

# Supporting Product Development: A3-assisted Communication and Documentation

Espen L. Polanscak  
GKN Aerospace Norge AS  
Kongsberg, Norway

Gerrit Muller  
University of South-Eastern Norway  
Kongsberg, Norway  
Gerrit.muller@usn.no

Copyright © 2017 by Espen Polanscak

**Abstract.** A3-assisted communication and documentation provides a holistic and systematic approach to the architecting process, including people, processes, and technology. The method is used to encourage people to identify problems and concerns, to stimulate communication, and to break people's habits on jumping to solution and detailed based decisions without seeing the implications on the whole. An important part of the process is the creation and utilization of different A3 overviews. Aims of A3 overviews are not to be complete, formal, or executable, only meant to capture and share knowledge of key aspects of a system, enhancing communication and understanding among exposed stakeholders.

We applied A3s at GKN Aerospace Norge AS (GAN) during the development of computer based support for a manufacturing cell. Observations and feedback recorded during this project indicate that the A3 approach is a useful tool to both share and capture architectural insight.

## LEAN and A3s

LEAN manufacturing is a manufacturing concept that builds on the principles of the Toyota Production System (TPS) (Monden 1983). LEAN product development is building on LEAN manufacturing and derived from Toyota production development system (Morgan 2006), where ideas from the repetitive production environment are transformed for use in the creative product development environment.

A challenge during the process of product development is that various factors often add “noise” that perturbs the process. Factors such as limited human processing capabilities and unstructured organizational work methods often leads to unclear and unfocused discussions, causing the project team to waste valuable time. Therefore, the flow of right information to the right people is critical to ensure progress and product success. An important part of this information flow is the process of communicating and documenting various aspects of a product or system.

To support this process, both LEAN manufacturing and LEAN product development often apply the usage of different A3s. A3 is a European standard paper size of 297 \* 420mm. A3 overviews within manufacturing are often used as a practical way to address and solve various problems, while in development these overviews often includes more architectural and design based information to drive the development further. An A3 overview or sheet contains a “human friendly” amount of information. On one hand the A3 permits the author to included detailed information, while on the other hand it forces the author to select and process the information carefully.

Daniel Borches introduces A3 Architecture Overviews as a tool for effective communication in product evolution in his PhD thesis (Borches 2010). Borches presents both an approach of creating A3s along with the structure and layout of the proposed content elements in the A3. As a starting point, the approach presented by Borches was adapted because both the creation approach along with the proposed structure and layout of the A3 elements seemed logical to use for the T-Case cell at hand. Borches A3 Architectural Overviews consists of one A3 with text and one A3 with models and visualizations as shown in 1.

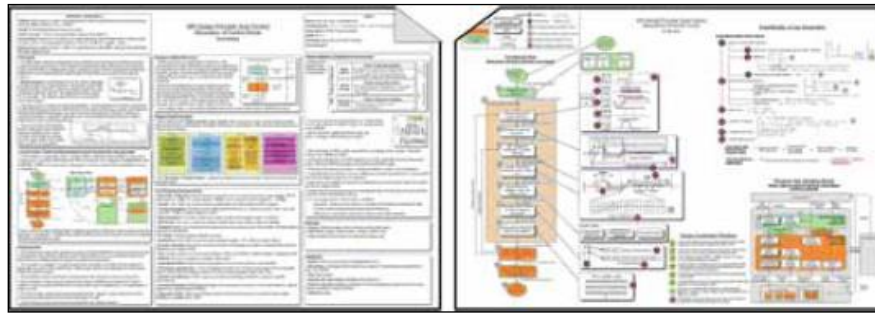


Figure 1 – Borches A3 Architecture Overview Example  
Left: A3 Summary; Right: A3 Model

This paper attempts to identify factors that contribute to the process of designing and implementing new technology into a specific manufacturing cell within the factory of GKN Aerospace Norge AS (GAN). The author of this paper has been observing, analyzing and evaluating different factors during creation, usage, and after use of several A3 overviews.

## Case: Production Cell at GAN

GAN is a Norwegian manufacturing company that produces jet engine components for demanding commercial and military customers in a global market. Main components are shafts, vanes, turbine cases and rear exhaust frames. Parts are delivered to major jet engine producers like GE (USA), Pratt and Whitney (USA) and Snecma (France). Manufacturing processes to make these parts mainly consists of milling, turning, drilling, de-burring, grinding, welding, heat and chemical treatment, and accurate measurements for quality control.

During a period of 5 months, the author of this paper has been working with incorporating new technology into a specific segment of the factory. This segment is referred to as the Turbine Case cell (T-Case cell) and consists of machines that execute turning, milling, and drilling operations. The cell is an important part of a bigger production line that executes the most time consuming operations for medium sized turbine cases. Figure 2 presents the cell's major inputs, outputs, functions, stakeholders, along with measurable performance parameters.

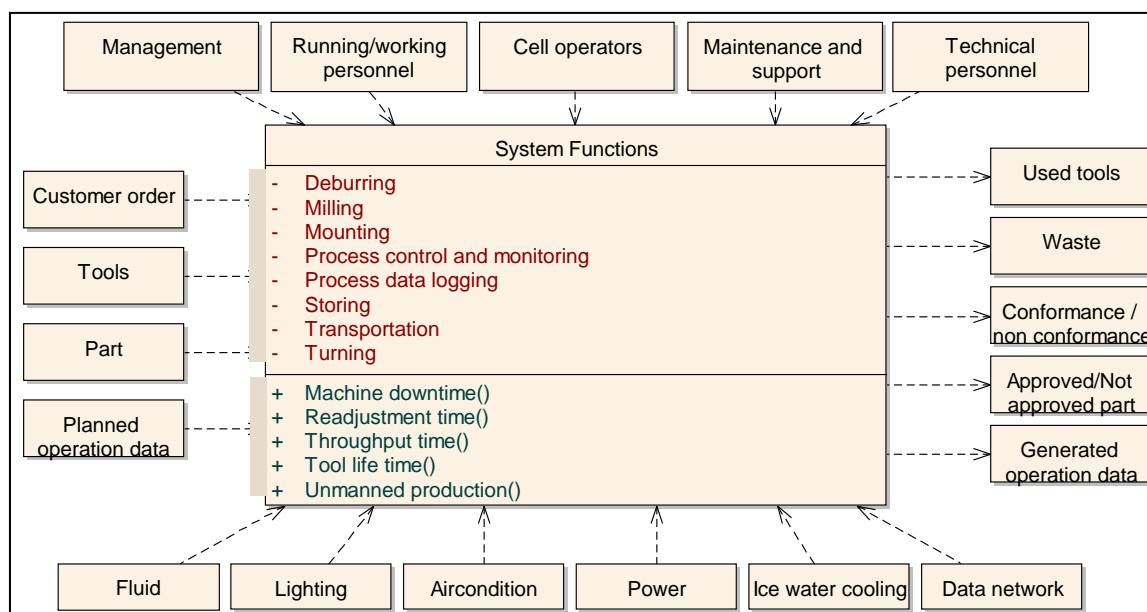


Figure 2 – IDEF0 top-level representation of the T-Case Cell

The production volume of turbine cases is characterised as “high” in aerospace production terms, meaning a production volume of 30-40 of relatively large parts per week, versus 10-12 parts typical for shafts. Turning, milling and drilling operations executed in the cell may take up to 10 hours to

complete. The operation times are not balanced in any way. The concern here is not to put the most effort into reducing the operation time itself, but rather optimize the utilization of the machines as well as making the operations more reliable and predictable. In this cell GAN experiences a lot of non-productive time where the machinery is not adding value to parts, on average 40% of total available production time (4 shifts: 120 hours/week). This “lost” time includes time spent on repair and maintenance along with time spent on waiting on necessary resources (parts, fixtures, tools).

In the manufacturing world, it is quite common to partition a production flow or line in cells. A cell takes care of one specific type of operation, where the operation of the cell is relatively autonomous.

To find proper partitioning into cells with an effective level of autonomy, GAN along with Kongsberg Defence and Aerospace (KDA) and SINTEF initiated a research project in 2008. The project intention is to improve the concept of operation of a cell as part of the factory. The T-case cell was chosen based on the state of the technology available and the overall business importance of the specific turbine case.

One of the decisions made in 2008 was that GAN would develop and implement a computer integrated manufacturing tool internally named C-SUP (Cell - SUPervisor) into the cell. The governmental research council allocated financial resources to GAN to research such cell by the development and implementation of this tool.

By having a computer tool integrated on each machine in the cell, GAN is able to control the machines and hence to automate (parts of) the cell operation. The computer tool also logs information about the operations executed. The foreseen automation is the internal machine pallet part transportation along with initiation and execution of machine programs.

## **The Challenge**

GAN engineers all have various tasks to perform related to different projects. Because of the variety in tasks, it is important that the time spent to discuss issues related to the system of interest, whether planned or not, is done in an efficient and effective manner. Individuals and the team working together need a common understanding of the essential aspects of the system.

The author of this paper has experienced challenges in both the communication and documentation process related to the development and implementation of the C-SUP tool. Unclear understanding of problem statements and goals, technological and organizational knowledge gaps between participants, and different ways to communicate and document are factors that often lead to volatile discussions. Observations have shown that participants often spend time discussing same issues several times, leading to similar conclusions made previously. As a mean to cope with these challenges, we propose the usage of A3-assisted communication and documentation. A3-assisted communication and documentation is a proposed method that aims to capture and share important system knowledge, support in answering and collecting system questions and concerns, support in decision making, and support the continuous work of system architecting by involving stakeholders to a higher level than before.

Meetings are expensive, especially when you add up the number of highly paid people in the room at the same time. It is important that meetings serve a clear purpose and that one is able to stay as efficient as possible. Based on previous experience, exposed stakeholders often do not share a common understanding of problems and goals. There exists knowledge gaps between participants and they all have different ways to communicate and document. These are among several factors that often lead to volatile discussions, both in planned and unplanned sessions.

## **Research Methodology**

We started out by making a set of A3s to incorporate relevant information about the C-SUP system following the approach of Borches. Based on our experiences we have tried variations of Borches

approach. For example, we tried combining both text and models/visualizations into one A3 instead of two A3s; such single A3s often make more sense when dealing with smaller “hot topics” and issues. Examples of A3s are presented in the section “A3 Examples”.

The approach to record and collect observations and feedback was based on the usage of an observation template. We named this “In Session Observation Template” (ISOT). This template incorporates a set of guiding questions and attributes that helped the author record observations before, during and after using an A3 in a planned or unplanned session or discussion. Table 1 shows some of the questions found in the ISOT. The ISOT is shown in Appendix A. It contains attributes to capture the kind of session, information about the A3, and questions about the use and appreciation of the A3.

Table 1 – Session attributes

Session questions/attributes
Kind of session
Physical location of session
Planned/unplanned session
A3 purpose
A3 usage/iteration number
Number of session participants
Supported in answering questions
Supported in generation new questions/concerns/ideas
General observations

As shown in Figure 3, the research process has consisted of two main paths. One path (yellow) including A3 creation, usage, and adjustments, and one path (green) including observation, feedback gathering, consolidation and analysis.

Based on the analysis of the recorded entries in the different ISOT’s along with feedback from different participants, we have been able to identify factors of success, blockers and challenges during creation, usage and after use of A3s. The process of selecting the factors was based on a content analysis/cluster analysis of each ISOT at the end of the research project. The ISOT content was divided up and structured in logical groups/segments; this gave us the ability to identify patterns and clues that further lead to the selection of the different factors.

We have also exchanged and discussed A3 experience in a broader forum of (potential) systems engineers. The assessment of this forum is included in the discussion on feedback on the A3 method.

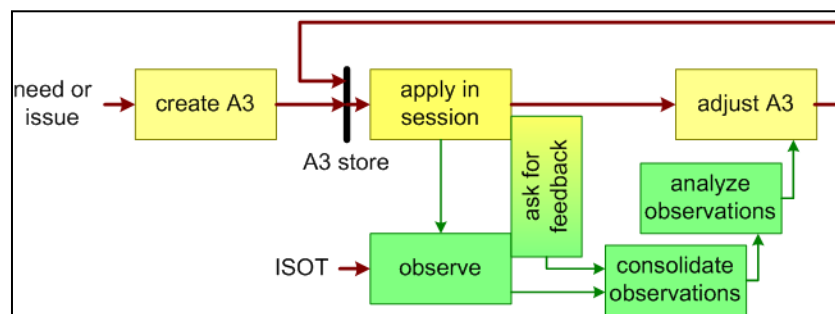


Figure 1 – Research approach

## A3 Examples

To support research findings we introduce the reader to A3s created and used during the project. Figure 4 shows examples of two-sided A3s, meaning one A3 with text and one A3 with models and

visualisations describing a specific subject or topic. Figure 5 shows examples of A3 singles, including both text and visualizations into one A3.

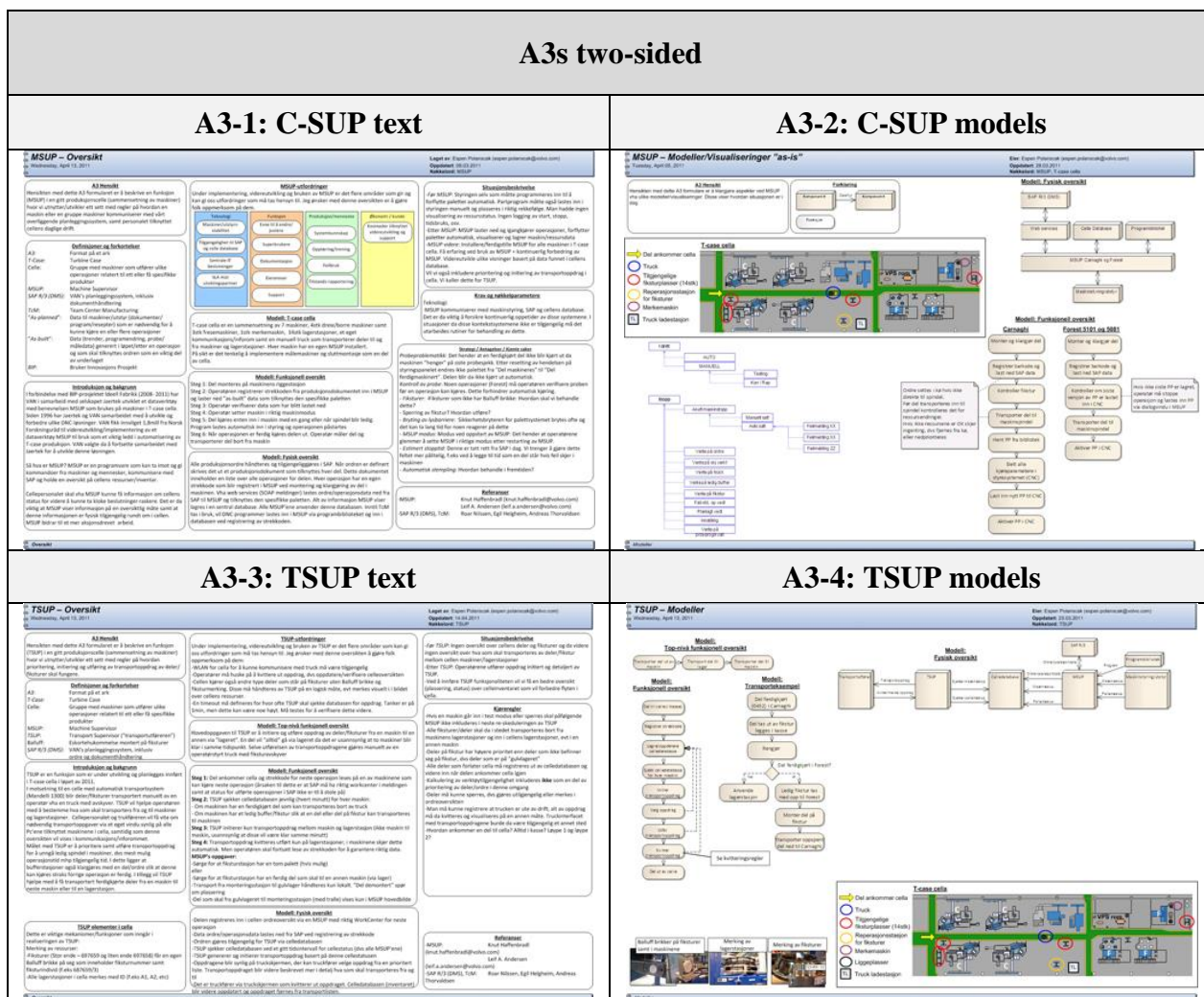


Figure 2 – Two-sided A3s

**A3-1/2: C-SUP text and C-SUP models:** One of the problems of architecture knowledge sharing is to know what information belongs to the architecture (Borches 2010). Even though GAN has a lot more process-based information, the challenge is the same. The C-SUP A3s were the first A3s created following Borches' approach. The reasons behind the creation of these A3s was to start the process of capturing information from exposed stakeholders turning tacit knowledge into explicit knowledge and further use this information as supporting material in different sessions.

**A3-3/4: TSUP text and TSUP models:** To be able to help support the flow of parts and fixtures inside the cell, it was decided to add the transportation system as a part of the logic in the C-SUP. By having a clear overview of machine status along with location of resources, the Transport Supervisor (TSUP), as an extended function of C-SUP, may provide useful information to the cell personnel on when, where, and what to transport of parts and fixtures between the machines and the storage racks inside the cell. These two A3s contain information to facilitate the discussion about the development and implementation of the TSUP.



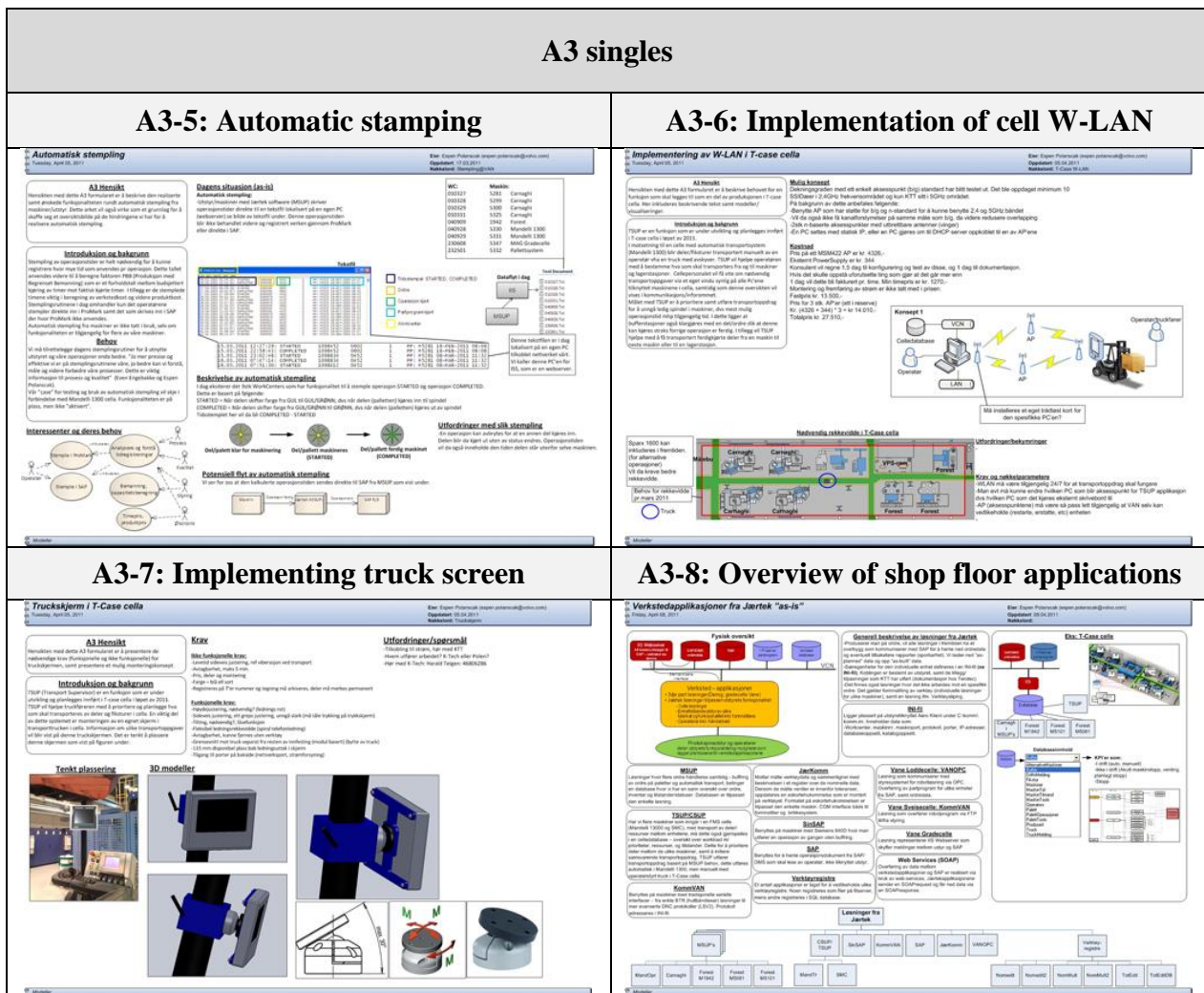


Figure 3 – A3 singles

**A3-5: Automatic stamping:** A participant in an ongoing improvement project raised the need to make this A3. The intention of the A3 was to support the communication and discussion of problems seen today based on the current concept of how operators manually registers time spent on different manufacturing operations in the shop floor. This specific subject is often raised in different settings and is a well known issue. A positive outcome after two discussions was that a need to run a specific test on possible new stamping routines was raised and further planned and executed.

**A3-6: Implementation of cell W-LAN:** In the T-Case cell the C-SUP has the need to communicate with a moving transportation truck. To facilitate this communication a wireless network is planned implemented. After a meeting with participants from both the IT-department and participants from the Technology division, the most important information captured was put into an A3. This A3 was used in a second session with the same participants from the first meeting together with a representative from a network service company. Based on conclusions made during the session and from a shop floor inspection, the network representative had enough information to provide an offer for a network installation.

This information was added in the A3 and given to the project leader as decision supporting material.

**A3-7: Implementing truck screen:** To show information about required transportation tasks to the operators, a screen has to be mounted in the truck. The process of making this A3 was conducted by the author along with another member of the same division (Technology). In advance the A3 had a short description of its purpose along with specific background information. Before making any

concept 3D drawings, top-level requirements were made and further placed in the A3. Based on this information the co-writer could generate a concept of how the mechanical interface could look like.

**A3-8: Overview of shop-floor application:** GAN today many different ICT (Information Communication Technology) systems are used by different stakeholders in different settings. One of these systems is the C-SUP system, operating in the T-case cell. As these systems evolve, it gets harder to keep track of what data goes where and how this data is managed. To capture key knowledge of all these different systems and synchronise further activities towards a common goal an A3 was created with relevant topic information. Today GAN has several different shop-floor applications that are operating with different kinds of manufacturing equipment. The A3 shows information about these applications, and highlights the T-case cell more in detail.

Tables 1 and 2 summarize statistical facts about A3s applied. Number of recorded sessions (entries) in the ISOT: 22.

Table 2 – A3 revisions and iterations with stakeholders

<b>A3 name</b>	<b>Number of revisions</b>	<b>Number of iterations with stakeholders</b>
A3-1/2: C-SUP text and models	5	5
A3-3/4: TSUP text and models	4	6
A3-5: Automatic stamping	3	3
A3-6: Implementation of cell W-LAN	2	2
A3-7: Implementing truck screen	2	3
A3-8: Overview of shop-floor applications	2	3

Changes in the different elements found in the A3s and hence a change in the A3 is primarily based on feedback received from stakeholders during and after sessions. As seen in Table 1, the number of revisions of each A3 is close or identical to the number of iterations with stakeholders. For single A3s such as A3-5 A3-6, and A3-7, two revisions and 2-3 iterations was sufficient for the time being. During this research project the A3-1/2 and A3-3/4 has the same pattern, but the content on these A3s will continue being changed based on the continuous development of the C-SUP system itself. The more the different A3s are used in other settings the more people will find things that should be changed, added, modified, etc (Borches 2010).

Table 3 – Session attributes

<b>Kind of session</b>	<b>Distribution</b>
Communicate status	4
Sell an idea/concept	4
Brainstorming/generating ideas	4
Solve/discuss problems	10
<b>Physical location</b>	<b>Distribution</b>
Defined meeting room	8
Colleagues' own office	10
At shop floor	4
<b>Planned or unplanned session</b>	<b>Distribution</b>
Planned	14
Unplanned	8

Ca 45% of the C-SUP and T-case cell specific discussions (ten of total 22 sessions as seen in Table 2) have been conducted in colleagues' own office The physical proximity (max 5 meters) between the group members has allowed sessions to be conducted without having to spend time arranging time and place via a tool such as Microsoft Outlook.. During C-SUP specific sessions, the group members most often had the need to discuss problems and issues related to further C-SUP development. In sessions where the author had the need to communicate status, sell an idea, or brainstorm with others, these meetings were often planned and

conducted in a defined meeting room outside the Technology division. This was required when having to discuss issues with stakeholders from other divisions located further away. When input was needed from operators, short stand up sessions were conducted close to the operators workplace in the shop floor.

## **Research Findings**

To structure our findings we present success factors, challenges and the blockers during creation, during use, and after use.

### ***During Creation***

***Architecting knowledge:*** To be able to capture and visualize architectural knowledge one has to have basic skills in making functional, physical and quantified models. A major part of the A3-2 and A3-4 consists of such models. At GAN “models of abstract nature are frequently used among engineers to describe flow of data between software” (Engebakken 2010). If several authors are working on related A3s, it is beneficial that the authors are in agreement on the level of detail put into these models. Observations made while dealing with different stakeholders at GAN tells us that abstract models are rarely used, especially when dealing with mechanical topics. 3D drawings are often seen more practical because they have a wide appeal and are easy to understand. This is also an observation made by Engebakken (Engebakken 2010). Instead of making functional and physical block models of the mechanical interface, 3D drawings were made to present a potential concept as shown in A3-7.

***Creation tool(s):*** A true benefit of making and using A3s is that the threshold for making them is very low, meaning that besides understanding the fundamentals of functional and physical architecting, there should be no need to educate people in any new custom-made software tool. Generic tools such as Microsoft Visio and PowerPoint as well as pen and paper go a long way of capturing important information about a topic. Although software tools do provide many benefits (automation, speed, verification, etc) custom-made tools require dedicated maintenance and expertise that need to be incorporated into the company (Borches 2010). Every A3 made during this project is made using Microsoft Visio, a company standard software tool. No cost in purchasing and training was needed in the beginning or during the project.

***Approach, format and content:*** Knowledge may be seen as an object that can be collected, moved, stored and distributed (Borches 2010). The A3 is a tool that supports in transforming tacit knowledge into explicit knowledge. If A3 is going to become a standard at GAN or in any company, it is important that engineers get the knowledge in what to include in such A3s. As we created the different A3s we observed that we became much more liberal in what to include based on the topic at hand. A3-5, A3-6, and A3-7 all have the elements: purpose, and introduction and background. This was included because the A3 topics introduce to-be elements that have not been implemented. When delivering the A3s out to exposed stakeholders in advance of a meeting, this information helps to introduce stakeholders to the topic, reducing the need to spend too much time in the beginning of a session. In A3-8 this information was left out, because the exposed stakeholders are familiar with the topic at hand.

A major benefit of the A3 method is that one knows what elements to include. A system of interest was chosen and information about this system was gathered and structured in a way of two A3s, one with text and one with models and visualizations as shown by A3-1, A3-2, A3-3, and A3-4. We observed that creating the A3 following a clear path gave the author much more control of the process. Before starting utilizing the A3 method, much time was often spent on figuring out what to write, how to write it and where to put it. Following an approach made us spend less time on this manner, reducing the level of non-valuable work.



However, when dealing with smaller topics or issues, using one text based A3 and one model based A3 often seemed too much. The result often ended up with combining text and models into one A3 as shown by the A3s in Figure 5. Many of the original text and model elements were used further, but some were left out. A challenge when not following an approach is that the format itself does not have the intended power/benefits as first proposed. It might become easy to leave out important information. “All views are important; therefore the time allocated to views should be time-boxed so proper views are created. “During iteration, additional time can be spent on those views that require additional effort” (Borches 2010).

The A3 format in itself is not new to GAN engineers, but the way information is structured on a piece of paper represents a new way of reading information. In A4 reports one reads top-down, while in an A3 there is no clear reading path. A fellow group member says that “While using A3s in sessions, the author has to guide the participants through its content to compensate for a missing reading path”. We often observed that when presenting an A3 to participants for the first time, people tend to get overwhelmed. We observed that too much information at once, with no clear way to read it often causes some people to lose interest of the information found in the A3. The challenge of combining elements into one A3, instead of having a set of A3s, is that it becomes difficult in adapting a standard that everybody can identify, follow and use by themselves. This becomes important if the intention is to create a common way of supporting communication and a common way of documenting.

Figure 6 and Figure 4 7 show the distribution of text and model-based elements in the different A3s. As shown in Figure 6, physical models including 2D/3D drawings are dominant and much more popular than the more abstract use cases and functional models. The distribution of text elements relies heavily on the A3 authors’ decision whether to make a two-sided A3 or an A3 single. In single A3s, text elements such as model descriptions, references, definitions, and abbreviations are often left out. A3 purpose, introduction and background information, and system and situation description are all elements that fit well into both two-sided A3s and single A3s.

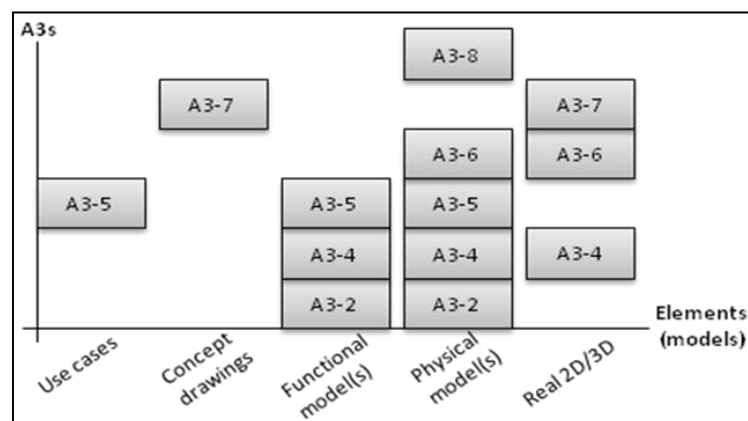


Figure 4 – Distribution of models and visualizations in A3s

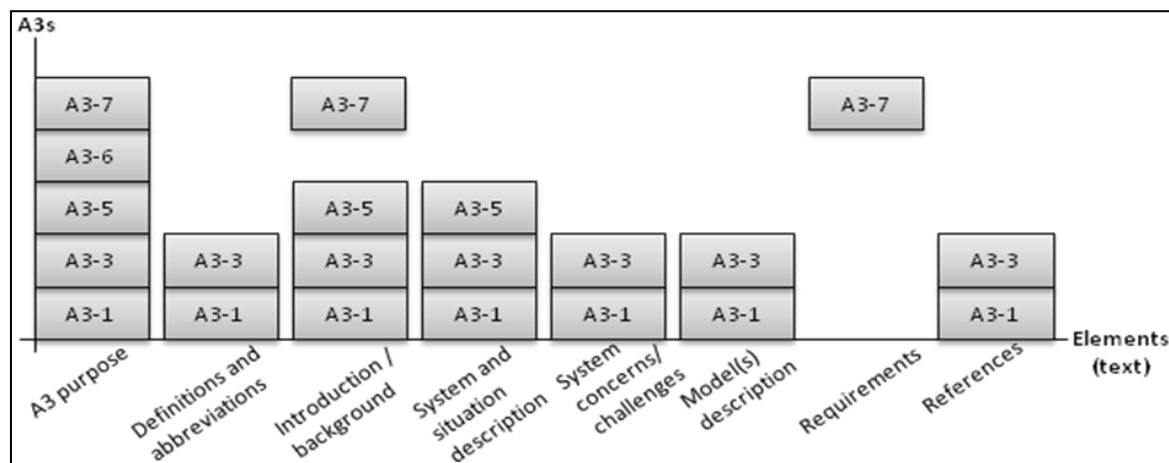


Figure 5 – Distribution of text elements in A3s

**Inclusive:** The author alone made most of the A3s, and updated them after use in one or more sessions. When making some of the specific “hot topic” related A3s (Figure 5), the author sometime chose to include another colleague in the creation process. An example of this was the creation of the A3-5. The trigger to make such an A3 came from a fellow colleague participating in a product improvement project. Elements of information were added based on the knowledge of what aspects usefully had been unclear in the past. Making the A3 together created a more dynamic working environment. Questions along with system concerns and comments got added and sometimes answered during the creation process itself. Making an A3 together creates ownership and understanding, and one is able to visualize the progress. The A3-5 took one day to complete and was used the day after in a dedicated session.

Another example of supporting A3 creation was the making of the A3-7. The author needed support of making a concept 3D-model of the mechanical interface connecting the truck screen to the truck itself. Before being able to make the concept version, the author and the colleague worked together to identify top-level functional and non-functional requirements. These were added into the A3 as they were identified. After just two sessions, the authors felt comfortable of starting the process of actually designing the interface in relation to the documented requirements. This resulted in a concept version visualized by several 3D models that were added into the A3. Having different views of the concept solution gave the author the opportunity to support the project leader in deciding to go further with the solution or not.

**Level of detail and formality:** A challenge present in the making of all A3s is to know when the A3 is “good enough”. During the creation of the first model based A3, much focus was put into making functional and physical models. When making these kinds of views one has to think of the intention of the views. If the reason is to re-architect the system and make this information a part of the system documentation, then it is important to have a certain level of detail. The same challenge relates to the level of included background information and problem description in an A3. During the first session using the A3-5 the author initiated the sessions by saying “there is a lot of text here, but what this really is about...” We agree that spending much time including formal information into an A3 may seem as waste compared to the level of output gained. It may be hard to make complete A3s before each session because sessions tend to get executed rapidly.

### During Usage

**Dynamic:** Presentations at GAN usually consist of one person presenting some material using a tool like PowerPoint. A problem often seen using this approach is that valuable feedback received from exposed participants sometimes get lost because it is delivered verbally and then

not documented in any way. A clear success or benefit using A3s is that the person responsible for the execution of a session or discussion can capture this feedback in real-time. Questions, concerns, changes in models are recorded instantly by noting them down on the A3 and further adjusted using a computerized tool. Another success factor of having an A3 close to exposed stakeholders is that one makes it easier for people to add comments by having the information available on a physical piece of paper.

During sessions with maximum three people, we observed that using an A3 as a center of attention worked well. The distance from the people to the A3 did not prevent them from reading and from noting down feedback. A challenge is when the number of participants expands from three up to five people or more. In one specific session the A3-8 was given out in advance and printed out and put on the table in the meeting room. Based on the number of participants (six), the author chose to make a PowerPoint-presentation to communicate the information instead of only using the A3. While presenting the content, we observed that the A3 (A3-8) located on the table was not used. The attention was clearly on the PowerPoint-presentation itself, and not the A3 on the table. Everybody should have their own A3 in front of them, instead of having just one A3 available. Based on what we observed during this session, more A3s were printed out in similar sessions including four or more participants.

**Focus:** A major challenge observed during sessions at GAN is that without a clear agenda and clear supporting material the discussion often tend to drift away, meaning that too many subjects or issues are discussed at once. During the early phase of a project, this is often necessary to get the discussion going. The problem arises when this becomes practice, meaning that almost every session ends up with no decisions made and unclear conclusions on the future work. The A3 has proven to be a useful tool to attack this problem. In A3-4, a specific functional model was included to be able to make a conclusion of an aspect of the system. During a discussion, the author observed that by referring to this particular model and always asking for confirmation of the different steps, we managed to reach a common agreement.

Another challenge when it comes to focus is that text-based elements are usually “unpopular”; they rarely get read if not referred to during the session. A model like the physical model in the top right corner in A3-8 often becomes a center of attention during a session much because of the color usage. Color and font size has proven to be an important factor when presenting and using A3s in sessions. It is important that A3s are made so that people want to read them. A benefit of including text elements into the A3s is that it supports the author when telling a story, and when questions are asked about the models and visualizations. A success factor using A3 is that less time is spent on recapitulating from previous sessions. The A3-4 has been used to support discussions on different aspects of the TSUP design. Previously the group often experienced spending up to 30 minutes on reaching the same agreement level as before. By using models and text while discussing, the author could reduce time spent on aspects already agreed on from previous sessions.

**Amount of information:** The amount of space on an A3 limits the author to include only the most important and relevant information about a topic at hand. A3-3 and A3-4 were presented to the Technology division supervisor, as a way to present the current status on the specifications on the TSUP system. The supervisor thought that the two A3s gave a good introduction and overview of the system. Especially the physical model was used during this session. This model was drawn on a whiteboard and further used to facilitate understanding. At the beginning, there was uncertainty on where functions were to be allocated in the different physical boxes. The text elements found in the text based A3 helped the author in describing the allocation in more detail. As the top-level functions became clear, the supervisor commented that the A3 was missing more detailed information on the specific rules of

operation. Because the TSUP system intends to support a manual transportation system, the system has to cope with non-ideal situations, meaning that it has to deal with various and/or missing input from cell personnel. This becomes important information to support the external programmer in the development of the system. Based on this input another A3 was developed with the intention to incorporate more details about the TSUP along with a concept of how the truck screen interface could look like.

***Generates interest/trigging effect:*** From the beginning of the founded research project, the group working with the C-SUP has been somewhat isolated from other divisions. The project group gave status presentations, but decisions made during the development have often not involved other stakeholders from different divisions. The A3-1 and A3-2 were distributed to the head of the Information Systems (IS) department. The intention was to inform him about the situation and the current status of the C-SUP system. Based on this, a session was planned to discuss the subject in more detail. During this session, it became clear that for a long time there has existed an uncertainty about the C-SUP system, what the C-SUP does, what data it stores and where, and further how this data is used or intended to be used. The head of the IS department says that “the reasoning behind my questions is not that we here at IS need to know everything, but we need to know the most important aspects of the system. We see a lot of computerized tools being developed without us even knowing”. Conclusions made from this session triggered us to make an A3 covering all of the different similar C-SUP solutions in the shop-floor, along with more detailed information about the C-SUP in the T-Case cell (A3-8). After making the A3 we arranged a meeting including several people both from the Technology and IS department to further discuss future actions and work. During this session, we observed that the physical/hierarchical model in the A3 was really helpful to visualize all the different configurations existing today. A question raised was why there existed so many configurations, and if there is a way of standardize these solutions. This question raised the attention to the author to make the physical model more detailed, to present why there exist so many different configurations. Besides the physical model, the A3 also includes some descriptive text about the different solutions as well as more detail about the C-SUP in the T-case cell. An important aspect of the A3-8 was the information about the C-SUP database content. Using a simple picture of the tables found in the database we were able to show what data is being recorded and stored. This information provided understanding of the data behind the calculation of possible Process Indicators (PI's).

The most important conclusion made based on this session was that we all have to become more aware of our common goals and the means used to reach these goals. We agreed to continue having regular and planned sessions about related topics.

***Reduce solution-based talk:*** We often observe in sessions that solutions are the center point of the discussion. Stakeholders spend much time discussing the “how” aspect of a topic, and not “what” and “why”. This is a challenge and the same aspect often appears in the author's project group. We have experienced that it is still difficult to distant people from solution-based talk, especially when one is located in a late phase of the project. However, we observed that using a functional decomposed view of possible PI's found in the A3-2, the author along with the project leader was able to focus on the “what” and not only the “how”. Several times, we reminded ourselves that constraints regarding solutions should be focused on at a later time and after receiving feedback from other stakeholders, especially the external developer in charge of implementing new functions. Having a clear model in front of us made us more focused and clear on the reasoning behind the discussion itself.

**Authority and ownership:** Almost all organizations (certainly *all* large ones) are cross-functional in operation while being functional in structure (Shook 2009). Being a large Norwegian company (ca 500 employees), we may say that GAN also has the same characteristics. This structure may result in a matrix that often leaves ownership of tasks unclear, preventing decision making that frustrates project participants. From the beginning of the development of the C-SUP tool the project group has been documenting system information in various files and formats. A challenge often seen during this project is that when the group is beginning discussing systems aspects after periods with less or no activity, confusions of what has been written, where it is located, and by who often causes spending wasteful time leading to frustration among the participants. Much time is spent on reaching the same level of agreement and understanding as before. A major success using A3s is that one creates ownership of the information located in the A3. Meta data such as title, author name, date, and revision is common to find on any A3s. Even though most organization, including GAN, uses templates to enforce this kind of information upon the creation of a document, we observe that this rarely is included for GAN PowerPoint-presentations and Word documents. We have observed that when a person is given clear ownership and authority of a topic the rest of the group tend to become more aware of their own writing activity. An example of this is the PI-tree located in the A3-2. This tree was first made in a PowerPoint-presentation because the project leader felt that this had to be created and further discussed. Just after making the first version of this PI-overview, the project leader contacted the author of the C-SUP A3 to inform about the model. This model was further added as a part of the A3-2 and removed from the previous file.

### **After Use**

**Way of working in the future:** A clear outcome of this project is that the author has been adapting the A3 method as a way of working in other projects as well. By doing this, the author has raised the understanding of the usage of this method and also many of its benefits to fellow colleagues.

**Increased interest of A3s:** During the project, many stakeholders have been exposed to the different A3s. An interesting observation is that this has increased the interest of A3s in other divisions at GAN. Both the manager of Case production and Shaft and Vane production has shown interest of using A3s as a mean to support communication and documentation in different problem solving projects.

This demonstrates the benefit of visualizing best practices inside the company and further try to adapt a work method in other projects dealing with different problems and issues, and different stakeholders.

**System documentation:** A challenge in creating and using A3s is to decide to what extend the A3 is going to be used. Following Borches approach in capturing and structuring information on two A3s may provide the benefit of having formal system documentation that may replace regular A4-reports. A complete set of A3s may serve as an object of knowledge that may be stored and further distributed to others when needed. The challenge here is to keep track if the topics described in the A3s are changed in any way. This demands clear ownership as for all available documentation. As for A3 singles the purpose has been more to support progress and decision making. If or when these proposed changes and implementations become part of the as-is situation, these elements should be put into context as part of an A3 two-sided system description and further made aware by exposed stakeholders.

## Other Feedback

Feedback from stakeholders indicates that A3-assisted communication and documentation is a great tool to capture and spread system information and knowledge. It creates awareness among involved stakeholders that contributes to a more common understanding of a topic at hand. It has the power to stay visual; it may replace a lot of text. This further makes the A3 content itself more appealing and suited to support discussion in smaller sessions. In sessions, dealing with complex issues stakeholder confirms that the A3 tool has proven to be a great way to guide the conversation along with keeping participants focused and involved. Stakeholders also confirm the importance of balancing the time and effort used to create the A3 itself with the intended output value.

At two third of the research project we presented our results at the Systems Engineering Study Group (SESG) in Kongsberg, Norway, see <[www.gaudiste.nl/SESG.html](http://www.gaudiste.nl/SESG.html)>. A valuable output of the A3 exchange and discussion forum was feedback from each of the participants on the top three advantages and disadvantages of creating and using A3s. An important input to the A3 discussion was five systems engineering students presenting example A3s along with personal observations from their own company and domain. Table 3 shows the number of participants and collected answers from this survey. The result is further illustrated by Figures 8 and 9.

Table 4 – A3 forum statistics

A3 forum statistics	
Number of A3 forum participants	22 (including five A3 presenters)
Advantages recorded	43
Disadvantages recorded	35

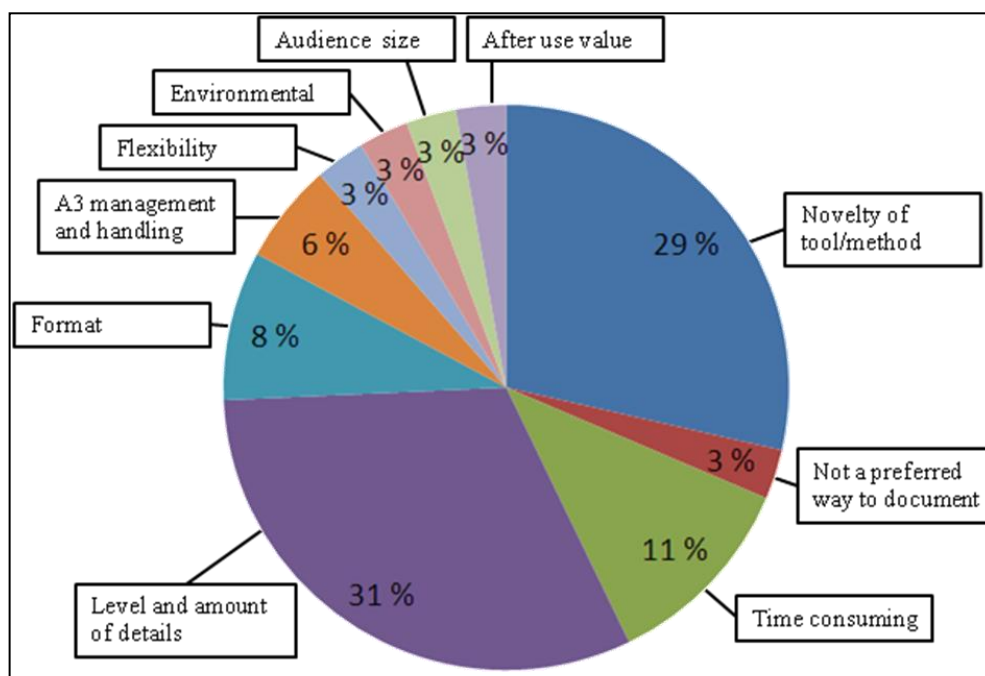


Figure 6 – Distribution of A3 disadvantages



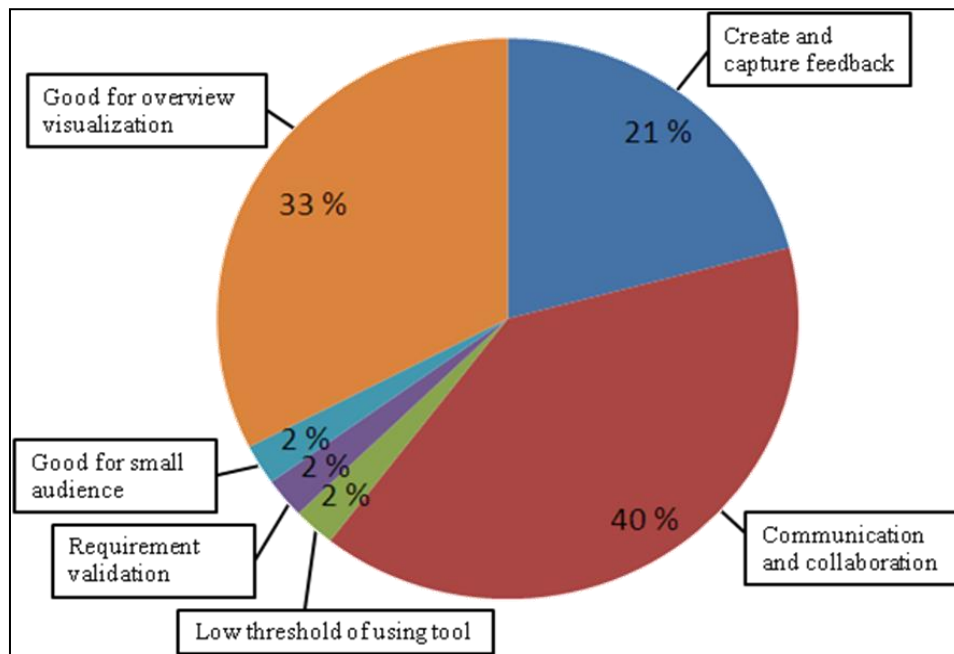


Figure 7 - Distribution of A3 advantages

The distribution of the feedback found in Figure 8 indicates two major aspects of possible disadvantages; *Level and amount of details*, and *Novelty of tool/method*. In addition we see that some participants think that the A3 process may become *too time consuming* and also that the *format* itself may have a negative influence. On the positive side, participants indicate that the A3 is as a useful *communication and collaboration tool*, a supportive tool to *create and capture feedback*, and a tool fit for *visualizing systems overview*.

The original intention was to get top three of both advantages and disadvantages from each participant. Without having spent more time discussing why there was not recorded equally among advantages and disadvantages we do claim that this survey indicates a positive rather than negative attitude (among the forum participants) towards the use of A3's.

## Conclusion

This paper sets out to identify factors regarding the creation and usage of A3-communication and documentation in a particular project at GAN. The A3 method has not revolutionized the way the author and group work at GAN, but it has contributed in a positive way to make us more synchronized, aware, and efficient. Feedback from GAN stakeholders confirm that utilizing A3s in different sessions, both planned and unplanned anywhere in the factory has made discussions more focused, dynamic and inclusive, supported answering and identifying new questions and concerns, as well as a serving as a great tool to distribute relevant information.

Feedback got from participants of the A3 forum indicates that there might be a need for basic training and understanding of the A3 process before starting adapting the tool as a mean to support communication and documentation.

There are many ways in which knowledge in the form of text and models can be captured. However what knowledge to capture and how to represent it is often unclear, and people do this in different ways. Based on our experience got from this research project, we do recommend applying the A3 tool as a mean to support product development in all kinds of engineering domains.

## Future Research

In Borches PhD thesis (Borches 2010), Borches concludes that the main value of an A3 Architecture Overview lies in its simplicity. "It is an effective way to capture architecting knowledge yet it does not require long hours of specialized training to create or use it" (Borches

2011). Findings from our research and feedback from the SESG forum indicates that the *Novelty of tool/method* seems to be factor that may prevent people from using and adapting A3s in their work. It would be interesting to conduct more research into this field to verify what kind of knowledge and how much time is necessary to spend on gaining this knowledge before being comfortable to start the A3 process.

Borches presents a “cook book” for making architectural overviews. This cook book fit well in relevant architectural based domains, but may become too unrelated in other domains where the most important knowledge is not pure architectural based. As we conducted our research we have tried variations of the Borches approach much because we felt too wired to the cook book and needed to include other elements. In light of the novelty factor mentioned above, we propose that other “cook books” related to other kind of domains be developed, applied, and further analyzed.

These are merely some of the possible topics which remain to be fully explored. Each of these issues and many more will constitute further necessary steps along the road of a more complete analysis of A3-assisted communication and documentation.

### **Acknowledgements**

To be able to create, apply, observe, and reflect on the usage of different A3s input from exposed stakeholders were needed. The research project with its activities and initiatives has been a necessary input to this paper. Working close together with several participants the author has been given a valuable framework to conduct such a research project. Leif Andersen, Knut Haffenbradl, Roar Nilssen, Ole Hoen, and Rasmus Rypdal served as important discussion and reflection partners. Bjørn Stalsberg and Even Engebakken served as important contributors of making some of the A3s used in the project. All of the mentioned participants also served as discussion and reflection partners during the project and provided valuable input.

### **References**

- Borches, D., 2010, ‘A3 Architecture Overviews’, PhD Thesis, University of Twente (Enschede, the Netherlands).
- Engbakken, E., 2010, ‘Supporting the System architect: Model-assisted Communication’, Systems Research Forum Vol 4, No2, pages 173-188
- Monden, Y., 1983, ‘The Toyota Production System’, Productivity Press, Portland
- Morgan, J. M., Liker, J. K., 2006. ‘Toyota Production Development System: Integrating People, Process, and Technology’, Productivity Press, Portland
- Shook, J., 2009, ‘Managing to Learn: Using the A3 management process to solve problems, gain agreement, mentor, and lead’, Cambridge, Ma, USA

## Biography

Espen Polanscak received his BSc in Computer Engineering from Ostfold University College in 2008 and in 2011 he received his MSc in Systems Engineering from Stevens Institute of Technology. He is currently employed as a Systems Engineer in the R&D Department at GKN Aerospace Norge AS.



Gerrit Muller.

Gerrit Muller, originally from the Netherlands, received his Master's degree in physics from the University of Amsterdam in 1979. He worked from 1980 until 1997 at Philips Medical Systems as a system architect, followed by two years at ASML as a manager of systems engineering, returning to Philips (Research) in 1999. Since 2003, he has worked as a senior research fellow at the Embedded Systems Institute in Eindhoven, focusing on developing system architecture methods and the education of new system architects, receiving his doctorate in 2004. In January 2008, he became a full professor of systems engineering at University College of South East Norway in Kongsberg, Norway. He continues to work as a senior research fellow at the Embedded Systems Innovations by TNO in Eindhoven in a part-time position.

All information (System Architecture articles, course material, curriculum vitae) can be found at: Gaudí systems architecting <http://www.gaudisite.nl/>

## Appendix 1

Session attributes – date (year/month/day)	
<b>Kind of session:</b>	Communicate information/status
	Sell a idea/concept
	Brainstorming/generate ideas
	Decision making
	Solve/discuss problem(s)/issue(s)
	Planning
	KPI/Performance/Action log
	Team building/training
	Presentation
<b>Physical location of session:</b>	Defined meeting room
	Colleague own office
	In the factory – “on the shop floor”
<b>Planned session or not:</b>	Planned
	Unplanned
<b>A3 purpose:</b>	
<b>A3 name/link:</b>	
<b>A3 usage/iteration number:</b>	
<b>A3 usage time with stakeholders:</b>	
<b>Number of participants:</b>	
<b>Did everyone understand the A3:</b>	
<b>Did it answer some of the stakeholders questions:</b>	
<b>Create any new questions/concerns:</b>	
<b>Models changed/added:</b>	
<b>Stakeholder participation:</b>	
<b>Prefer A3 instead of A4:</b>	
<b>Observations/recordings:</b>	