Christian Fabig, Michael Völker, Thorsten Schmidt
Institute of Material Handling and Industrial Engineering – Technische Universität Dresden, Dresden/Germany

Provision of Model Parameters for Capacity Planning of Aircraft Maintenance Projects: A Workload Estimation Method based on Enterprise Resource Planning Data

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Presenter – Christian Fabig

- studied Industrial Engineering (M.Sc.) at the Technische Universität Dresden, Germany
- Research Assistant at Technische Universität Dresden (since 2011)
- Research interests:
  - Production Planning and Control (PPC) in multi-project manufacturing,
  - robust scheduling,
  - Discrete-Event Simulation (DES),
  - Enterprise Resource Planning (ERP) systems
- Contact:

Dipl.-Wi.-Ing. Christian Fabig

Technische Universität Dresden
Institute of Material Handling and
Industrial Engineering
Dresden, 01062, GERMANY

Tel.: +49 351 463 32584
E-Mail: christian.fabig@tu-dresden.de
Internet: http://tu-dresden.de/mw/tla

Agenda

1. Problem Description
2. Quantitative Analysis of Maintenance Workloads in Aircraft MRO
3. Workload Estimation Method
4. Case Example
5. Real-life Application
6. Conclusion

Problem Description

Capacity planning of aircraft Maintenance, Repair and Overhaul (MRO)

- workloads are stochastic in nature
  - estimates of the sum of working hours of (yet unknown) associated work plan activities
  - corrective maintenance (“non-routine”) is a significant part of MRO projects and becomes known during project execution
- data of historical projects can assist the capacity planning process
  - gathered within Enterprise Resource Planning (ERP) system
  - requires (company-specific) classifications

Objective 1
to quantitatively analyze the capacity planning problem in aircraft MRO

- in order to provide model input, ERP systems data are found to have shortcomings
  - ambiguous classifications (e.g. project types), non-use of industry standards (e.g. aircraft zoning), outdated work centers, …
  - manual data preparation possible, but cumbersome (especially on a daily basis)

Simulation-based planning systems

- require consistent models (here: Multi-Mode Resource-Constrained Project Scheduling Problem, MRCMPSP)
- gaps between model capabilities and its practical application

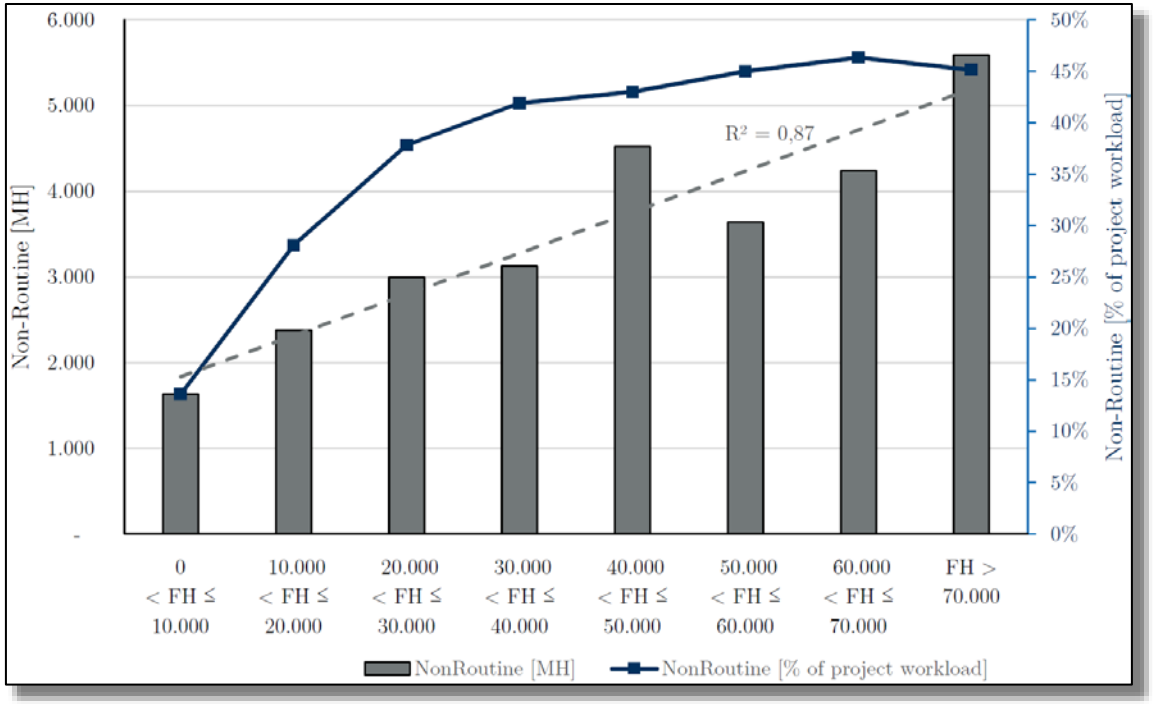
Objective 2
to propose an ERP-based workload estimation method

Quantitative Analysis of Maintenance Workloads

- project workload diverges greatly (from 1,000 man-hours to 55,000 man-hours) – project classification needed
- corrective maintenance (“non-routine”) is between 14 - 56% of project workload
  - non-routine increases throughout the service life of an aircraft
  - aging aircraft (40,000 FH or more) comprise of approximately 45% non-routine

Event Type	# of projects [-]	Project workload [MH, median]	Routine [% of project workload]	Non-Routine [% of project workload]
COMPONENTCHANGE--ENGINES	4	464	56%	44%
COMPONENTCHANGE--GEARS	29	659	75%	25%
MODIFICATION--AVIONICS	4	718	67%	33%
CHECK--A	5	1.103	64%	36%
REPAIR--STRUCTURE	13	1.512	47%	53%
CHECK--B	23	6.659	56%	44%
CHECK--C	54	8.159	44%	56%
MODIFICATION--CABIN	28	13.010	65%	35%
CHECK--D	20	16.612	54%	46%
MODIFICATION--STRUCTURE	17	23.450	86%	14%
MODIFICATION--PTOF	4	55.210	64%	36%
Overall (median)	**201**	**6.641**	**62%**	**38%**

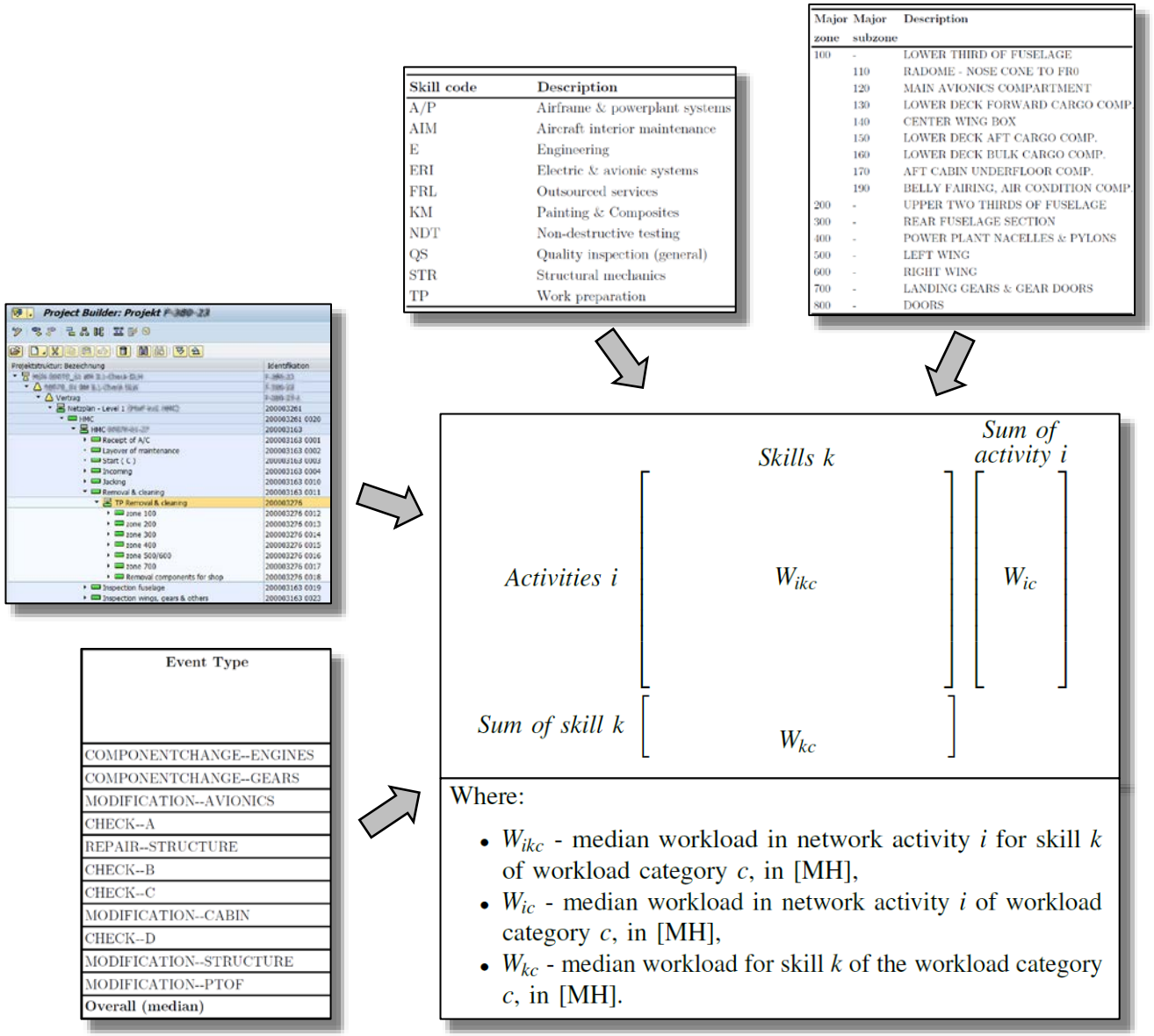
Maintenance actions and origin of workloads in aircraft maintenance projects.



Median of non-routine workload by age of aircraft

Workload Estimation Method

- method consists of
  - a set of data mining procedures based on aircraft maintenance data stored in an ERP system
  - procedures to transform and map operation data by means of rule-based data wrangling
- allows for configuration and selection of historical projects to analyze by maintenance managers
- results consolidated in a *workload distribution matrix*
- ERP system interface to a discrete-event simulation software implemented
  - workload distribution matrix,
  - project network,
  - aircraft zones
  - skills, resources, and resource availabilities



Structure of the workload distribution matrix and considered classifications of event types, network activities, skills, and aircraft zones

Case Example

- Airbus A380 cabin modification event
- workload distribution matrix for routine and non-routine workloads has been obtained analyzing five historical projects
- roughly 700 work centers defined in the ERP system were mapped to relevant skills by maintenance managers
- resulting workload distribution matrix
  - total ”routine” workload is estimated at 8,915 MH (64 %)
  - total ”non-routine” workload is estimated at 4,960 MH (36 %),
  - corresponds to the workload characteristics of a “typical” cabin modification (see former slides)

Estimated MH of Workload Category “Routine”:

Skills k

Activities i (extract)

Vorg.	Kurztext Vorgang	A/P	AIM	E	ERI	FRL	KM	QS	STR	TP	Summe
0041	INSTALLATION - ZONE 400	244	6	0	5	0	0	7	0	0	262
0065	ROUTINEWORK & SERVICING - ZONE 5	30	0	0	0	0	4	1	0	0	35
0060	SYSTEM CHECKS - OTHERS	49	45	0	20	0	0	90	0	0	204
0017	REMOVAL & CLEANING - ZONE 700	96	0	0	1	0	0	1	0	0	98
0052	INSPECTION - ZONE 700	55	1	0	1	1	1	3	0	0	62
0071	MODIFICATION - ZONE 500/600	2	0	0	0	0	0	0	0	0	2
0042	INSTALLATION - ZONE 500/600	149	0	0	2	0	35	1	0	0	187
0066	ROUTINEWORK & SERVICING - ZONE 7	19	0	0	0	0	0	1	0	0	20
0018	REMOVAL COMPONENTS FOR SHOP	0	0	0	0	0	0	0	0	0	0
0055	ENGINE WASH	7	0	0	0	0	0	1	0	0	8
0072	MODIFICATION - ZONE 700	4	0	0	0	0	0	0	0	0	4
0043	INSTALLATION - ZONE 700	83	0	0	0	0	1	2	0	0	86
0056	ENGINE RUN	12	0	0	0	0	0	11	0	0	23
0031	ROUTINEWORK & SERVICING	1	4	0	11	0	0	1	2	0	19
0032	MODIFICATION	0	4	0	24	0	1	0	4	0	33
0036	INSTALLATION	3	1	0	1	0	0	1	0	0	6
0045	FINAL PHASE	36	2	0	5	0	0	12	0	0	55
----	----------	0	0	0	0	0	0	0	0	0	0
		2.412	3.850	0	1.329	6	338	498	482	0	8.915

Example of a workload estimation matrix of a cabin modification
(above: impressions of cabin modification at a German aircraft MRO provider)

Conclusion

Summary:

- In aircraft maintenance projects approx. 40% of workload is corrective and becomes known after project start.
- Order operations of completed projects can be utilized for proper workload estimation and provision of consistent model parameters.
- Classifications of maintenance event types, skills, aircraft locations, and project workflow in ERP system.
- Integrated data wrangling and assignment method has been implemented. Adequate level of detail and can be defined by ‘rules’.
- In case examples, the resulting workload distribution could be validated using expert surveys. Interface from ERP system to a simulation-based capacity planning software has been created.

Future investigations

- Solving the underlying MRCMPSP of aircraft MRO through discrete-event simulation (DES)
- Use of DES to assist a daily production planning and control routine of a third-party aircraft MRO provider

Thank you for your attention

Dipl.-Wi.-Ing. Christian Fabig

Technische Universität Dresden
Institute of Material Handling and
Industrial Engineering
Dresden, 01062, GERMANY

Tel.: +49 351 463 32584
E-Mail: christian.fabig@tu-dresden.de
Internet: http://tu-dresden.de/mw/tla

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