting time with extensive searches. A Set-based design process model (partial view) B Knowledge shelf software (user window) C Knowledge shelf database Capture key product attributes, their weight values and rationale behind values. Knowledge shelf software enables user to input the key results 42 Industrial Engineer window. This knowledge then is stored in the relational database. The research team's vision is that this mechanism allows for the storage of more than one expert's knowledge. As a result, the knowledge shelf makes engineers more productive by supporting them with much needed information about relevant projects without requiring an extensive search. Trade-off curves Trade-off curves are used in set-based design for visualizing knowledge about previously developed technologies and to highlight knowledge and technology gaps, also saving time. Trade-off curves help to describe the trend of crucial parameters within a given design approach in a simple visual form. They typically characterize the relationship between two or more key parameters that relate design decision(s) to factor(s) that customers care about over a range of values. Trade-off curves can be used in different activities of the set-based design process; however, its main application is to generate sets of feasible design solutions and then help them converge on the optimal design solution. In combination with the results of simulation and modeling tools, the engineer can identify a region containing feasible design solutions from previous projects and research and development in a visual way. Furthermore, trade-off curves enable the transformation of data into usable knowledge on the present project. To understand how the trade-off curves can be used to support the setbased design process, the research team has developed a process that consists of eight steps. These are: 1. Define decision criteria/key attributes. 2. Collect the data related to each of the decision criteria/key attributes. For example, data from material providers; data from previous projects, incomplete projects and research and development; and data from simulation and engineering calculations. 3. Generate relevant trade-off curves using the product parameters collected in point No. 2. 4. Plot customer requirements of corresponding trade-off curves to understand where the new solution is positioned in terms of comparing parameters. 5. Define feasible and infeasible regions. 6. Locate and extract the feasible design solution (where possible). 7. Develop a set of potentially feasible solutions for the project under consideration. 8. Explore and analyze these solutions to enable agile convergence based on knowledge. Set-based design applications can use trade-off curves in many ways. To demonstrate one, let's show an example of how they can be used to identify existing solutions that could meet a project's requirements. This is a hypothetical case used to design a single spool turboshaft engine. Similar approaches can be applied to any product or service. First, researchers need to discover the customer requirements. Second, they need to perform calculations to generate a system design concept. This concept is represented with several different thermodynamic and basic geometrical parameters, such as engine shaft power, engine-specific fuel consumption and shaft-power engine thermal efficiency. Finally, the output of the calculations is projected as a trade-off curve. This trade-off curve is assumed to have been created from previous projects, as shown in Figure 5. This case uses only two parameters, engine shaft power and engine-specific fuel consumption, both of which have an impact on the customer's minimal requirements. By projecting the output of engine shaft power against specific fuel consumption, the feasible region can be identified – it is shown by the blue box in Figure 5. This tradeoff curve illustrates that three feasible design solutions meet the customer's minimal requirements. This exercise shows how this tradeoff curve simplifies and improves the efficiency of designers in investigating design solutions from previous projects. flying into aerospace's next generation solutions with a chance Figure 5. A scenario of the use of trade-off curves illustrates that three solutions, shown in the blue box, are feasible and meet customer requirements. Main thermodynamic output parameters 1. Engine shaft power – (pw = 24363.68 kW) 2. Engine-specic fuel consumption – (SFC = 0.2455 kg/kwh) 3. Shaft-power engine thermal eciency – (ETATH = 34.0294%) Feasible region SFC Each dot represents one solution from a previous project or R&D Engine shaft power October 2014 43 The future of flight The benefits of using the set-based design process when developing new products have been acknowledged by CONGA's industrial partners. This has resulted in various changes to the way they are carrying out product development. Furthermore, the research team has received positive feedback about the current state of the knowledge shelf, including the way it captures the design rationale and the information generated in the summary reports. The benefit of trade-off curves for visualizing information has been favorably received. Current research is working to integrate them into the industrial partners' product development processes. The contribution of the CONGA project is expected to help deploy radical new technologies and superior products to meet changing environmental and cost targets for aircraft and power propulsion systems that will enter service after 2025. d Ahmed Al-Ashaab is the technical coordinator of the LeanPPD project, the key investigator of the Configuration Optimization of Next Generation Aircraft (CONGA) project and leader of the LeanPPD research team at Cranfield University. He is a senior lecturer in the university's manufacturing department. His research interests are lean product development, set-based concurrent engineering, lean knowledge life cycle, knowledge-based environment and A3 thinking. He is the author or co-author of 47 research papers published in major international journals and internationally refereed conferences. Matic Golob is a research fellow and project manager in the Cranfield University manufacturing department, where he is a task leader and main researcher for the set-based design activities of the CONGA project. His main area of research is lean product and process development, set-based concurrent engineering and process improvement. He has a master's degree in global product development and management from Cranfield University. John Oyekan is a research fellow for the CONGA project in the Cranfield University manufacturing department. His research interests include computational intelligence for lean product development and bio-inspired techniques to solve engineering problems, including problems related to unmanned aerial vehicles and transportation systems. Oyekan earned his M.S. and Ph.D. in robotics from the University of Essex. He has published more than 12 international conference and journal papers. Zehra Canan Araci is a Ph.D. researcher at Cranfield University. Her research interests include trade-off curves, knowledge management and visualization, and lean thinking. Araci earned her B.S. in industrial engineering at Dumlupinar University and her M.S. in industrial engineering and operations management at the University of Nottingham. Muhammad Khan is a research fellow in the Manufacturing Department of Cranfield University, where he is leading several knowledge deployment capability tasks of the CONGA project. He completed his Ph.D. on the subject of lean product development at Cranfield University. He has a B.S. and M.S. in computer-aided mechanical engineering from King's College London. He gained industrial experience in the aerospace division of BAE Systems. Dhuha Deli is a visiting researcher at LeanPPD research group at Cranfield University. Her main research interests are set-based concurrent engineering and automated manufacturing. Deli has a B.S. in advance manufacturing process from Baghdad University and is pursuing her M.S. in automated manufacturing engineering. Esraa Al-Ali is a visiting researcher at LeanPPD research group at Cranfield University. Her main research interests are trade-off curves to enable set-based concurrent engineering and automated manufacturing. Al-Ali holds a B.S. in advance manufacturing process from

Baghdad University and is pursuing her M.S. in automated manufacturing engineering. continuing on with lean development The Lean Product and Process Development (LeanPPD) project was a four-year European partnership that included five industrial partners and six European universities and research centers. The industrial partners were Rolls-Royce plc, Visteon Engineering Services (U.K.), Volkswagen (Germany), Sitech (Poland) and Indesit (Italy). The universities and research centers were Fundación Labein Tecnalia (Technological Research Centre), Cranfield University, Warwick Manufacturing Group (part of the School of Engineering at the University of Warwick), the Institute for Applied Systems Technology Bremen, École Polytechnique Fédérale de Lausanne and Politecnico di Milano. Although the LeanPPD project ended in 2013, Cranfield University's LeanPPD group remains active working with industrial partners. LeanPPD became part of another consortium, Configuration Optimization of Next Generation Aircraft (CONGA), and continues to reach out to industry and hold LeanPPD workshops. The 4th LeanPPD Industrial Workshop is scheduled for Oct. 28 at Cranfield University.